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A Multi-dimensional Analysis of Food Security in Kyrgyzstan: Intersection of Economic, Political, and Environmental Challenges

Summary

This study investigates the driving forces behind food insecurity in Kyrgyzstan, focusing on economic, environmental, and political factors. Economic constraints, including GDP per capita, inflation, and income inequality affected the accessibility and affordability of food. Environmental challenges, such as climate-induced extreme weather events and uneven water distribution, negatively affect agricultural productivity and livelihoods. Additionally, political instability and governance issues obstruct effective policy formulation and development. Through the analysis of economic indicators such as GDP per capita, inflation, and income inequality, alongside political stability and environmental variables like temperature and precipitation patterns, this research reveals that economic inequality and environmental stressors significantly impact food security outcomes. Political stability moderates the influence of these factors but remains an essential component of effective food security strategies. The findings highlight the need for integrated approaches that address these interrelated challenges. Recommendations include consolidating small agricultural enterprises, promoting sustainable farming practices, enhancing rural economic development, and improving governance structures.

Keywords: food security, political stability, control of corruption, climate change.

Introduction

Food security remains one of the most pressing global challenges of the 21st century, closely linked to economic stability, social well-being, and sustainable development. Despite significant international efforts, such as the United Nations' Sustainable Development Goals (SDG 2: Zero Hunger), millions worldwide still face hunger and malnutrition due to disruptions in agricultural systems, climate change, and socio-political instability (FAO, 2023; IFPRI, 2019; WFP, 2021).

Globally, food security is increasingly threatened by economic inequalities, volatile food prices, and environmental degradation. Climate change has emerged as a critical factor, intensifying weather unpredictability and diminishing agricultural productivity (Bozsik et al., 2024; IPCC, 2022). Additionally, recent global events such as the COVID-19 pandemic exposed vulnerabilities in supply chains, amplifying food insecurity in many regions (FAO, 2023; Nugroho et al., 2023). Geopolitical conflicts further exacerbate these challenges by disrupting key agricultural exports and supply routes (WFP, 2021).

In Kyrgyzstan, a landlocked and mountainous nation in Central Asia, food insecurity manifests through a complex interplay of economic, environmental, and political factors. The country's transition from a centrally planned economy to a market-oriented system in the 1990s significantly impacted its agricultural sector, leading to reduced state support, fragmented landholdings, and a decline in productivity (ADB, 2014; Spoor, 1999). These changes disproportionately affect rural communities, where approximately 63% of the population resides and remains heavily reliant on small-scale farming (Serova & Yanbykh, 2023).

Economic constraints further amplify food insecurity in Kyrgyzstan, with over 60% of household income allocated to food, leaving limited resources for other essential needs (WFP, 2023). The reliance on imported staples exposes the nation to global market fluctuations, further straining accessibility and affordability. Concurrently, environmental vulnerabilities—such as climate-induced extreme weather events and unevenly distributed water resources—pose significant risks to agricultural productivity and rural livelihoods (IPCC, 2022; World Bank, 2021).

Despite ongoing interventions by international organizations and government-led initiatives aimed at rural development and agricultural modernization, Kyrgyzstan continues to face significant barriers to achieving sustainable food security. Addressing these multifaceted challenges requires an integrated approach that considers economic, environmental, and political dimensions.

This study investigates the underlying factors driving food insecurity in Kyrgyzstan, focusing on the intersections of economic disparities, environmental vulnerabilities, and political instability. The research is guided by the following questions:

- How do economic factors, such as GDP per capita, inflation, and income inequality, affect food security in Kyrgyzstan?
- In what ways do political stability and governance influence food security?
- How do environmental variables, including temperature changes and precipitation patterns, impact food security outcomes?

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Table 1. Indicators of the dynamics of production of basic food products in Kyrgyzstan

Agricultural products	Production in 2022, tsnd tons	Average production for the period 2018–2022, tsnd tons	Deviation from average production for the period	Dynamics (growth/ decrease in the production trend) for the period 2018–2022
Grain (in weight after refinement)	1867.3	1715.06	±2%	growth
Wheat	592.5	600.58	±2%	growth
Barley	539.6	443.8	±3%	decrease
Sugar beet	468.1	559.32	±28%	growth
Potatoes	1275	1342.34	±7%	growth
Vegetables	1163.6	1123.5	±3%	decrease
Fruits and berries	275.5	268.16	±7%	decrease
Meat (in slaughter weight), thsnd tons	248.3	232.24	±5%	decrease
Raw milk, thousand tons	1734.1	1663.7	±5%	decrease
Eggs, mln pc	607.9	565.72	±6%	decrease

Source: Calculated by the author based on data from the National Statistical Committee of the Kyrgyz Republic (NSC KR, 2023a).

– What is the combined effect of economic, environmental, and political factors on food security?

This study is essential for its potential to provide a comprehensive understanding of these complex and interrelated factors driving food insecurity in Kyrgyzstan. By analyzing the economic, environmental, and political dimensions of food security, the research aims to uncover the root causes of these challenges and propose actionable recommendations for policymakers and stakeholders. Such insights are critical for developing targeted strategies that enhance food production, improve access to nutritious foods, and build resilience against future challenges.

Literature Review

Kyrgyzstan's approach to food security has evolved significantly since its transition from a centrally planned to a market-oriented economy. The formal recognition of food security as a national priority came with the adoption of the Law on Food Security on August 4, 2008. This law identified food security as an integral component of national security, crucial for ensuring societal stability and long-term development (CBD KR, 2023).

