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INPUT ACCESS CONSTRAINTS IN AZERBAIJAN'S AGRICULTURE: THE CASE OF FERTILIZER USE

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Abstract

This study examines the relationship between fertilizer use and agricultural value added, with a specific focus on input access constraints in Azerbaijan's agriculture. Using cross-country data for 161 countries in 2023, a simple linear regression model estimates the association between fertilizer application per hectare and agricultural value added. The results show a positive and statistically significant relationship ($\beta = 700.8$, $p < 0.001$), indicating that higher fertilizer intensity tends to correspond with higher agricultural output. However, the model explains only about 11% of cross-country variation, confirming that agricultural performance depends on multiple structural and institutional factors. Azerbaijan's fertilizer use (38.8 kg/ha) remains substantially below that of developed economies and many emerging agricultural producers. This low input intensity likely reflects broader constraints, including limited farmer financing, import dependence, and weak distribution systems. The findings suggest that improving access to fertilizers could contribute to productivity growth, though policy interventions must address underlying structural barriers.

Keywords: *agricultural inputs, fertilizer, Azerbaijan, value added, regression analysis*

Introduction

Agriculture continues to play an important role in the economy of Azerbaijan, particularly in terms of rural employment, food production, and regional development. Although the sector accounts for a modest share of gross domestic product, it remains a major source of income for rural households and contributes to national food security. Improving agricultural productivity, therefore, remains an important policy objective for the country.

Access to production inputs are main determinants of agricultural productivity and competitiveness. Among these inputs, fertilizer occupies a central position because of its direct effect on soil fertility, crop yields, and production efficiency. In modern agricultural systems, adequate and timely fertilizer applications are closely associated with higher productivity levels and stronger agricultural output. At the same time, insufficient use of fertilizer often reflects broader structural

problems such as limited farmer financing, weak input distribution systems, high import dependence, and rising production costs.

Compared with many other countries, fertilizer use per hectare in Azerbaijan remains relatively low. This is particularly important because low fertilizer intensity may indicate that farmers face constraints in accessing essential agricultural inputs. Such constraints can limit productivity growth, reduce competitiveness, and slow the modernization of the agricultural sector. Although fertilizer use alone does not determine agricultural performance, it serves as an important indicator of the broader level of input utilization within agriculture.

Literature review

The relationship between fertilizer use and agricultural productivity has been widely examined in the agricultural economics and development literature. Existing studies generally conclude that fertilizer application plays an important role in increasing crop yields, improving land productivity, and strengthening agricultural output, particularly in developing countries where nutrient depletion and low-input farming remain widespread problems.

A large body of literature emphasizes that insufficient access to fertilizer constrains agricultural productivity in many developing economies. According to Donkor et al. (2016), limited farmer access to chemical fertilizers significantly reduces productivity potential, while improved agricultural extension services can increase fertilizer adoption and rice yields in developing countries. Their study on Ghana demonstrates that fertilizer adoption is closely associated with higher agricultural productivity and rural development outcomes.

Similarly, Martey et al. (2019) found that mineral fertilizer use significantly improves land productivity and agricultural income in Ghana. The authors argue that timely and affordable access to fertilizer remains essential for improving agricultural performance and reducing rural poverty. Their findings also underline the importance of state support mechanisms and efficient distribution systems in promoting fertilizer adoption among farmers.

The broader international literature also supports the existence of a positive relationship between fertilizer use and agricultural output. Research published in Global Food Security highlights that improved nutrient management contributes not only to higher yields but also to greater production efficiency and profitability for smallholder farmers. Xu et al. (2021) demonstrate that site-specific nutrient management practices can increase crop yields while improving fertilizer-use efficiency, particularly in rice, wheat, and maize production systems across developing countries.

Several studies also focus on the structural causes of low fertilizer use in developing countries. The literature emphasizes that many smallholder farmers face financial, institutional, and infrastructural barriers that limit access to agricultural inputs. Combary (2022), for example, shows that financial constraints lead to the underutilization of fertilizer and reduce potential agricultural productivity among maize farmers in Burkina Faso. The study estimates that expenditure constraints can result in productivity losses of approximately 25 percent.

Research examining agricultural systems in sub-Saharan Africa further highlights the consequences of insufficient fertilizer application. Johnson et al. (2023) found that higher fertilizer application rates are associated with smaller rice yield gaps across 24 African countries. The authors

also note that low fertilizer use often contributes to soil nutrient depletion and limits agricultural intensification.

