Substaminale development in agricultural investments and the food security system

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Abstract. Agricultural investments play a crucial role in boosting productivity, reducing poverty, and enhancing food security. By increasing food availability and stabilizing prices, these investments make essential food more accessible to low-income groups. They also foster rural development through job creation and infrastructure growth, contributing to poverty reduction and consistent food consumption. In the face of challenges like climate change, shrinking land availability, declining fertility, and water scarcity, agricultural investments are vital for sustaining and increasing production. As global population growth heightens food demand, effective investment becomes even more critical to prevent famine. However, expanding agricultural land is limited, so future agricultural growth will rely on productivity improvements driven by investments. It is imperative for governments to create a conducive environment to attract such investments while ensuring that they are allocated efficiently. Mismanagement or ineffective use of investments can lead to negative social and environmental impacts. Therefore, continuous monitoring and analysis of agricultural investments are essential to maximize their effectiveness in ensuring food security.

1 Introduction

Agricultural investments is an important food security tool. They improve the productivity of agricultural production by increasing the volumes of manufacture goods. One of the main investors in agriculture is the state, which directs funds to develop infrastructure, increase productivity and ensure the high quality of food produced [1]. Private investors also invest in the agricultural sector by lending to production, creating or acquiring enterprises. At the same time, the investment climate and the quality of state investment policy directly affect the amount

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of funds invested and the quality of their use. A favorable investment climate and effective government policy contribute to the mobilization of capital, new technologies and other resources to ensure the most productive use of resources, increase profitability, and achieve the maximum possible economic and social effect.

Interestingly, investments in agriculture is highly risky. It is due to production and price risks. Pests, diseases, unfavorable weather, problems in the economy and, as a result, volatile prices have a negative impact on the profitability of investments and their volume. All governments must ensure that risk management tools are developed to help investors manage risk.

State investments should ensure high quality agricultural education and build a system for the dissemination of knowledge and advice to farmers. Investments should help ensure international partnerships, protect intellectual property rights, and develop a business culture [2]. Leading agricultural organizations have developed investment principles that all participants must adhere to in order for investment to be harmless, sustainable and conducive to development. The main principles of investment include the following areas: respect for rights to land and resource, securing transparency, good governance and an appropriate favorable legal and business environment, ensuring food security, responsible agricultural investment, and ensuring social and environmental sustainability. At the same time, agricultural policies and regulations must be well thought out so that investments bring both economic and social benefits and contribute to food security. That is why it is important to analyze the effectiveness of investments, the degree of their impact on food security.

2 Review of previous research

Sustainable agriculture seeks to balance the growing need for food production with the imperative of preserving environmental health. By integrating practices such as crop rotation, organic farming, and conservation tillage, sustainable agriculture works to maintain soil health, ensuring that the land remains fertile for future generations [1, 3]. Crop rotation helps prevent soil depletion and reduces the risk of pest infestations by varying the types of crops planted in a given area [4]. Organic farming eliminates the use of synthetic chemicals, thereby reducing pollution and minimizing the carbon footprint of agricultural activities. Conservation tillage, by minimizing soil disturbance, helps retain moisture and organic matter in the soil, which in turn supports robust plant growth and reduces the need for irrigation [4]. These practices not only contribute to a more resilient agricultural system but also play a crucial role in reducing greenhouse gas emissions and enhancing biodiversity [5]. By fostering a harmonious relationship between agriculture and the environment, sustainable farming practices are essential for ensuring long-term food security and ecological stability [1, 6].

Food security involves ensuring that all people have consistent access to sufficient, safe, and nutritious food, necessary for a healthy life [7]. Achieving food security is a complex challenge that requires a stable food supply, which can be threatened by various factors such as economic instability, climate change, and population growth [2, 8]. Sustainable agricultural practices play a vital role in addressing these challenges by enhancing productivity and resilience. By adopting methods like crop diversification, water conservation, and soil management, sustainable agriculture helps to increase yields while reducing the environmental impact [9]. These practices also improve the resilience of food systems to climate change, ensuring that food production can adapt to shifting weather patterns and environmental conditions. Ultimately, sustainable agriculture is essential for maintaining a stable and reliable food supply, which is crucial for global food security [2, 10].