The Law on Food Security established a legal foundation for achieving food security in Kyrgyzstan, setting out goals to ensure the availability, accessibility, and stability of food supplies. Central to this framework is the identification of nine basic food products as benchmarks for assessing the country's food security status. These include bread and bakery products, meat and meat products, vegetables and melons, seed oil, potatoes, milk and dairy products, fruits and berries, sugar, and eggs. The selection of these products reflects Kyrgyzstan's cultural, and climatic characteristics, as well as the dietary habits of its population (CBD KR, 2009).

To facilitate the implementation of food security policies, the Regulation on the Food Security Council of the Kyrgyz Republic was adopted on October 8, 2007. This regulation established an institutional framework for overseeing food security, emphasizing the importance of coordinated efforts among government bodies, local authorities, and international organizations. The council is tasked with monitoring food availability, managing strategic food reserves, and responding to crises such as natural disasters or market disruptions.

A critical metric within Kyrgyzstan's food security strategy is maintaining sufficient reserves of essential staples to meet the 90-day needs of socially vulnerable populations, defined as those living below the poverty line, representing approximately 22.4% of the population(NSC KR, 2023c). These reserves, managed within the national material reserve system, aim to mitigate food shortages, stabilize prices, and support vulnerable groups during crises. However, challenges persist in the efficient management and replenishment of these reserves (CBD KR, 2023; Wengle et al., 2024).

The dynamics of agricultural production in Kyrgyzstan reflect a mix of growth and decline across the key food categories, underscoring the sector's uneven development and its challenges in achieving self-sufficiency. *Table 1* highlights recent trends in the production of critical agricultural products during 2022, compared to the average production for the period 2018–2022 (NSC KR, 2023a).

Grain production showed overall growth, with output peaking at 1,867.3 thousand tons in 2022, surpassing the five-year average. Wheat production demonstrated stability, fluctuating around 600 thousand tons annually, but remained below its 2020 peak of 629.1 thousand tons. Barley production experienced significant variability, with a sharp decline in 2021 to 274.1 thousand tons due to unfavorable conditions but rebounded strongly in 2022 to 539.6 thousand tons (NSC KR, 2023a).

Potato production showed a gradual decline over the period, decreasing from 1,446.6 thousand tons in 2018 to 1,275 thousand tons in 2022 as shown in *Table 2*. This steady drop highlights challenges in maintaining high productivity levels. Conversely, vegetable production increased steadily, reaching 1,163.6 thousand tons in 2022 (NSC KR, 2023a), indicating a positive trajectory supported by favorable conditions and demand.

Fruits and berries saw moderate growth from 251.4 thousand tons in 2018 to 275.5 thousand tons in 2022. Dairy production, including raw milk and eggs, demonstrated consistent improvement. Milk production increased steadily, reaching

1,734.1 thousand tons in 2022, while egg production rose from 533.2 million pieces in 2018 to 607.9 million pieces in 2022, reflecting increased efficiency in livestock management (NSC KR, 2023a).

Table 2. Production of basic food products in Kyrgyzstan

Agricultural products	2018	2019	2020	2021	2022
Grain (in weight after refinement)	1741.5	1781.4	1856	1329.1	1867.3
Wheat	615.9	601.2	629.1	564.2	592.5
Barley	429.3	465.8	510.2	274.1	539.6
Sugar beet	773	741.1	448.8	365.6	468.1
Potatoes	1446.6	1373.8	1327.2	1289.1	1275
Vegetables	1094.9	1113.6	1131.2	1114.2	1163.6
Fruits and berries	251.4	269.5	278	266.4	275.5
Meat (in slaughter weight). thsnd tons	221.3	226.2	230.4	235	248.3
Raw milk. thousand tons	1589.7	1627.8	1668	1698.9	1734.1
Eggs. mln pc	533.2	561.3	562	564.2	607.9

Source: National Statistical Committee of the Kyrgyz Republic (NSC KR, 2023a).

Meat production, measured in slaughter weight, showed a steady upward trend, growing from 221.3 thousand tons in 2018 to 248.3 thousand tons in 2022 (NSC KR, 2023a). This growth signifies gradual improvements in livestock productivity despite challenges like high feed costs and limited access to modern farming techniques.

While certain categories such as grain, vegetables, milk, and eggs show a positive trajectory, others like potatoes and sugar beet reflect a declining trend. These mixed results underline the sector's vulnerability to systemic challenges, including fluctuating climatic conditions, limited access to modern technology, and inefficiencies in supply chains. Additionally, the country's reliance on food imports, particularly for staples such as bread and meat, exacerbates its vulnerability to global market fluctuations. Import dependency not only undermines food security but also exposes the population to price shocks and supply disruptions. Addressing these vulnerabilities requires a concerted effort to strengthen domestic production and reduce reliance on imports.

Economic accessibility remains a critical barrier to food security in Kyrgyzstan. High poverty rates, coupled with a significant share of household income spent on food, limit the ability of many families to purchase adequate quantities of nutritious food. In 2018, food expenses accounted for 53% of household budgets, compared to the 20–30% typical in developed countries (NSC KR, 2023b). Additionally, undernourishment remains prevalent, with nearly half the population consuming fewer than 2,100 kcal per day, far below the recommended average of 2,981 kcal (CBD KR, 2010). Such deficiencies contribute to widespread health issues, including anemia and increased susceptibility to infections.