The literature additionally suggests that fertilizer use can serve as a broader indicator of agricultural modernization and input accessibility. A review by Chianu et al. (2020) argues that fertilizer use in many developing countries remains below optimal levels because farmers frequently lack financial resources, market access, and institutional support. The authors emphasize that inadequate fertilizer application is often associated with low-productivity agricultural systems and persistent rural poverty.

At the same time, the literature recognizes that fertilizer use alone cannot fully explain agricultural performance. Agricultural productivity depends on multiple factors, including irrigation infrastructure, climate conditions, mechanization, land quality, technology adoption, and government policies. Therefore, empirical studies commonly report moderate or relatively low explanatory power when fertilizer use is analyzed independently. Nevertheless, most studies still identify a statistically significant positive association between fertilizer application and agricultural output.

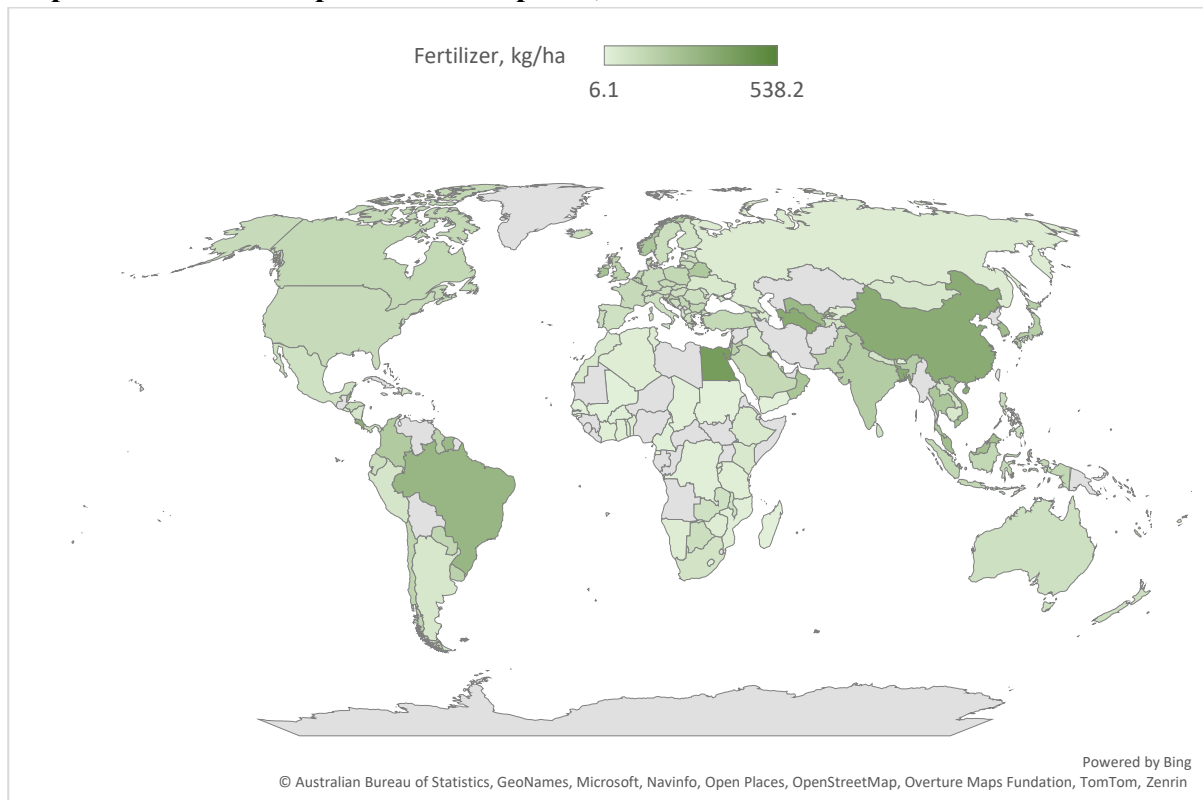
In the context of Azerbaijan, relatively limited research has focused specifically on fertilizer intensity and farmer access to agricultural inputs. However, international literature provides an important analytical framework for understanding how comparatively low fertilizer use may reflect broader structural constraints within the agricultural sector. The present study contributes to this discussion by examining cross-country evidence on fertilizer use and agricultural value added while placing particular emphasis on Azerbaijan's comparatively low level of fertilizer application per hectare.

Background information

Compared with many countries in the dataset, Azerbaijan demonstrates a relatively low level of fertilizer use per hectare. Azerbaijan's fertilizer application rate stands at approximately 38.8 kilograms per hectare, placing the country well below both advanced agricultural economies and many emerging market countries. This suggests that farmers in Azerbaijan operate with comparatively limited access to one of the most important agricultural production inputs.