Investments in sustainable agriculture can yield significant economic benefits for farmers, primarily by increasing crop yields and reducing costs associated with chemical inputs like pesticides and synthetic fertilizers [11]. By adopting sustainable practices such as organic

farming and integrated pest management, farmers can achieve higher productivity with fewer resources, leading to greater profitability over time [2, 12]. Sustainable agriculture often involves the use of renewable resources and efficient water management, further lowering operational costs [13, 14]. Socially, these investments have the potential to improve livelihoods in rural areas by creating more stable and rewarding agricultural jobs [15]. As sustainable practices reduce dependency on expensive chemical inputs, farmers can retain more of their income, which can then be reinvested into their communities [9, 16]. This not only helps to alleviate poverty but also strengthens rural economies by promoting local development and self-sufficiency [2, 17]. Ultimately, investments in sustainable agriculture contribute to both economic prosperity and social well-being, fostering a more equitable and resilient agricultural sector.

While sustainable agriculture offers numerous benefits, it also presents challenges that must be carefully managed [18]. One of the primary challenges is the need for significant initial investments in new technologies, infrastructure, and training for farmers [1, 2, 19]. These upfront costs can be a barrier, particularly for small-scale farmers who may lack access to financial resources [20]. The transition to sustainable practices may result in short-term yield reductions as farms adjust to new methods and techniques [1, 21]. This can create uncertainty and financial strain, especially in regions where food production is already precarious [22]. Balancing these trade-offs is essential for achieving long-term sustainability, as the short-term sacrifices must be weighed against the long-term benefits of improved soil health, increased biodiversity, and enhanced resilience to climate change [23, 24]. Policymakers and stakeholders must work together to provide support and incentives that help farmers navigate these challenges, ensuring that the transition to sustainable agriculture is both feasible and beneficial for all [1, 24, 25].

Many scientists have focused on issues related to sustainable development in agricultural investments and the food security system. P. Pingali [26] notes that traditional food supply chain fails to meet the growing demand for diet diversity. The latter needs the changes in the food sector and food supply chain. Agricultural investments can help solve these problems. The necessity to provide sustainable investment framework in food and agriculture can be realized by promotion of the achievement of the UN Sustainable Development Goals [27 – 29]. A particular role in improving food security and securing the meeting of human needs for adequate food in compliance with food security policy on the national level is played by responsible investment in agriculture and food [30, 31]. It is important to tackle all food security dimensions since there is a need to have increased global food production by 60% by 2050. This policy should be based on expanding the availability of food on the market, maintaining affordable prices, securing bonuses for producers, and increasing food accessibility in rural and urban communities [32, 33]. Investments in agriculture provide a range of benefits in the form of new job opportunities, extended market access, reinforced land rental market, and boosted infrastructure development. These benefits can be essential for battling poverty and enhancing food security as they lead to income growth and better food distribution [34]. Meanwhile, investment in food or agriculture shouldn't be considered separately but rather as the link in some interrelated and dynamic system, with its interdependencies, reverse causalities, and trade-offs [35]. Sustainable investments can also enhance food security indirectly, through rising rural incomes, which may also improve access to more nutritious diets and improved food utilization [36, 37]. Agricultural investments that have enough scale to generate jobs may add to household food security condition in the neighboring areas [33]. Some researchers also address the role of private sector in agricultural development and emphasize that private investment seems to improve agricultural productivity [38]. Such factors as increasing GMOs use, reducing food waste, and increasing R&D investment are the key ones in trade in agricultural products that add to food security [39, 40]. The analysis of existing research shows that agricultural investments are essential for enhancing food security, through rising

agricultural productivity, rural incomes, improving infrastructure, food utilization and access to more nutritious diets.