The transition to a market economy introduced structural challenges to Kyrgyzstan's agricultural sector. The dismantling of collective farming structures, coupled with insufficient integration between agriculture and food industries, has led to inefficiencies. Small-scale farmers, who dominate the agricultural landscape, face barriers such as limited access to credit, modern machinery, and high-quality inputs, further hindering productivity (Spoor, 1999).

Governance issues, including weak institutional frameworks, corruption, and inadequate policy implementation, further exacerbate the challenges facing Kyrgyzstan's food security(Musarova & Adamkulova, 2023). Strengthening these frameworks and promoting transparency in resource allocation are critical for improving the effectiveness of food security policies.

Kyrgyzstan's mountainous terrain and limited arable land pose inherent challenges to agricultural productivity. Climate change has compounded these issues, introducing irregular precipitation patterns, more frequent droughts, and soil degradation. These changes have had a detrimental impact on crop yields and livestock production, increasing the vulnerability of the agricultural sector.

To address these challenges, Kyrgyzstan has implemented several initiatives aimed at improving food security. These include policies to increase agricultural production, enhance food storage infrastructure, and expand social safety nets for vulnerable populations. However, significant gaps remain, particularly in addressing economic accessibility and reducing reliance on food imports.

Materials and Methods

This study employs a quantitative research design to investigate the comprehensive impact of economic, political, and environmental factors on food security, defined as a composite measure encompassing the prevalence of undernourishment (PoU) and the consumption of nine basic food products (potato, vegetable, fruit, meat, milk, sugar, egg, seed oil, and bread). This composite approach provides a multidimensional view of food security, capturing both the availability and quality of food.

Data Collection. The research employed time series data. The secondary data was collected from 2002 to 2022. Data for the analysis was sourced from reputable and publicly accessible databases. Economic indicators, including GDP per capita PPP, inflation, and the Gini coefficient, were obtained from the World Bank (WB) and the International Monetary Fund (IMF). Political factors, such as political stability and corruption control, were retrieved from the World Governance Indicators (WGI). Environmental data, including temperature and precipitation metrics, were sourced from the Climate Change Knowledge Portal of the World Bank Group (CCKP WB) and other relevant climate databases. The dependent variables, comprising PoU and the consumption of basic food products, were collected from the Food and Agriculture Organization (FAO) and the National Statistical Committee of the Kyrgyz Republic.

Data Preparation. Prior to analysis, data were meticulously cleaned and prepared, addressing missing values, outliers, and inconsistencies. Appropriate imputation techniques were applied to handle missing data, ensuring a complete dataset. The data were then transformed as necessary to meet the assumptions of regression analysis.

Table 3. Variables and data sources for the study

Dependent Variables	Symbol	Source
Prevalence of Undernourishment (%) (3-year average)	PoU	FAOSTAT
Consumption of Bread and bakery products	ConsBread	NSC KR
Consumption of Potatoes	ConsPotato	NSC KR
Consumption of Vegetables and melon	ConsVeg	NSC KR
Consumption of Fruit and berries	ConsFruit	NSC KR
Consumption of Meat and meat products	ConsMeat	NSC KR
Consumption of Milk and dairy products	ConsMilk	NSC KR
Consumption of Seed oil	ConsOil	NSC KR
Consumption of Sugar	ConsSugar	NSC KR
Consumption of Eggs	ConsEgg	NSC KR
Independent Variables		
Political:		
Political Stability and Absence of Violence/Terrorism (percentile rank)	POLST	WGI
Control of Corruption	CC	WGI
Economic:		
GDP per capita PPP	GDP	WB
Inflation, Consumer Prices (annual %)	INF	IMF
Gini Coefficient	GINI	IMF
Environmental:		
Annual Average Temperature	Tave	CCKP WB
Annual Maximum number of consecutive dry days	Dry	CCKP WB
Annual Maximum number of consecutive wet days	Rainy	CCKP WB

Source: Author's own construction

The study used eight explanatory variables and ten dependent variables to represent the food security of the country, including nine basic product consumptions and the prevalence of undernourishment as indicated in *Table 3*.

Diagnostic Tests. To ensure the validity and reliability of the regression models, several diagnostic tests were conducted:
- Multicollinearity: Variance Inflation Factor (VIF) was used to detect multicollinearity among independent variables. A VIF value greater than 10 indicates high multicollinearity.
- Heteroskedasticity: The Breusch-Pagan test was employed to detect heteroskedasticity in the residuals. Significant p-values indicate the presence of heteroskedasticity.
- Autocorrelation: The Durbin-Watson statistic was used to check for autocorrelation in the residuals. Values close to 2 suggest no significant autocorrelation, while values far from 2 indicate positive or negative autocorrelation.

Regression Analysis. In this study, regression analysis was used to examine the impact of various factors on food security and consumption patterns. Separate regression models were run for each component of the composite food security index. Robust standard errors were used to correct for heteroskedasticity, and the results were checked for autocorrelation using the Durbin-Watson statistic (Nugroho et al., 2021).

$$Y_i = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \beta_3 X_{3,i} + \ldots + \beta_n X_{n,i} + \varepsilon_i \quad (1)$$

Where:

Y_i is the dependent variable (e.g., potato consumption, PoU, etc.).

β_0 is the intercept.

$\beta_1, \beta_2, \beta_3, \ldots, \beta_n$ are the coefficients for the independent variables.

$X_{1,i}, X_{2,i}, X_{3,i}, \ldots, X_{n,i}$ are the independent variables (e.g., GDP, inflation, etc.).

ε_i is the error term.