The contrast is particularly visible when Azerbaijan is compared with developed economies characterized by intensive agricultural production. Countries such as the Netherlands (126.5 kg/ha), Belgium (186.6 kg/ha), Japan (170.3 kg/ha), the Republic of Korea (252.6 kg/ha), and Israel (180.8 kg/ha) apply several times more fertilizer per hectare than Azerbaijan. These countries also demonstrate substantially higher levels of agricultural value added, reflecting more intensive and technologically advanced farming systems. Even large developed agricultural producers such as the United States of America (107.7 kg/ha), Germany (103.7 kg/ha), and France (111.4 kg/ha) record fertilizer use rates that are nearly three times higher than Azerbaijan's level.

Graph 1. Fertilizer use per area of cropland, 2023



Source: Created by the author using the FAOSTAT database

A similar pattern can be observed among emerging economies. China applies around 334.9 kilograms of fertilizer per hectare, while Viet Nam records 242.6 kg/ha, Thailand 210.9 kg/ha, and Malaysia 246.2 kg/ha. These countries have pursued more input-intensive agricultural development strategies, which contributed to higher agricultural output and export competitiveness. Even middle-income countries with structural challenges, such as Morocco (40.2 kg/ha) and Tunisia (28.6 kg/ha), remain close to Azerbaijan's level despite differences in agricultural structure and resource endowments.

The comparison with neighboring and regional countries is also important. Among post-Soviet and nearby economies, Azerbaijan performs below several countries with more intensive agricultural sectors. Georgia records fertilizer use of approximately 119.8 kg/ha, more than three times the Azerbaijani level. Türkiye applies around 118.1 kg/ha, while Belarus reaches nearly 196 kg/ha. Ukraine, despite wartime disruptions, still records fertilizer use of around 41.5 kg/ha, slightly above that of Azerbaijan. At the same time, some neighboring countries, such as Armenia (35.3 kg/ha) and Iran (60.9 kg/ha), remain closer to Azerbaijan's position, although Iran still demonstrates noticeably higher input intensity.

The data, therefore, place Azerbaijan in an intermediate but relatively low-input category. Fertilizer use in the country remains significantly below the levels observed in most developed economies and many successful emerging agricultural producers. This pattern may indicate structural constraints related to farmer access to inputs, including affordability issues, financing limitations, dependence on imported fertilizers, and weaknesses in agricultural supply and distribution systems.

Although fertilizer use alone does not determine agricultural performance, Azerbaijan's comparatively low fertilizer intensity suggests that the country has not yet reached the level of input utilization commonly associated with highly productive agricultural systems.

Methodology

This study examines the relationship between fertilizer use and agricultural performance using cross-country data for 161 countries in 2023. The analysis is based on a simple linear regression model in which agricultural value added is treated as the dependent variable, while fertilizer use per hectare serves as the explanatory variable. The objective is to determine whether countries with higher fertilizer application rates also tend to demonstrate higher levels of agricultural value added.

The study uses fertilizer consumption measured in kilograms per hectare of arable land as an indicator of agricultural input intensity. Agricultural value added is used as a proxy for agricultural performance and productivity. The dataset combines information from international statistical sources and includes countries with different levels of economic development and agricultural structures.

To estimate the relationship between the variables, the following ordinary least squares (OLS) regression model is employed:

$$AVA_i = \beta_0 + \beta_1 Fertilizer_i + \varepsilon_i$$

where:

AVA - represents agricultural value added for country *i*,

Fertilizer - denotes fertilizer use per hectare,

β_0 - is the intercept term,

β_1 - measures the effect of fertilizer use on agricultural value added,

ε - is the error term.

The regression analysis is conducted using Stata statistical software. Descriptive statistics and scatterplot analysis are also used to examine the data distribution and the overall relationship between fertilizer use and agricultural value added across countries.

The analysis focuses primarily on identifying statistical associations rather than establishing direct causality. Many additional factors, including climate conditions, irrigation systems, land quality, mechanization, technological development, institutional capacity, and government support policies, influence agricultural performance. Consequently, fertilizer use alone is not expected to explain the majority of variation in agricultural value added across countries. Nevertheless, fertilizer intensity remains an important indicator of farmers' access to production inputs and the overall level of agricultural modernization.