Ongoing research is essential for developing new technologies and practices that advance sustainability in agriculture. This research includes breeding crops that are more resilient to climate change, which is crucial for maintaining food production in the face of increasingly unpredictable weather patterns. Additionally, there is a need to develop more effective and environmentally friendly pest management strategies that reduce reliance on harmful chemicals. Researchers are also exploring innovative methods to improve soil health and water conservation, both of which are critical for sustainable farming. By continuously advancing these areas, research can provide the tools and knowledge needed to support a more sustainable and resilient agricultural system for the future.

3 Materials and methods

The study addresses the following issues:

a) What investments have an impact on the prevalence of undernourishment?

b) What is the level of relationship between agricultural investments and the prevalence of undernourishment?

The indicators chosen for the analysis include the Agriculture share of Government Expenditure, Agriculture value added share of GDP, Development flows to Agriculture, Development flows to Food security and Food safety, Credit to agriculture (Table 1).

Table 1. Key indicators meaning.

Indicator	Meaning
Prevalence of undernourishment	The prevalence of undernourishment (PoU) is the share of the population with consumption traditions failing to meet the dietary energy levels needed to secure a decent life. It is expressed as a percentage
Agriculture share of Government Expenditure, %	The indicator is expressed as a percentage and defines the volume of agriculture government spending in total government expenditure, where agriculture refers to the agriculture, forestry, fishing and hunting sector
Agriculture value added share of GDP (%)	The indicator is expressed as a percentage and defines the share of agriculture value added in Gross Domestic Product, where agriculture includes agriculture, forestry, fishing and hunting
Development flows to Agriculture, value, thousands US$	The Development Flows to Agriculture dataset relies on the OECD's Creditor Reporting System (CRS), which outlines information on all donor-recipient flows since the early 1970s. The CRS is essential for the DFA dataset as it is based on the OECD experience and helps eliminate the data replication
Development flows to Food security and Food safety, value, US$	The indicator "Development Flows to Food security and Food safety" secures quick access to available data on aid flows and their directions, focusing on food security and food safety
Credit to agriculture, value, mln US$	The dataset includes the data on loans granted by the commercial banking sector to entities in agriculture, forestry, and fishery for over 120 countries

Source: [30; 41].

In the study the data for *all* the *world's countries* with the period from 2011 to 2019 have been used. Table 2 outlines the indicators' rates.

The study is based on the correlation and regression analysis. The dependent variable (*Y*) is the indicator "Prevalence of undernourishment". The explanatory variables are following

indicators: “Agriculture share of Government Expenditure” (*X*1), “Agriculture value added share of GDP” (*X*2), “Development flows to Agriculture” (*X*3), “Development flows to Food security and Food safety” (*X*4), “Credit to agriculture” (*X*5).

Table 2. The indicators impacting food security.

Parameters	Year								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Prevalence of undernourishment, %	9.0	8.9	8.8	8.3	8.3	8.3	8.1	8.3	8.4
Agriculture share of Government Expenditure, %	1.76	1.84	1.89	1.89	2.09	2.04	2.02	2.10	2.12
Agriculture value added share of GDP, %	4.00	4.03	4.16	4.13	4.16	4.10	4.06	3.92	4.00
Development flows to Agriculture, value, thousands US$	12.6	14.0	13.7	12.9	13.4	13.5	18.7	19.1	16.9
Development flows to Food security and Food safety, value, US$	18.4	17.3	17.5	17.3	8.7	2.4	5.3	99.5	347.6
Credit to agriculture, value, mln US$	33.4	35.6	37.5	39.2	38.8	39.1	41.3	44.4	45.2

Source: [41].

4 Results and discussion

The Eviews program was utilized to construct the model. This powerful software allowed for sophisticated statistical analysis and modelling. Initially, a correlation matrix was compiled to determine the relationships between the various indicators used in the model. This matrix serves as a fundamental tool for assessing how each indicator is interrelated. Understanding these relationships is crucial for accurate model interpretation and analysis. The detailed correlation matrix is presented in Table 3 for further examination.

Table 3. The correlation matrix.

