Sustainable agricultural progress in the Republic of Moldova: through economic indicators and growth opportunities

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Abstract. *Agriculture, as the most important branch of the economy, is affected by climate change. Adverse impacts of climate conditions can have serious consequences for the population in the context of deteriorating food insecurity and hampering economic growth. It should be noted that the profitability of agricultural enterprises plays a key role in the development of this industry, as high profit rates can stimulate investment in agriculture, promote the introduction of new technologies and increase overall productivity, which makes this aspect relevant and key to further study in scientific research. In this study, an overview of the situation in agriculture is based on data provided by agricultural enterprises, as this category of producers usually has a larger scale of production and also has more structured data, which allows them to study their activities in a comprehensive and reliable manner. The purpose of the scientific work is to analyze and quantify the factors that determine the dynamics of the key performance of agricultural enterprises – net profit based on the use of the method of correlation analysis as an effective tool for identifying patterns of financial activity of agricultural enterprises under the influence of various factors. The initial information for the analysis was the official data of the National Bureau of Statistics of the Republic of Moldova for the period 2015-2022. The results of the correlation analysis showed that the dynamics of net profit of agricultural enterprises by 98.02 % depends on changes in the factors included in the economic model, which allows to conclude the high practical significance of the results obtained and can be used to develop effective management strategies and increase financial stability in this sector of the economy.*

Keywords*: agricultural enterprises; climate change; financial performance; investments; soil mineralization.*

JEL Classification*: O13; R11; E22.*

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1. Introduction

Agriculture of the Republic of Moldova plays a significant role in the economic development of the country and is one of the key sectors that determine its economic stability and well-being (Vsemirnyi bank, 2013). However, despite its importance, agriculture faces a number of challenges that require integrated and systematic approaches to addressing them. To solve these challenges, the National Strategy for Agricultural and Rural Development 2023–2030 was developed. It focuses on developing a competitive agri-food sector based on high-potential value chains, environmentally friendly and resilient to climate change, which strengthens food security and safety while ensuring well-being and better living conditions in rural areas (Government of the Republic of Moldova, 2022). Starting from the development needs related to agricultural inputs, production processes, markets, and community involvement in rural development, the strategy defines four general strategic objectives: 1. Strengthening the potential of a climate-resilient agricultural sector; 2. Promoting smart, efficient, and sustainable agricultural practices; 3. Developing the local market and increasing export potential; 4. Supporting sustainable socio-economic rural development. These strategic directions aim to transform the agri-food sector into a driver of sustainable development and improved quality of life in rural areas. (NSARD 2030)

Modern agriculture is influenced by many factors, ranging from climatic conditions and natural resources to the economic environment (Moldova Inform, 2022). This type of activity has faced the challenges associated with insufficient modernization and inefficient use of resources. In this regard, there is a need for systematic improvements in the material and technical base and revision of the organizational structure of agricultural enterprises (Vsemirnyi bank, 2013).

Investment plays a key role in the development of agriculture and is a driver of economic growth (Litvin & Petrascu, 2015; Litvin & Petrascu, 2016). Supporting agriculture and stabilizing the financial situation of agricultural producers contributes to the development of high-performance production and affects the price level of agricultural products (Kiselev et al., 2016; Guth et al., 2020). This is especially important for Moldovan agricultural enterprises that face various financial difficulties, including cash shortages (Traci et al., 2019; Litvin & Coşer, 2014).

Thus, it seems interesting to assess the current situation in agriculture and to identify certain patterns of development of this type of activity.

2. Literature review

The concept of sustainable development represents a new paradigm for humanity's progress, introduced at the 1992 United Nations World Conference on Sustainable Development in Rio de Janeiro. This concept marked a fundamental shift in addressing human development challenges, focusing on maintaining a dynamic balance between natural capital and socio-economic systems.

The most widely recognized definition of sustainable development is provided by the World Commission on Environment and Development (WCED) in the Brundtland Report, titled Our Common Future: "Sustainable development is development that seeks to meet the needs of the present, without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987).

Sustainable development aims to establish a stable and adaptable framework for decision-making in any context involving the relationship between humans and the environment, whether addressing environmental, economic, or social dimensions. Initially, the concept of sustainable development was proposed as a response to the ecological crisis caused by the intensive industrial exploitation of natural resources and the ongoing degradation of ecosystems, with the primary goal of preserving environmental quality. However, the scope of the concept has since broadened to

encompass the overall quality of life, addressing economic and social aspects as well. Today, sustainable development also includes a focus on justice and equity, not only between generations but also among nations, highlighting the importance of fairness in addressing global challenges.

