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ANALYSIS OF FOOD SAFETY ASSESSMENT INDICATORS

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A B S T R A C T

In this scientific work, the state of food security in Uzbekistan was analyzed using statistical and econometric methods. In the study, the relationship between the production volumes of agricultural products, agriculture and livestock, food imports and levels of environmental pollution was studied using linear regression models. The results of the study show that while food imports have a positive impact on all production sectors, harmful substances emitted into the atmosphere have a negative impact. Based on the analysis, practical and theoretical proposals have been developed for the rational use of imported resources and the reduction of environmental pollution in ensuring food security.

K E Y W O R D S

Food security, agriculture, farming, animal husbandry, import, environmental pollution, harmful substances, linear regression, correlation analysis, regression analysis.

Introduction

Assessment and analysis of food security in Uzbekistan is carried out with the aim of further improving the well-being and quality of life of the population of our republic, as well as developing specific parameters for ensuring adequate food supply for the population.

Today, due to the lack of systematic recording of food security indicators in our country and the current population size, we conditionally linked food security with the level of agricultural production, agricultural production, and livestock production, and tried to analyze each of them separately. In the "Development Strategy of New Uzbekistan for 2022–2026" put forward by the President of the Republic of Uzbekistan, ensuring food security is identified as one of the priority areas, and the tasks of "Diversifying agriculture, increasing food production, strengthening food security, and increasing export volumes" are clearly defined. At the same time, this strategy sets out such important goals as filling the domestic market with environmentally friendly, affordable, and high-quality food products, ensuring the stability of food prices, and modernizing the logisticse [1].

The effective development of the economy of Uzbekistan and the well-being of the population directly depend on increasing the effectiveness of food security indicators based on the implementation of the food program.

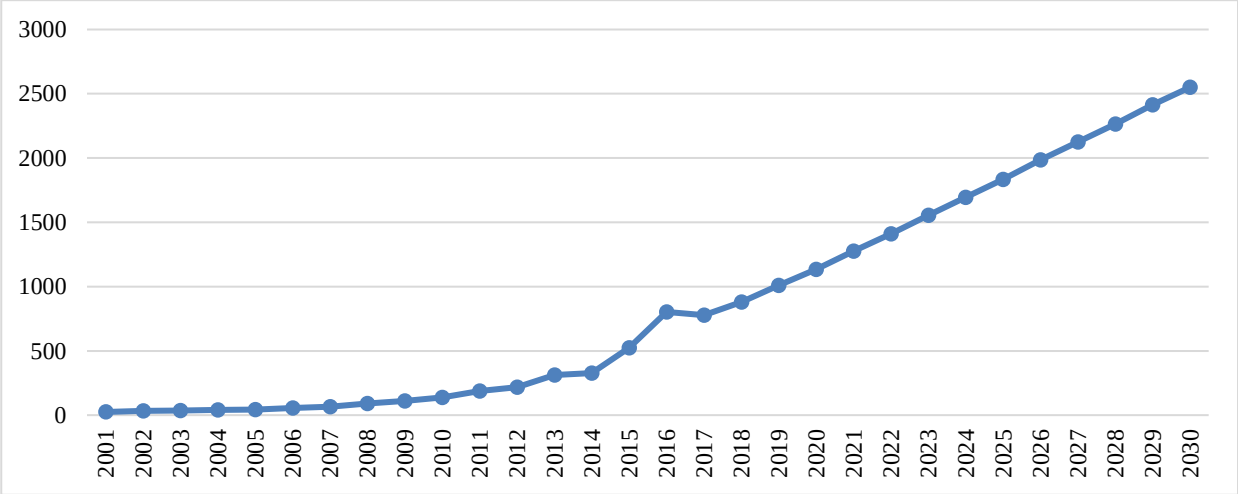

Figure 1. Per capita food consumption (thousands of soums) [2]

From the data presented, it can be seen that in the forecast period (2019-2030), the per capita food production in our republic will increase by 2.9 times, the permanent population by 17.7 percent, the growth dynamics of the total food production volume in 2030 compared to the previous year will be 6.3 percent, the share of food industry production in the structure of industrial production will be 44.6 percent, the share of food production in the structure of consumer goods production will be 0.7 percent, the average number of employees employed in the food industry will be 0.5 percent, the yield of grain products among agricultural crops will increase by 0.9 percent, the production of cereals and legumes by 2.2 times, the production of milk and dairy products by 2.3 times, and the reduction in the volume of technical crops (cotton cultivation) in agricultural arable land by 3.1 percent[3].