Comprehensive regression models incorporating economic, political, and environmental factors were also developed to provide a holistic understanding of the factors impacting food security and consumption patterns.

When significant autocorrelation was detected, Newey-West standard errors were applied to address both heteroskedasticity and autocorrelation simultaneously. The lag length for the Newey-West adjustment was determined based on the data frequency and the sample size.

Interpretation of Results

The interpretation of regression results focused on the significance and direction of coefficients for each independent variable:
- ***Economic Factors:*** GDP per capita, inflation, and income inequality were examined for their effects on food consumption patterns and food security. Higher GDP generally indicates better economic conditions, leading to improved food security. Inflation impacts the cost of living and food affordability, while income inequality affects equitable access to food.
- ***Political Factors:*** Political Stability and Corruption Control were included to understand their influence on food security. These factors are critical in creating a conducive environment for economic growth and development, which in turn impacts food security.
- ***Environmental Factors:*** Temperature and Precipitation were analyzed to assess their impact on agricultural productivity and food availability. Extreme weather conditions can significantly affect crop yields and food supply, thus influencing consumption patterns.

Robustness Checks

To ensure the reliability of the findings, several robustness checks were conducted:
- ***Sensitivity Analysis:*** Sensitivity analyses were performed by varying the lag lengths in the Newey-West adjustment and re-running the models. This ensured that the results were not overly sensitive to specific model specifications.
- ***Model Validation:*** Cross-validation techniques were used to validate regression models. This involved splitting the data into training and testing sets and evaluating the models' performance on unseen data.

– ***Documentation and Replicability:*** All steps of the data preparation, diagnostic testing, and regression analysis steps were thoroughly documented to ensure replicability and transparency in the research process.

This study's comprehensive approach ensures a robust analysis of how economic, political, and environmental factors impact food security. By combining PoU and food consumption metrics into a composite index, the study captures a multidimensional view of food security. Addressing issues of multicollinearity, heteroskedasticity, and autocorrelation, robust standard errors, and Newey-West adjustments ensures the reliability of regression results.

Results

Descriptive Statistics of Economic, Political, and Environmental Indicators.

The analysis of economic, political, and environmental factors provides critical insights into the broader context influencing food security in Kyrgyzstan *(Table 4)*.

Political Indicators:

POLST: The index mean is 23.00, with high variability (SD = 7.69), indicating periods of instability disrupting food supply chains.

– CC: The average score of 10.86 (SD = 3.53) underscores persistent governance challenges affecting resource allocation and policy implementation.

Economic Indicators:

GDP: The mean of $3,749.29 reflects significant economic disparities, with variability impacting food affordability.

– INF: Averaging 6.99% (SD = 5.69%), inflation peaks (24.5%) likely contribute to price instability for basic commodities.
– GINI: A mean of 29.77 indicates moderate income inequality exacerbating food accessibility disparities.

Environmental Indicators:

Annual Average Temperature: Minor variability (mean = 0.81°C; SD = 0.40) can still have outsized effects on traditional farming practices.

– Consecutive Wet and Dry Days: Variability in precipitation patterns (wet days: mean = 80.34; dry days: mean = 94.99) highlights risks to crop yields from droughts and inconsistent water availability.

Table 4. Descriptive Statistics of Economic, Political, and Environmental Indicators

Variables	Mean	SD	Min	Max
Political Stability and Absence of Violence/ Terrorism	23.00063	7.686012	11.5942	39.68
Control of Corruption	10.86258	3.526673	4.30622	17.14286
GDP per capita PPP	3749.291	1351.246	1986.151	6572.383
Inflation, Consumer Prices	6.990909	5.693932	.4	24.5
Gini Coefficient	29.76818	2.805333	26.4	37.4
Annual Average Temperature	.8086364	.3988113	–.09	1.5
Annual Maximum number of consecutive wet days	80.33627	7.984725	65.96	99.01
Annual Maximum number of consecutive dry days	94.99939	8.691203	84.23	116.75
N	22			

Source: Authors calculation using STATA 16.0 program

These results illustrate the complex interplay between food consumption patterns, undernourishment prevalence, and external factors, emphasizing the multifaceted nature of food security in Kyrgyzstan.

Impact of Economic Factors on Food Security

The analysis investigates the impact of economic factors, specifically GDP per capita, inflation, and income inequality (Gini coefficient), on food security in Kyrgyzstan. The dependent variables include the consumption of nine basic food products

Table 5. The results of multiple regression analysis for economic factors

	ConsPotato	ConsVeg	ConsFruit	ConsMeat	ConsMilk	ConsSugar	ConsEgg	ConsOil	ConsBread	PoU
GDP	–0.00326***	0.00358**	0.00250**	0.00194***	–0.00155	0.000148	0.00972***	0.000419	–0.00284	–0.00163**
	(–7.51)	(3.52)	(3.00)	(5.39)	(–1.01)	(0.33)	(7.03)	(1.59)	(–1.58)	(–3.02)
INF	0.0130	0.420*	–0.245	–0.0422	–0.178	0.0609	–0.214	0.0342	–0.466	0.0411
	(0.12)	(2.19)	(–1.59)	(–0.77)	(–1.06)	(1.03)	(–1.14)	(1.36)	(–0.63)	(0.80)
GINI	0.220	0.540	–0.714	–0.349*	0.118	0.284	0.373	–0.112	–2.833	–0.0988
	(0.50)	(1.10)	(–1.15)	(–2.69)	(0.29)	(0.86)	(0.81)	(–1.31)	(–0.83)	(–0.65)
_cons	53.78**	44.19*	38.21	21.41***	90.63***	4.478	16.03	11.89**	219.4*	16.17*
	(3.88)	(2.58)	(1.93)	(4.41)	(5.07)	(0.41)	(0.89)	(3.35)	(2.11)	(2.48)
N	22	22	22	22	22	22	22	22	22	22