The statistical significance of the estimated coefficient is evaluated using conventional significance levels. In addition, the adjusted R^2 statistic is used to assess the explanatory power of the model. Although the model is intentionally simple, it provides useful comparative evidence regarding the relationship between input use and agricultural performance across countries and offers a framework for discussing agricultural input access constraints in Azerbaijan.

Results

The empirical analysis examines the relationship between per-hectare fertilizer use (kg) and agricultural value added across a cross-section of 161 countries. The estimated ordinary least squares (OLS) regression indicates a positive and statistically significant association between fertilizer use and agricultural value added.

Graph 2. Results of the regression analysis

Source	SS	df	MS	Number of obs	=	161
Model	6.7738e+17	1	6.7738e+17	F(1, 159)	=	19.43
Residual	5.5430e+18	159	3.4861e+16	Prob > F	=	0.0000
				R-squared	=	0.1089
				Adj R-squared	=	0.1033
Total	6.2203e+18	160	3.8877e+16	Root MSE	=	1.9e+08

ag	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
fert	700815	158986.4	4.41	0.000	386817.4	1014812
_cons	-2.45e+07	2.11e+07	-1.16	0.247	-6.61e+07	1.71e+07

Source: Created by the author using the FAOSTAT data and STATA software

The coefficient on fertilizer use is positive and precisely estimated ($\beta = 700,815$; $SE = 158,986$), and is statistically significant at the 1% level ($t = 4.41$; $p < 0.001$). The corresponding 95% confidence interval (386,817 to 1,014,812) suggests a robust positive effect, indicating that higher fertilizer application per hectare is associated with higher agricultural value added across countries.

The model explains a modest proportion of the variation in agricultural value added, with an R-squared of 0.1089 (adjusted R-squared = 0.1033), implying that approximately 11% of the cross-country variation is accounted for by fertilizer use alone. The overall model is statistically significant ($F(1,159) = 19.43$; $p < 0.001$), confirming that fertilizer use contributes explanatory power beyond the intercept-only specification.

Overall, the findings indicate a statistically significant and economically meaningful positive relationship between fertilizer intensity and agricultural value added in a cross-country setting, though the relatively low R-squared highlights that agricultural performance is also driven by a wide range of other structural, technological, and institutional factors not captured in this bivariate specification.

Conclusions

The descriptive evidence places Azerbaijan in a distinct position. With approximately 38.8 kilograms of fertilizer per hectare, the country applies significantly less than most developed economies (e.g., the Netherlands, Germany, Japan) and many successful emerging agricultural producers (e.g., China, Viet Nam, Thailand). Even among regional comparators, Georgia and Türkiye record fertilizer use rates roughly three times higher than Azerbaijan's level. This pattern suggests that

Azerbaijani farmers face structural constraints in accessing one of the most important agricultural production inputs.

What might these constraints be? The literature and background evidence point to several interrelated factors. First, affordability remains a central issue. Fertilizer prices have risen substantially in recent years, and without adequate subsidy mechanisms or concessional credit, many smallholder farmers in Azerbaijan may find fertilizers financially out of reach. Second, limited farmer financing, including restricted access to agricultural loans, weak rural banking infrastructure, and high collateral requirements, prevents farmers from purchasing inputs at the optimal time and quantity. Third, Azerbaijan remains somewhat dependent on imported fertilizers, exposing domestic farmers to global price volatility and supply chain disruptions. Fourth, weaknesses in agricultural input distribution systems, particularly in remote rural areas, further constrain timely access. Taken together, these factors create an environment in which fertilizer application remains suboptimal relative to the country's agronomic potential.

The policy implications are straightforward but challenging to implement. Improving fertilizer access in Azerbaijan requires a coordinated approach rather than a single intervention. Expanding subsidized credit or targeted fertilizer voucher programs could address affordability constraints, particularly for smallholder farmers. Strengthening domestic fertilizer storage and distribution networks, especially in regions with poor market access, would reduce logistical barriers. Over the longer term, reducing import dependence through domestic production or strategic reserve mechanisms could stabilize supply and prices. Importantly, these supply-side measures should be accompanied by complementary investments in agricultural extension services, soil testing, and nutrient management training to ensure that additional fertilizer use translates efficiently into higher yields rather than environmental degradation.

Several limitations of this study should be acknowledged. The cross-country regression analysis identifies association, not causation. Unobserved heterogeneity across countries, including differences in soil quality, crop composition, farming systems, and policy environments, may bias the estimated coefficient. Moreover, aggregate fertilizer use per hectare does not capture variation in application timing, fertilizer type, or application methods, all of which affect productivity outcomes. Future research using farm-level panel data from Azerbaijan would provide more precise evidence on the causal effects of fertilizer access on productivity and the specific mechanisms through which constraints operate.