Research Methodology

The analyses were performed using MS Excel and Stata programs. Regression equations were calculated using the OLS (Ordinary Least Squares) method, and the statistical reliability of the model was assessed using t-statistics, p-value, R^2, AIC and BIC indicators for each model. The following econometric and statistical methods were used in the study: Descriptive statistics To identify general trends between food products, imports and environmental indicators. Correlation analysis To determine the direction and degree of correlation between variables. Linear regression analysis (OLS) To identify the main factors affecting the production of agricultural products and assess their impact.

Analysis and Results

First of all, we tried to form an existing database in the process of selecting related and unrelated factors for the implementation of the econometric analysis process. The table below lists the main factors affecting the volume of agricultural production and their indicators. First of all, the factors affecting the volume of agricultural production were analyzed, and we can see this in the table below.

Table 1 Table with indicators of QSMH, IMP and AZM [4]

Y	QXMH (Billion soums)	IMP (Billion soums)	AZM (t)
2015	81794.3	1727.9	1162.1
2016	99604.6	1691.4	975.1
2017	115599.2	1717.2	1008.2
2018	148199.3	1049	853.5
2019	187425.6	1327.4	883.7
2020	216283.1	1608.5	952.8
2021	250250.6	1851.3	924.4
2022	303415.5	2509.5	908.7
2023	345191.7	3392.9	873.6
2024	405418	3495.7	763.2

This table shows the volume of agricultural products and the volume of food imports that contribute to this volume, as well as the volume of harmful substances emitted into the atmosphere.

The following shows the correlation between these factors.

Variables	(1)	(2)	(3)
(1) QXMH	1.000		
(2) IMP	0.838	1.000	
(3) AZM	-0.748	-0.430	1.000

According to this correlation, while the volume of food imports has a positive impact on the volume of agricultural production, harmful substances emitted into the atmosphere have an inverse effect on the volume of agricultural production.

The table below shows the regression relationship between them.

Table 2 Regression correlation table between QXMH, IMP, and AZM factors [5]

QXMH	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
IMP	83,742	18,666	4.49	.003	39,605	127,879	***
AZM	-489.953	145,564	-3.37	.012	-834.156	-145.749	**
Constant	500645.15	156214.46	3.20	.015	131256.64	870033.65	**

Mean dependent variable		SD dependent var	109763.630
R-squared	0.886	Number of observations	10
F-test	27,285	Probe > F	0.000
Akaike crit. (AIC)	243,704	Bayesian crit. (BIC)	244,612

**** p<.01, ** p<.05, * p<.1*

Economic analysis based on regression analysis between the volume of agricultural products (VAP), imports (IMP), and emissions of harmful substances into the atmosphere (AZM) shows that there is a significant statistical relationship between these factors. According to the regression results, the impact of the import indicator on agricultural production is positive and statistically significant. More precisely, every 1 billion soums increase in the volume of imports can increase the volume of agricultural production by an average of 83.742 billion soums. This means that imported technologies,

fertilizers, agricultural machinery and other necessary resources have a direct positive impact on productivity[6].

On the other hand, the amount of harmful substances emitted into the atmosphere has the opposite, that is, negative, effect. The negative and statistically significant coefficient in the model means that the volume of agricultural products decreases as environmental pollution increases. This directly indicates that in regions with a low level of environmental sustainability, productivity and total production volume decrease. Increased emissions of harmful substances reduce agricultural efficiency by negatively affecting plant and soil quality [7].

The model has a high level of accuracy, with an R-squared of 0.886. This means that 88.6 percent of the variation in the dependent variable of the regression model is explained by two main factors: imports and emissions. The F-statistic and p-values confirm the overall significance of the model.

In the case resulting from the analysis, we can write the regression equation as follows.

QXMH = 500645.15 + 83.742 * IMP - 489.953 * AZM

On this basis, it can be said that imports are an important source of agricultural production in Uzbekistan, and the ecological environment serves as a significant risk factor. In the future, along with the effective use of imported resources to ensure food security, measures aimed at reducing environmental pollution should also be considered as an important factor in ensuring the sustainability of production.

It is also important to study the impact of imports on food security and the production of agricultural products, which are key to the supply chain in this sector, and the impact of harmful substances emitted into the atmosphere. The table below provides quantitative indicators of these factors.