	Y	*X*1	*X*2	*X*3	*X*4	*X*5
Y	1.000000	-0.788669	-0.093349	-0.525446	-0.121872	-0.732914
*X*1	-0.788669	1.000000	-0.111644	0.609996	0.485125	0.867551
*X*2	-0.093349	-0.111644	1.000000	-0.603499	-0.456613	-0.337896
*X*3	-0.525446	0.609996	-0.603499	1.000000	0.421861	0.785067
*X*4	-0.121872	0.485125	-0.456613	0.421861	1.000000	0.674846
*X*5	-0.732914	0.867551	-0.337896	0.785067	0.674846	1.000000

Source: own analysis based on the methodology [30].

It shows that the indicator “*Y*” does not correlate with any variable indicator “*X*”. And rightly so, because as investment increases, the prevalence of undernourishment should decline. Meanwhile, it is worth mentioning that all factors cannot be analyzed linearly, but it is important to consider them as a system, taking into account the return on investment and the efficiency of the use of funds.

According to the results obtained, the indicator "Prevalence of undernourishment" has the greatest indirect relationship with the indicators "Agriculture share of Government Expenditure" and "Credit to agriculture". The dependence of the prevalence of undernourishment on agriculture share of government expenditure is "-0.788669". This means that as the share of public spending on agriculture declines, the prevalence of undernourishment increases, highlighting the importance of public policies in combating malnutrition and hunger.

There is also an indirect strong relationship between the indicators "Prevalence of undernourishment" and "Credit to agriculture", which is "-0.732914", which underlines the important role of credit in fight the prevalence of undernourishment. The positive effect of the use of credit resources is highlighted by many researchers. However, in this case, it is important to emphasize the stimulating function of lending and the indirect effect of credit to agriculture. The results show that credit resources not only have a positive effect and stimulate the work and development of enterprises and the agricultural sector, but also have an impact on the provision of the population with food and a decrease in the prevalence of malnutrition.

The research builds a multivariate regression model and calculates the coefficients of the regression equation:

$$Y = \beta 0 + \beta 1 \cdot X1 + \beta 2 \cdot X2 + \beta 3 \cdot X3.$$

The data shown by multiple regression are given in Table 4.

The Table shows that *R*-squared = 0.853047. Therefore, *Y* is 85.30% dependent on variables *X*1, *X*2, *X*3, *X*4 and *X*5. The indicators *X*3 and *X*4 are too small. So, we won't to include these indicators in the model.

The following is the multifactor model:

$$Y = 14.72574 - 0.579708X1 - 0.442238X2 - 0.094276X5.$$

Table 4. The results of multiple regression.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
*X*1	-0.579708	1.222865	-0.474057	0.6678
*X*2	-0.442238	1.414275	-0.312696	0.7750
*X*3	0.020670	0.067252	0.307350	0.7787
*X*4	0.001800	0.001122	1.604540	0.2069
*X*5	-0.094276	0.066168	-1.424806	0.2494
C	14.72574	5.448319	2.702825	0.0736
R-squared	0.853047	Mean dependent var		8.488889
Adjusted R-squared	0.608126	S.D. dependent var		0.321887
S.E. of regression	0.201501	Akaike info criterion		-0.131327
Sum squared resid	0.121808	Schwarz criterion		0.000157
Log likelihood	6.590969	Hannan-Quinn criterium		-0.415066
F-statistic	3.482941	Durbin-Watson stat		2.553322
Prob(F-statistic)	0.166650			

Source: own analysis based on the methodology [30].