In conclusion, Azerbaijan's low fertilizer intensity is not merely a technical statistic but rather a symptom of deeper structural constraints affecting farmers' access to essential production inputs. While fertilizer use alone explains only a modest share of cross-country variation in agricultural value added, the statistically significant positive relationship suggests that improving input access could contribute to productivity growth. However, raising fertilizer application rates without addressing underlying financing, distribution, and affordability constraints is unlikely to succeed. For Azerbaijan to modernize its agricultural sector, improve rural incomes, and strengthen food security, policymakers must treat input access as a systemic challenge requiring coordinated interventions across credit markets, input supply chains, and extension services. Fertilizer matters, but it matters most as part of a broader agricultural transformation strategy.

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Azərbaycan Qida Təhlükəsizliyi Agentliyi

Azərbaycanda kənd təsərrüfatı istehsal amillərinə çıxışda məhdudiyyətlər: gübrə istifadəsi nümunəsində

Xülasə

Bu tədqiqat Azərbaycanda kənd təsərrüfatı istehsal amillərinə çıxışda məhdudiyyətlərə diqqət yetirərək gübrədən istifadə ilə kənd təsərrüfatı əlavə dəyəri arasındakı əlaqəni təhlil edir. Məqalədə 161 ölkə üzrə məlumatlardan istifadə edilərək xətti regressiya modeli vasitəsilə hektar başına gübrə tətbiqi ilə kənd təsərrüfatı əlavə dəyəri arasındakı əlaqə qiymətləndirilmişdir. Nəticələr müsbət və statistik cəhətdən əhəmiyyətli bir əlaqə göstərir ($\beta = 700.8$, $p < 0.001$), bu da daha yüksək gübrə intensivliyinin daha yüksək kənd təsərrüfatı məhsulu ilə müşayiət olduğunu göstərir. Lakin model ölkələrarası dəyişikliyin yalnız təxminən 11%-ni izah edir və kənd təsərrüfatı məhsuldarlığının bir çox struktur və institusional amillərdən asılı olduğunu təsdiqləyir. Azərbaycanın gübrə istifadəsi (38.8 kq/ha) inkişaf etmiş iqtisadiyyatlar və bir çox inkişaf etməkdə olan kənd təsərrüfatı istehsalçılarından xeyli aşağı olaraq qalır. Bu aşağı resurs intensivliyi, ehtimal ki, məhdud fermer maliyyələşdirməsi, idxaldan asılılıq və zəif paylama sistemləri daxil olmaqla daha geniş məhdudiyyətləri əks etdirir.

Beləliklə, nəticələr göstərir ki, gübrələrə çıxışın yaxşılaşdırılması məhsuldarlığın artmasına töhfə verə bilər.

Açar sözlər: kənd təsərrüfatı girişləri, gübrə, əlavə dəyər, regressiya təhlili

А.Ф. Азимов

Азербайджанской Агентство Пищевой Безопасности

Ограничения доступа к ресурсам в сельском хозяйстве Азербайджана: пример использования удобрений.

Резюме

В данном исследовании изучается взаимосвязь между использованием удобрений и добавленной стоимостью в сельском хозяйстве Азербайджана, с особым акцентом на ограничения доступа к ресурсам. Используя данные по 161 стране, простая линейная регрессионная модель оценивает связь между применением удобрений на гектар и добавленной стоимостью в сельском хозяйстве. Результаты показывают положительную и статистически значимую взаимосвязь ($\beta = 700,815$; $p < 0,001$), указывая на то, что более высокая интенсивность использования удобрений, как правило, соответствует более высокой сельскохозяйственной продукции. Однако модель объясняет лишь около 11% межстрановой вариации, подтверждая, что сельскохозяйственная эффективность зависит от множества структурных и институциональных факторов. Использование удобрений в Азербайджане (38,8 кг/га) остается существенно ниже, чем в развитых странах и многих развивающихся сельскохозяйственных предприятиях. Эта низкая интенсивность использования ресурсов, вероятно, отражает более широкие ограничения, включая ограниченное финансирование фермеров, зависимость от импорта и слабые системы распределения. Результаты показывают, что улучшение доступа к удобрениям может способствовать росту производительности.

Ключевые слова: сельскохозяйственные ресурсы, удобрения, Азербайджан, добавленная стоимость, регрессионный анализ