Table 3 Table with DHM, IMP, and AZM indicators

Y	DHM	IMP	AZM
2015	43194.3	1727.9	1162.1
2016	55429	1691.4	975.1
2017	61754.8	1717.2	1008.2
2018	83303.6	1049	853.5
2019	98406.4	1327.4	883.7
2020	111904.5	1608.5	952.8
2021	123858.8	1851.3	924.4
2022	152130.4	2509.5	908.7
2023	177962.7	3392.9	873.6
2024	203082.7	3495.7	763.2

This table shows the volume of agricultural products, imports, and emissions of harmful substances into the atmosphere between 2015 and 2024. These factors are considered to have a direct and indirect impact on food security; therefore, an attempt was made to develop practical and theoretical proposals by conducting correlation and regression analysis through these factors.

Below is a correlation analysis between these factors.

Variables	(1)	(2)	(3)
(1) DMH	1.000		
(2) IMP	0.834	1.000	
(3) AZM	-0.768	-0.430	1.000

This correlation analysis shows that there is a positive relationship between agricultural production and import volumes but an inverse relationship between emissions and agricultural production.

From the regression analysis below, we can see that these two factors are considered the most important factors, directly and indirectly, in the production of agricultural products.

Table 4 Regression correlation table between DMH, IMP and AZM factors

DMH	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
IMP	39,869	8.51	4.69	.002	19,746	59,991	***
AZM	-252.918	66,364	-3.81	.007	-409.843	-95.993	***
Constant	265234.62	71219.461	3.72	.007	96827.358	433641.89	***
Mean dependent variable		111102.720	SD dependent var		53600.918		
R-squared		0.901	Number of observations		10		
F-test		31,819	Probe > F		0.000		
Akaike crit. (AIC)		227,995	Bayesian crit. (BIC)		228,903		

**** p<.01, ** p<.05, * p<.1*

This regression analysis examines the relationship between the volume of agricultural production, i.e., the volume of agricultural products, and imports (IMP) and emissions of harmful substances into the atmosphere (AZM). According to the results, the coefficient of imports is positive and significant (39.869; p=0.002), which means that an increase in imports has a positive effect on the volume of agricultural products. On the contrary, the coefficient of AZM is negative (-252.918; p=0.007), which indicates that the volume of agricultural production decreases as environmental pollution increases. The R^2 indicator of the model is 0.901, which means that 90.1 percent of the dependent variable is explained. This indicates that the model has high explanatory power and is statistically reliable. Therefore, increasing the volume of imports and reducing environmental pollution are important factors that have the strongest impact on the volume of agricultural products.

Based on the above, we can write the linear regression equation in the following form.

DHM = 265234.62 + 39.869 * IMP - 252.918 * AZM

Another area that is also important for food security and its supply chain is the volume of livestock products. The table below shows the volume of livestock production from 2015 to 2024 and the factors affecting it.

Table 5 Table with DHM, IMP, and AZM indicators

Y	CHMH	IMP	AZM
2015	38600	1727.9	1162.1
2016	44175.6	1691.4	975.1
2017	53844.4	1717.2	1008.2
2018	64895.7	1049	853.5
2019	89019.2	1327.4	883.7
2020	104378.3	1608.5	952.8
2021	126391.8	1851.3	924.4
2022	151285.1	2509.5	908.7
2023	167229	3392.9	873.6
2024	202335.3	3495.7	763.2

This table shows the volume of livestock products and the factors affecting them, such as the volume of imports and the volume of emissions into the atmosphere. There are many influencing factors, but these factors are indirectly influencing the increase in the volume of livestock products.

The correlation between these factors is as follows.

Variables	(1)	(2)	(3)
(1) CHMH	1.000		
(2) IMP	0.840	1.000	
(3) AZM	-0.727	-0.430	1.000

As can be seen from this correlation matrix, imports have a positive impact on the volume of livestock products, while emissions of harmful substances into the atmosphere have a negative impact.
In the table below, we can see the regression analysis between them.