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors calculation using STATA 16.0 program

Table 6. The results of multiple regression analysis for political factors

	ConsPotato	ConsVeg	ConsFruit	ConsMeat	ConsMilk	ConsSugar	ConsEgg	ConsOil	ConsOil	PoU
POLST	–0.113	0.257	0.0321	0.122	0.158	–0.0871	0.532	–0.00144	–0.00144	0.0858
	(–0.47)	(0.92)	(0.15)	(0.81)	(0.63)	(–1.33)	(1.11)	(–0.02)	(–0.03)	(0.68)
CC	–0.494	–0.721	1.062**	0.353	–0.117	–0.155	1.235*	–0.00791	–0.00791	–0.270*
	(–1.07)	(–1.85)	(3.40)	(1.88)	(–0.44)	(–1.59)	(2.36)	(–0.11)	(–0.12)	(–2.14)
_cons	56.17***	78.54***	12.33*	11.34***	84.70***	17.58***	36.42***	10.49***	10.49***	8.382**
	(9.81)	(13.44)	(2.43)	(4.02)	(17.34)	(11.28)	(4.00)	(10.14)	(11.54)	(3.27)
N	22	22	22	22	22	22	22	22	22	22

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors calculation using STATA 16.0 program

and PoU. The results provide insights into how economic conditions influence dietary patterns and nutritional outcomes in the country *(Table 5)*.

GDP. The findings reveal that GDP per capita has a statistically significant impact on several dimensions of food security. Notable results include:

– Potato Consumption: A significant negative relationship exists between GDP per capita and potato consumption (β = –0.00326, t = –7.51, p < 0.01). This suggests that higher income levels lead to reduced reliance on staple foods like potatoes, as households diversify their diets.
– Vegetable Consumption: A positive relationship is observed (β = 0.00358, t = 3.52, p < 0.05), indicating that economic prosperity enhances access to vegetables, contributing to improved dietary quality.
– Fruit Consumption: GDP per capita positively influences fruit consumption (β = 0.00250, t = 3.00, p < 0.05), enabling households to incorporate more fruits into their diets, fostering nutritional balance.
– Meat Consumption: A positive and significant relationship (β = 0.00194, t = 5.39, p < 0.01) suggests that higher incomes facilitate increased consumption of protein-rich foods.
– Egg Consumption: A strong positive relationship (β = 0.00972, t = 7.03, p < 0.01) highlights that economic growth enhances access to eggs, a vital protein source.
– PoU: A significant negative association (β = –0.00163, t = –3.02, p < 0.05) underscores the role of economic growth in reducing food insecurity.

Other food products, including milk, sugar, oil, and bread, do not exhibit statistically significant relationships with GDP per capita, suggesting that their consumption patterns are less sensitive to income changes.

INF. Inflation demonstrates limited and variable effects on food security:

– Vegetable Consumption: A significant positive relationship (β = 0.420, t = 2.19, p < 0.10) suggests that inflation-induced price increases may alter consumption.
– Other Food Products and PoU: No significant relationships are observed, implying that inflationary pressures do not substantially affect the consumption of most food products or overall undernourishment rates.

GINI. Income inequality, as measured by the Gini coefficient, has a mixed impact on food security:

– Meat Consumption: A significant negative relationship (β = –0.349, t = –2.69, p < 0.05) indicates that higher income inequality reduces access to meat, highlighting disparities in dietary quality among socioeconomic groups.
– Other Food Products and PoU: Income inequality does not significantly influence the consumption of other food items or the prevalence of undernourishment, suggesting its effects are more pronounced in specific dietary components.

The analysis demonstrates that GDP per capita is a critical determinant of food security in Kyrgyzstan, significantly enhancing the consumption of several food products and reducing undernourishment. In contrast, inflation primarily affects vegetable consumption, while its impact on other aspects of food security remains minimal. Income inequality notably affects meat consumption, reflecting disparities in access to protein-rich foods among lower-income households.

Impact of Political Factors on Food Security

The multiple regression analysis examines the influence of political factors on food security in Kyrgyzstan, focusing on POLST and CC. The dependent variables include the consumption of nine basic food products and the PoU. The results shed light on how political conditions and governance affect dietary patterns and nutritional outcomes *(Table 6)*.

POLST. The results indicate that political stability does not have a statistically significant impact on the consumption of most food products or PoU. Specifically, potato consumption shows no significant relationship with political stability (β = –0.113, t = –0.47). Similarly, no significant effects are observed for vegetable consumption (β = 0.257, t = 0.92), fruits consumption (β = 0.0321, t = 0.15), meat consumption (β = 0.122, t = 0.81), milk consumption (β = 0.158, t = 0.63), sugar consumption (β = –0.0871, t = –1.33), eggs consumption (β = 0.532, t = 1.11), and seed oil consumption (β = –0.00144, t = –0.02). PoU also shows no significant relationship with political stability (β = 0.0858, t = 0.68), suggesting that political stability alone may not be a strong determinant of food security in Kyrgyzstan.