The received results indicate that the "Prevalence of undernourishment" declines by 0.5797 with the "Agriculture share of Government Expenditure" growth by 1 unit at a constant level of the "Agriculture value added share of GDP", "Credit to agriculture", "Development flows to Agriculture" and "Development flows to Food security and Food safety". Secondly, the "Prevalence of undernourishment" is reduced by 0.4422 with an increase in the "Agriculture value added share of GDP" by 1 at a consistent level of the "Agriculture share of Government Expenditure", "Credit to agriculture", "Development flows to Agriculture" and "Development flows to Food security and Food safety". Thirdly, the "Prevalence of undernourishment" is reduced by 0.0942 with the "Credit to agriculture" growth by 1 unit at a constant level of the

"Agriculture share of Government Expenditure", "Agriculture value added share of GDP", "Development flows to Agriculture" and "Development flows to Food security and Food safety".The research also verifies the results for autocorrelation. The verification results are presented Table 5.

The obtained results bring us to conclusion that that there is no autocorrelation in the model, which confirms the high quality of the model.

Table 5. The results of autocorrelation. Source: own analysis based on the methodology [30].

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.311	-0.311	1.1952	0.274
		2	-0.162	-0.286	1.5662	0.457
		3	0.154	0.001	1.9584	0.581
		4	-0.429	-0.498	5.5994	0.231
		5	0.235	-0.091	6.9702	0.223
		6	0.096	-0.112	7.2741	0.296
		7	-0.112	-0.048	7.8895	0.342
		8	0.028	-0.284	7.9648	0.437

The results were assessed for heteroskedasticity using the ARCH test, a common method for detecting variations in volatility over time. Table 6 presents the outcomes of this test. The test is essential in determining whether the assumption of constant variance in the errors holds true. Identifying heteroskedasticity is crucial, as it can significantly impact the accuracy of statistical models.

Table 6. The results of ARCH test.

Heteroskedasticity Test : ARCH				
F-statistic	0.175290	Prob. F(1.6)		0.6900
Obs*R-sguared	0.227086	Prof. Chi-Squsre (1)		0.6337
In cluded observations: 8 after a djustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.016988	0.009242	1.838192	0.1157
RESID`2(-1)	-0.172334	0.411615	-0.418677	0.6900
R-squared	0.028386	Mean dependent var		0.014401
Adjusted R-s quared	0.133550	S.D. dependent var		0.018257
S.E. of regression	0.019438	Akaike info criterion		-4.830891
Sum squared resid	0.002267	Schwarz criterion		-4.811030
Log likelihood	21.32356	Hannan-Quinn criter.		-4.964841
F-statistic	0.175290	Durbin-Watson stat		2.138862
Prob(F-statistic)	0.690026			

Source: own analysis based on the methodology [30].

The results of the verification for heteroskedasticity indicate that this issue is absent in the model. This finding suggests that the model's residuals exhibit constant variance, which is a desirable property. The absence of heteroskedasticity helps ensure the reliability of the model's estimates and predictions. Consequently, this result contributes to the overall assessment of the model's quality. Overall, it is one of the factors that affirm the high quality of the model.

5 Conclusions

The research confirms the strong indirect relationship between prevalence of undernourishment and such indicators as "Agriculture share of Government Expenditure",

"Agriculture value added share of GDP" and "Credit to agriculture". The indicator "Prevalence of undernourishment" has the strong indirect relationship with the indicators "Agriculture share of Government Expenditure" and "Credit to agriculture". The dependence of the prevalence of undernourishment on agriculture share of government expenditure is "-0.788669". This means that as the share of governmental agricultural expenditures declines, the prevalence of undernourishment increases, highlighting the importance of public policies in combating malnutrition and hunger.

There is also an indirect strong relationship between the indicators "Prevalence of undernourishment" and "Credit to agriculture" (-0.732914), which underlines the important role of credit in fight the prevalence of undernourishment. In this case, it is important to emphasize the stimulating function of lending and the indirect effect of credit to agriculture. The results show that credit resources not only have a positive effect and stimulate the work and development of enterprises and the agricultural sector, but also have an impact on the provision of the population with food and a decline in the prevalence of malnutrition.

The results achieved in the research can be the ground for the government, OECD, FAO, and other authorities to create and elaborate agricultural production stimulation programs and policies and ensure food security. The data revealed in the study may be relevant for agricultural enterprises, international funds, and other entities to fight against prevalence of undernourishment and to prevent starvation.

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