Table 6 Regression correlation table between CHMH, IMP, and AZM factors

CHMH	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
IMP	43,873	10.27	4.27	.004	19,588	68.157	***
AZM	-237.034	80.09	-2.96	.021	-426.417	-47.652	**
Constant	235410.45	85949.988	2.74	.029	32171.021	438649.87	**
Mean dependent variable		104215.440		SD dependent var		56302.717	
R-squared		0.869		Number of observations		10	
F-test		23.256		Probe > F		0.001	
Akaike crit. (AIC)		231,755		Bayesian crit. (BIC)		232,663	

*** p<.01, ** p<.05, * p<.1

This regression analysis shows the relationship between the volume of livestock products, i.e., the volume of livestock products, and imports (IMP) and emissions of harmful substances into the atmosphere (AZM). According to the regression results, the effect of imports on livestock products is positive and statistically significant (coef. = 43.873; p = 0.004), which means that technologies and resources coming through imports increase the efficiency of livestock production. On the other hand, emissions of harmful substances have a negative effect (coef. = -237.034; p = 0.021); that is, as environmental pollution increases, the volume of livestock products decreases. The model $R^2 = 0.869$, which means that 86.9 percent of the dependent variable is explained. These results confirm that

increasing imports and improving the ecological environment are important factors in the development of livestock production. Based on the above, we can write the linear regression equation as follows.

CHMH = 235410.45 + 43.873 * IMP - 237.034 * AZM

Based on the above statistical and econometric analyses, it is clear that the main sectors of agricultural production in Uzbekistan, namely agriculture and livestock, and the factors determining their production volumes and their interdependence, play a significant role in ensuring food security. The analyses show that imports have a positive impact on the production volumes in all sectors (general agricultural products, agriculture, and livestock). This means that imported products, in particular, as machinery, seeds, fertilizers, fodder, and technological resources, serve as a means of supporting local production.

In particular, the regression results show that the impact of imports on the volume of agricultural products is high and statistically significant, indicating the need to consider this factor as an important resource in the food security strategy. On the other hand, the environmental factor, namely the volume of harmful substances emitted into the atmosphere, is found to have a negative impact on the volume of production in all analyzed sectors. Increased emissions of harmful substances have a direct negative impact on plant growth rates, soil fertility and animal health, resulting in a decrease in overall productivity and output.

On this basis, it can be said as a general conclusion that in ensuring food security in Uzbekistan, rational use of import resources, improving the quantitative indicators of agricultural production and simultaneously strengthening environmental safety measures are urgent strategic directions. By effectively managing import infrastructure, expanding agro-cluster systems, introducing resource-saving technologies, and pursuing a strict environmental policy on environmental protection, Uzbekistan can achieve significant results in ensuring the stability of food security. At the same time, the opportunities for fully satisfying the needs of the population of the republic for healthy nutrition, improving their well-being, and ensuring sustainable economic growth in the agricultural sector will expand.

Conclusion and Suggestions

A comprehensive analysis of the situation in Uzbekistan regarding food security showed that the agricultural sectors—general production, agriculture, and livestock—are the main pillars of direct food security. The regression analysis conducted in the study yielded the following results:

Imports have a positive and statistically significant impact on agricultural production across all sectors. Imports of technology, fertilizers, and other resources help increase productivity.

The amount of harmful substances emitted into the atmosphere had a negative impact on all three sectors. This means that productivity and production efficiency are reduced as a result of the deterioration of the ecological environment.

The R-squared values in the model are high (ranging from 0.869 to 0.901), indicating that the selected factors are the main explanatory factors.

The F-test and p-values for all three regression models confirm the overall statistical significance of the model.

Based on these results, it can be said that effective management of imported resources and reduction of environmental pollution are of strategic importance in ensuring food security.

As a result of the research, we can make the following suggestions.

1. Creating a system for rational use of imported resources:

Stabilize the import of agricultural machinery, fertilizers, seeds, technological equipment, and fodder through strategic sources.

Encourage the import of modern agricultural technologies through the introduction of preferential customs procedures.

2. Strengthening measures aimed at ensuring environmental sustainability:

Strengthen monitoring of harmful substances emitted into the atmosphere, introduce strict restrictions and economic sanctions against sources of pollution.

Widespread introduction of environmentally friendly technologies in agriculture, such as "green technologies".

3. Formulation of food safety indicators:

Continuously record key food security indicators (calorie consumption, food supply index, volume of produced products, etc.) annually at the republican, regional and district levels.

4. Development of agroclusters and logistics infrastructure:

Expand agro-cluster systems that provide local producers with uninterrupted access to imported resources.

Develop modern storage, transportation and logistics systems to reduce losses in product delivery.

5. Supporting scientific research and innovation:

Financial support for scientific research in the field of food security, agroecology and technological innovations.

Establish ongoing training and advisory services for farmers and farms to reduce environmental pollution and use resources efficiently.

6. Learning from international experience and strengthening integration:

Strengthening the exchange of experiences by expanding cooperation with FAO (Food and Agriculture Organization of the United Nations), IFAD and other international institutions.

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