These findings suggest that political stability alone may not be a strong determinant of food security in Kyrgyzstan. Its lack of significant influence on both the consumption of the nine basic food products and the prevalence of undernourishment points to the need for further exploration of other factors that may have more direct impacts on food security.

CC. The analysis reveals that corruption control significantly affects certain aspects of food security. There is a significant

Table 7. The results of multiple regression analysis for environmental factors

	ConsPotato	ConsVeg	ConsFruit	ConsMeat	ConsMilk	ConsSugar	ConsEgg	ConsOil	ConsBread	PoU
Tave	0.391	6.538**	–3.934	1.026	2.324	0.614	3.811	0.0479	–17.42	–0.269
	(0.11)	(3.08)	(–1.14)	(0.55)	(0.99)	(0.50)	(0.76)	(0.07)	(–0.95)	(–0.26)
Rainy	0.000352	–0.407**	–0.132	–0.173*	–0.000432	0.000781	–0.406*	–0.0366	0.754	0.0605
	(0.00)	(–2.94)	(–1.63)	(–2.47)	(–0.00)	(0.02)	(–2.26)	(–1.44)	(0.88)	(1.73)
Dry	0.0849	0.0783	–0.119	–0.0394	–0.114	0.0321	–0.100	0.0139	–0.661	–0.00788
	(0.58)	(0.69)	(–0.71)	(–0.46)	(–0.98)	(0.88)	(–0.30)	(0.62)	(–1.23)	(–0.13)
_cons	39.79*	96.59***	49.73*	34.82**	96.04***	10.29	101.1*	11.95***	137.5*	3.525
	(2.47)	(6.34)	(2.56)	(3.32)	(4.79)	(1.90)	(2.79)	(4.50)	(2.47)	(0.56)
N	22	22	22	22	22	22	22	22	22	22

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors calculation using STATA 16.0 program

positive relationship between corruption control and fruit consumption (β = 1.062, t = 3.40, p < 0.05). This indicates that effective corruption control measures can lead to increased fruit consumption, possibly by improving the efficiency of food distribution systems and reducing the diversion of resources. Additionally, a significant positive relationship is observed between corruption control and egg consumption (β = 1.235, t = 2.36, p < 0.10). This suggests that better governance and reduced corruption can enhance access to protein-rich foods such as eggs.

However, the relationship between corruption control and potato consumption is not statistically significant (β = –0.494, t = –1.07), indicating that corruption control does not substantially affect potato consumption patterns. Similarly, corruption control does not have a significant impact on the consumption of vegetables (β = –0.721, t = –1.85), meat (β = 0.353, t = 1.88), milk (β = –0.117, t = –0.44), sugar (β = –0.155, t = –1.59), oil (β = –0.00791, t = –0.11), or the PoU (β = –0.270, t = –2.14, p < 0.10).

These findings highlight that corruption control can significantly enhance food security by increasing the consumption of fruits and eggs. However, its effects on other food products and undernourishment remain limited.

The results demonstrate that POLST does not significantly impact food security in Kyrgyzstan, as measured by the consumption of nine basic food products and the prevalence of undernourishment. In contrast, corruption control plays a more substantial role, significantly increasing the consumption of fruits and eggs. These findings underscore the importance of improving governance and reducing corruption to enhance food security, particularly by increasing access to diverse and nutritious foods.

Impact of Environmental Factors on Food Security

The analysis of the multiple regression analysis investigates the impact of environmental factors, including average temperature (Tave), the number of rainy days (Rainy), and the number of dry days (Dry), on food security in Kyrgyzstan. The dependent variables include the consumption of nine basic food products and the PoU. These results provide insights into how environmental conditions influence dietary patterns and nutritional outcomes in the country *(Table 7)*.

Tave. The analysis reveals a significant positive relationship between average temperature and vegetable consumption (β = 6.538, t = 3.08, p < 0.05), suggesting that higher temperatures may enhance vegetable consumption, possibly due to improved growing conditions. However, average temperature does not significantly affect the consumption of other food products or the PoU.

Rainy. An increase in the number of rainy days is significantly associated with decreased consumption of vegetables (β = –0.407, t = –2.94, p < 0.05), meat (β = –0.173, t = –2.47, p < 0.10), and egg (β = –0.406, t = –2.26, p < 0.10). This negative relationship may be due to adverse effects of excessive rainfall on crop and livestock production. The number of rainy days does not significantly impact the consumption of other food products or the PoU.

Dry. The analysis indicates no statistically significant impact of the number of dry days on the consumption of basic food products or the prevalence of undernourishment. This suggests that dry conditions alone may not be a critical determinant of food security in Kyrgyzstan.

In conclusion, environmental factors, particularly average temperature and the number of rainy days, significantly influence certain aspects of food security in Kyrgyzstan. Higher average temperatures are associated with increased vegetable consumption, while more rainy days correlate with reduced consumption of vegetables, meat, and eggs. These findings underscore the importance of considering environmental conditions in efforts to improve food security and agricultural productivity in the country.

Combined Impact of Economic, Political, and Environmental Factors on Food Security.

This section provides an interpretation of the combined impact of economic, political, and environmental factors on food security in Kyrgyzstan. The analysis includes the consumption of nine basic food products and the prevalence of undernourishment as dependent variables. The results offer a comprehensive understanding of how these diverse factors interact and influence food security *(Table 8)*.