Sustainable development is intrinsically connected to the sustainable advancement of agriculture, which plays a crucial role in strengthening the agricultural sector. This advancement supports the achievement of economic objectives, promotes environmental responsibility, and advocates for social fairness. Câmpeanu et al. (2006) describe sustainable development as a transformative process that integrates resource use, investment directions, technological advancement, and institutional change while balancing present and future needs. Similarly, Popescu and Dobrotă (1999) argue that the traditional development model has been replaced by the sustainable development approach, which fosters a new relationship between humans and nature—one characterized by partnership, balance, and harmony. Vădineanu (1999) emphasizes that sustainable development is a gradual process enabling long-term environmental use while ensuring economic progress and maintaining environmental quality at acceptable levels.

In the rural context, sustainable development entails the efficient, effective, and responsible use of resources to benefit both current and future generations. Achieving this requires fostering social stability in rural areas alongside sustained economic growth, optimizing the use of limited natural resources, and ensuring environmental protection. Sustainable rural development is shaped by the interaction of internal and external factors impacting rural communities, making an integrated approach essential for its success.

3. Methods and data

A comprehensive methodology was used to carry out scientific research. Statistical methods such as time series and trend analysis were used to take into account the dynamics of the studied parameters. This allowed us to take into account seasonal fluctuations and to identify long-term trends in the development of agricultural enterprises. To assess the relationship between various aspects of agricultural activity and the key indicator of its effectiveness (net profit), this study applied a correlation analysis. This method of analysis is a useful instrument of economic data research, enabling the identification of patterns as well as trends underlying the financial performance of agricultural enterprises.

4. Research results and comments

4.1. Assessment of the current situation in agriculture

Agriculture is characterized by a wide variety of different forms of ownership and management, including enterprises, farmers and households.

In this study, an overview of the situation in agriculture is based on data provided by agricultural enterprises, as this category of producers usually has a larger scale of production and also has more structured data, which allows them to study their activities in a comprehensive and reliable manner. Thus, the analysis of the activities of agricultural enterprises allows us to conclude about the state of agriculture as a whole.

The evolution of the main results of agricultural enterprises' activity is provided in Table 1.

Table 1. Evolution of key performance parameters of agricultural enterprises

Indicators	2015	2016	2017	2018	2019	2020	2021	2022
Number of agricultural enterprises, units	3168	3439	3847	4210	4428	4681	5077	5454
Average number of staff, persons	46353	46602	45447	45214	43523	40402	40159	39697
Sales revenue, million lei	11835.5	14421.4	15983.8	17215.6	17501.7	15974.0	24713.5	27900.1
Net profit (loss) for the reporting period, million lei	37.1	1153.6	2264.1	1461.7	1445.7	-264.2	5787.6	3780.3

Source: developed by the authors based on information from Biroul Național de Statistică al Republicii Moldova, 2022a.

Over the period under consideration, there was a steady growth in the number of agricultural enterprises, indicating the progress of the industry and the attractiveness of agriculture to entrepreneurs. So, in particular, in 2022, in the industry functioned 5454 enterprises. The reverse dynamics is observed in the average number of personnel of agricultural enterprises, which decreased in 2022 to 39,697 thousand people or by 14.4 % compared to 2015, which may indicate an increase in labor efficiency and new technology implementation.

There was a stable dynamic of enhancement in income from sales of agricultural production, noticeable enhancement in incomes was observed in 2021 and 2022, which indicates an increase in demand for agricultural products. In 2022, revenues from sales of agricultural enterprises amounted to 27900,1 million lei. However, the profitability of agricultural enterprises was not always stable, and in some years, there were losses. For example, in 2020, enterprises noted net losses in the amount of 264.2 million lei.

According to experts, the agriculture of Moldova is significantly dependent on natural conditions and emergency events, which creates high variability in production and instability of financial results (Cimpoieș & Grubleac, 2023).