Economic Factors. Economic variables, particularly GDP and income inequality, exert a substantial influence on food security outcomes. Higher GDP is significantly associated with increased consumption of vegetables (β = 0.00345, p < 0.01), fruits (β = 0.00286, p < 0.05), meat (β = 0.00169, p < 0.001), and eggs (β = 0.0102, p < 0.001). Simultaneously, GDP reduces potato consumption (β = –0.00398, p < 0.001), likely reflecting dietary shifts from staple crops to higher-value food products as income levels improve. Moreover, GDP significantly reduces

the PoU (β = –0.00190, p < 0.01), underscoring its critical role in enhancing food access and nutrition.

GINI negatively impacts the consumption of meat (β = –0.369, p < 0.05) and oil (β = –0.231, p < 0.01), likely reflecting reduced purchasing power among lower-income groups for these higher-cost food items. These findings indicate that economic growth, while critical, must be accompanied by measures to reduce socioeconomic disparities to ensure equitable improvements in food security across all population segments.

Political Factors. POLST plays a pivotal role in reducing undernourishment (β = 0.146, p < 0.10), emphasizing the importance of governance and institutional stability in fostering food security. CC, while showing limited impacts on overall consumption patterns, significantly reduces oil consumption (β = –0.141, p < 0.10), indicating its potential to influence dietary composition through market dynamics and resource allocation.

Environmental Factors. Environmental conditions show nuanced effects on food security. The number of dry days is positively associated with oil consumption (β = 0.0490, p < 0.05), suggesting adaptive dietary behaviors in response to environmental stressors. Other environmental variables, including average temperature and rainy days, do not exhibit statistically significant effects on consumption patterns or undernourishment.

In conclusion, the analysis reveals that economic, political, and environmental factors all play significant roles in shaping food security in Kyrgyzstan. Higher GDP per capita positively influences the consumption of vegetables, fruits, meat, and eggs, and reduces the PoU, indicating the crucial role of economic growth in enhancing food security. POLST contributes to lowering undernourishment rates but does not significantly impact the consumption of most food products. In contrast, CC significantly reduces oil consumption and, to some extent, impacts the consumption of other foods.

Environmental factors such as average temperature, number of rainy days, and dry days have mixed effects on food security. Higher average temperatures significantly increase vegetable consumption, while more rainy days reduce the consumption of vegetables, meat, and eggs. Dry days notably increase oil consumption but do not significantly affect other food products.

Overall, these findings underscore the importance of fostering economic growth, improving governance to reduce corruption, and managing environmental conditions to enhance food security.

Discussion

The findings of this study provide nuanced insights into the multifaceted nature of food security in Kyrgyzstan, emphasizing the interconnected roles of economic, political, and environmental factors. This discussion contextualizes these results within broader literature, highlighting the implications for policy and future research.

The results reveal that economic growth positively influences food consumption patterns, with GDP growth enhancing dietary diversity, particularly for nutrient-rich foods like vegetables, fruits, and eggs. These findings corroborate established literature that links economic development with improved food security through increased purchasing power and access to diversified diets (Serova & Yanbykh, 2023).

However, the significant negative impacts of income inequality on meat and oil consumption highlight persistent disparities in food access across socioeconomic strata. This duality underscores a critical challenge: economic growth alone can-

Table 8. The results for combined economic, political, and environmental factors

	ConsPotato	ConsVeg	ConsFruit	ConsMeat	ConsMilk	ConsSugar	ConsEgg	ConsOil	ConsBread	PoU
POLST	–0.0442	–0.0146	–0.0575	0.00441	0.268	–0.0967	0.289	–0.0393	–0.238	0.146*
	(–0.30)	(–0.09)	(–0.35)	(0.10)	(1.28)	(–1.40)	(1.91)	(–1.80)	(–0.29)	(2.75)
CC	–0.0227	–0.752	0.736	0.109	0.130	–0.151	0.318	–0.141*	3.561	0.00510
	(–0.05)	(–1.50)	(1.56)	(0.79)	(0.28)	(–0.72)	(0.77)	(–2.23)	(1.00)	(0.04)
GDP	–0.00398***	0.00345**	0.00286*	0.00169***	–0.00238	0.000345	0.0102***	0.000498	–0.00144	–0.00190**
	(–4.35)	(3.16)	(2.75)	(4.50)	(–1.38)	(0.69)	(7.01)	(2.07)	(–0.32)	(–3.60)
INF	–0.100	0.142	0.0227	–0.0210	–0.0224	–0.0114	0.0330	–0.0464	1.357	0.0870
	(–0.45)	(0.45)	(0.09)	(–0.22)	(–0.07)	(–0.12)	(0.12)	(–1.21)	(1.00)	(0.97)
GINI	–0.0951	0.105	–0.0405	–0.369*	0.184	0.162	1.218	–0.231**	–0.283	–0.0346
	(–0.20)	(0.19)	(–0.07)	(–2.64)	(0.40)	(0.42)	(1.94)	(–3.25)	(–0.11)	(–0.29)
Tave	3.391	4.102	–5.691	0.643	2.797	0.351	–6.152	0.339	–16.66	0.596
	(1.29)	(1.13)	(–1.90)	(0.60)	(0.87)	(0.34)	(–1.55)	(0.70)	(–0.76)	(0.92)
Rainy	–0.213	–0.227	0.00174	–0.0465	–0.0869	–0.0152	0.0936	0.00740	0.535	–0.00987
	(–1.59)	(–1.29)	(0.01)	(–1.17)	(–0.48)	(–0.32)	(0.52)	(0.53)	(0.66)	(–0.34)
Dry	0.111	0.0113	–0.0878	0.0130	–0.131	0.0175	–0.181	0.0490*	–0.969	–0.0413
	(0.82)	(0.07)	(–0.57)	(0.25)	(–0.83)	(0.24)	(–1.29)	(2.26)	(–0.97)	(–0.87)
_cons	71.78**	81.88**	21.08	23.49*	100.3**	10.99	–8.002	12.62**	154.8	15.78*
	(3.47)	(3.28)	(0.90)	(2.61)	(3.78)	(1.22)	(–0.28)	(3.45)	(1.55)	(2.28)
N	22	22	22	22	22	22	22	22	22	22