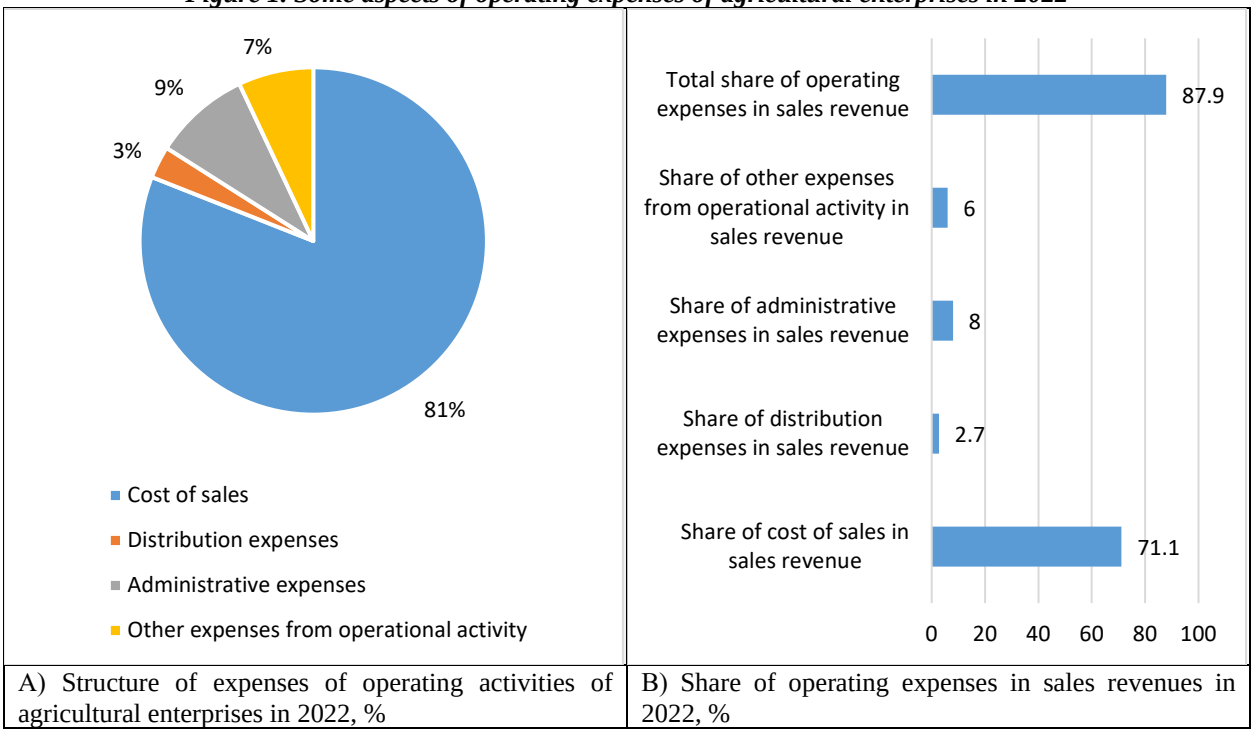
Thus, Table 1 data show that agriculture is a dynamic industry, but faces certain challenges in ensuring stable profitability. Further research may be aimed at examining the efficiency of agricultural production.

Figure 1 presents some aspects of the costs of operating activities of agricultural enterprises in 2022. The major part in the total volume of operating expenses is the cost of sales (80.9 % in 2022). This situation can be attributed to the inclusion of substantial operating costs within the cost of sales: the cost of material resources acquired in the current year in order to produce agricultural products, payment of services to third-party organizations (persons) for the work performed (plowing, cleaning, etc.), remuneration of employees, contributions to social compulsory insurance, made for employees, etc.

In general, the costs of operating activities of agricultural enterprises are significant, and their share in sales revenues left 87.9 % in 2022, including the share of the cost of sales – 71.1 %.

Thus, the total operating expenses of agricultural companies in 2022 show that the cost of sales plays a key role in total costs, which emphasizes the need for effective cost management improving the financial standing as well as the competitiveness of the industrial sector.

Figure 1. Some aspects of operating expenses of agricultural enterprises in 2022



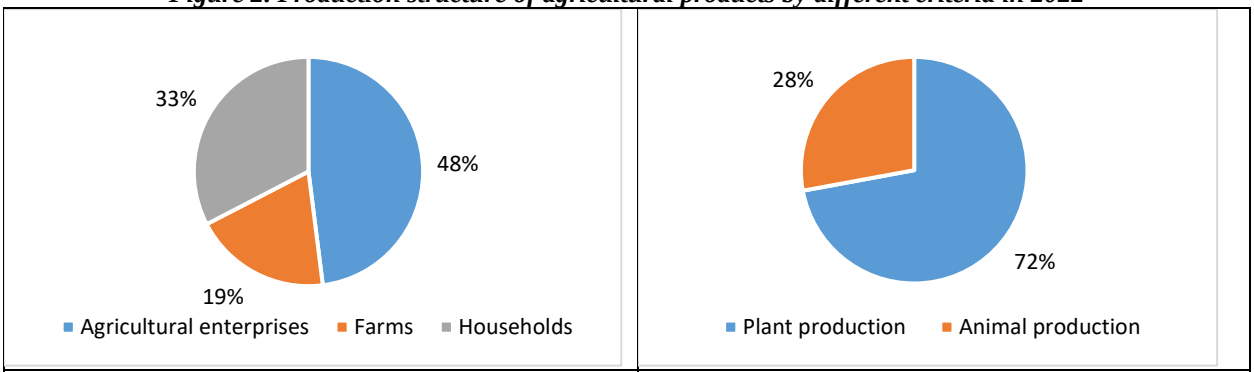
A) Structure of expenses of operating activities of agricultural enterprises in 2022, %

B) Share of operating expenses in sales revenues in 2022, %

Source: developed by the authors based on information from Biroul Național de Statistică al Republicii Moldova, 2022a.