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors calculation using STATA 16.0 program

not ensure equitable food security. As prior research suggests, addressing structural inequalities is essential to achieving universal access to nutritious food (Bozsik et al., 2022). To bridge this gap, policies should prioritize inclusive economic frameworks, such as progressive taxation, equitable distribution of agricultural subsidies, and enhanced access to social protection systems (Mulyo et al., 2023).

Political stability emerges as a critical enabler of food security, with its positive association with reduced undernourishment underscoring the importance of stable governance. Stable political environments facilitate the development and implementation of food security policies, from market regulation to social welfare programs (Abdullah et al., 2022).

Conversely, limited effects of corruption control suggest that while governance quality is crucial, its influence on food security outcomes may be indirect or mediated by other factors. This aligns with studies that advocate for comprehensive governance reforms, emphasizing institutional efficiency, transparency, and accountability (Nugroho et al., 2022). For Kyrgyzstan, these findings underscore the importance of maintaining political stability and enhancing governance mechanisms to bolster food security outcomes (Musarova & Adamkulova, 2023).

Environmental factors, while less statistically dominant, shed light on the adaptive strategies employed in response to climatic variability. The observed increase in oil consumption during drier periods suggests shifts in dietary behavior, potentially as a coping mechanism against environmental stressors (Nugroho et al., 2023).

While other environmental variables, such as rainfall and temperature, exhibit limited direct effects, their influence cannot be overlooked in the context of long-term agricultural productivity and food system resilience. Prior studies highlight the importance of adaptive agricultural practices, such as drought-resistant crops and improved irrigation systems, in mitigating the adverse effects of climatic variability.

This study highlights the importance of adopting a multidimensional lens to address food security challenges. By integrating economic equity, political stability, and environmental resilience into policy frameworks, Kyrgyzstan can advance toward a sustainable and inclusive food system that ensures access to nutritious food for all.

Conclusion

Ensuring food security in Kyrgyzstan requires addressing three interconnected dimensions: the physical availability, economic affordability, and safety of basic food products. These efforts are fundamental to meeting the needs of the population and ensuring national stability.

The availability of food hinges on increasing the volume of basic food products. To achieve this, Kyrgyzstan must prioritize consolidating small private agricultural producers into larger cooperatives. Modern approaches to cooperative formation, focused on production, processing, supply, and marketing, are essential for improving efficiency and output. However, addressing farmers' reluctance and overcoming negative historical perceptions of cooperatives require targeted strategies. Establishing a national agricultural development center, staffed by well-qualified experts in various fields, could help consolidate efforts, provide guidance, and attract investments.

Improving the economic affordability of food is closely tied to empowering rural business entities. Developing processing enterprises in each region, aligned with local priorities, could generate effective employment and raise incomes. Incentivizing investors through preferential loans, tax benefits, and property rights guarantees is critical for fostering sustainable rural development. Such initiatives not only enhance affordability but also contribute to the broader economic resilience of rural communities.

Food safety remains a pressing challenge that requires substantial reforms and investments. Key priorities include formulating an integrated food safety policy, modernizing laboratory infrastructure, and aligning national standards with international frameworks such as HACCP and GlobalGAP. Addressing the shortage of qualified specialists and improving private sector engagement in food safety efforts are also vital. A comprehensive policy framework and structured advisory systems could enable agribusinesses to meet international standards and enhance the competitiveness of Kyrgyz agricultural products.

Political stability and governance are essential to ensuring food security in Kyrgyzstan. Effective policy implementation, governance reforms, and consistent support for agricultural development depend on stable political institutions. Transparent governance can foster trust among stakeholders, encouraging investment and participation in food security initiatives. Moreover, addressing socioeconomic inequalities through equitable distribution of resources and targeted support programs can significantly impact food accessibility and affordability for marginalized groups.

Environmental factors also play a critical role in determining food security. Kyrgyzstan's vulnerability to climate change and extreme weather events, such as droughts and floods, threatens agricultural productivity and food supply chains. Developing adaptive measures, such as climate-resilient farming practices and water management systems, is essential to mitigating these risks. Furthermore, promoting sustainable agricultural practices can help preserve natural resources and ensure long-term productivity. Policymakers must prioritize environmental resilience as part of their broader food security strategy.

The findings of this study underscore the need for an integrative approach to food security, emphasizing the interplay between economic, political, and environmental factors. Consolidating agricultural enterprises, fostering economic empowerment in rural areas, reforming food safety systems, and addressing political and environmental vulnerabilities represent critical pathways for achieving sustainable food security.

To build on these efforts, future research should investigate the longitudinal impacts of governance reforms and environmental variability on food security. Additionally, exploring innovative financing models to support small-scale farmers and enhancing public-private partnerships could provide new insights for addressing persistent challenges.

By adopting a holistic approach that integrates these priorities, Kyrgyzstan can create a resilient food system that meets the nutritional needs of its population while fostering sustainable development and national stability.

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