At the same time, it should be noted that in the total structure of agricultural producers (in households of all categories), the share of agricultural enterprises as legal entities producing agricultural products in 2022 amounted to about half of all producers - 48.0% (Figure 2A).

Figure 2. Production structure of agricultural products by different criteria in 2022



A) Composition of agricultural output based on producer categories (as a proportion of the overall production volume) in 2022, %

B Composition of agricultural output by branches, in all producer categories in 2022, %

Source: developed by the authors based on information from Biroul Național de Statistică al Republicii Moldova, Anuarul Statistic al Republicii Moldova, Editions 2002-2023, 2022.

Along with agricultural enterprises in 2022, farms (19 % in the structure of all categories of agricultural producers) and households (33.0 %, respectively) carried out agricultural activities. It is obvious that the presented categories of the farm, despite the lack of legal personality status, have a

significant impact on agriculture, making up more than half of agricultural producers. Understanding the dynamics and peculiarities of the functioning of these forms of management is of special significance for the achievement of sustainable transformation of rural areas and improving the living standards of their population.

It is worth highlighting that the structure of agricultural products is dominated by plant production (72.0 % in 2022), according to figure 2B. This situation indicates a significant focus of the industry on growing plants. This is due to both climate and economic factors. If we consider plant production from a financial point of view, then this type of activity in comparison with animal production can be more profitable for several reasons:

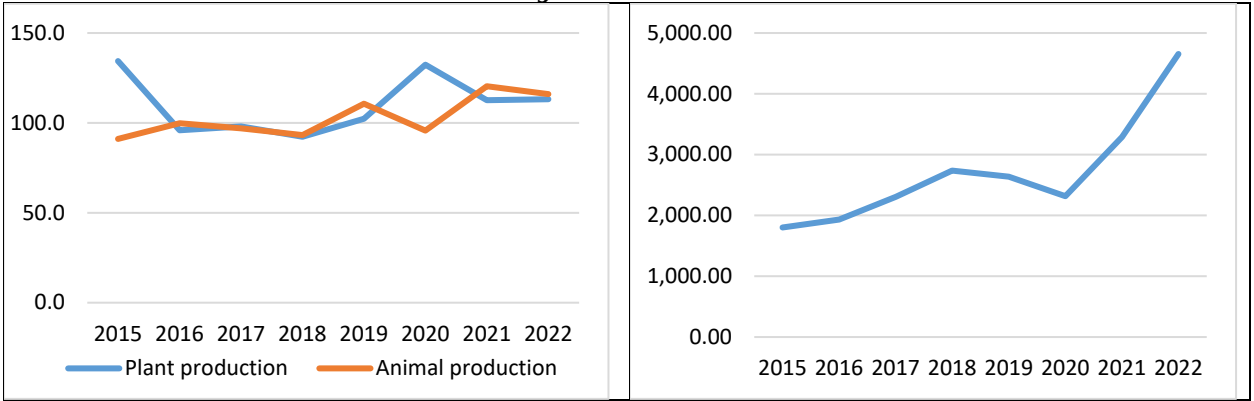
- Plant maintenance costs may be less expensive than the costs of animal husbandry activities;
- Plant production usually has a shorter production cycle, which increases the turnover of funds and the overall profitability of the enterprise;
- Plant production may be less exposed to disease and biological risks than animal husbandry.

The preference for plant production over animal production is due to its potential higher profitability and lower maintenance costs, and in the perspective of the current economic development of the market, high crop prices further emphasize the attractiveness of the agricultural sector for the financial success of agricultural enterprises (Figure 3A).

During 2015-2022, prices for plant production and animal production are characterized by noticeable volatility. The dynamics of prices for plant products showed significant fluctuations in 2015 and 2022 (chain growth rates), but in general, the growth rate of prices remained relatively stable, while the average annual increase in prices for animal products for the period under review was more moderate compared to the increase in prices for crop products, amounting to 4.2 % and 6.0 %, respectively.

The outpacing of price growth for plant products indicates an increase in demand for them, which may be due to changes in consumer preferences, including due to the increase in the level of income of the population, as well as changes in the global and regional markets. Stable growth rates of plant prices can have a favorable influence on financial performance of agribusinesses in terms of increasing the income and profitability of enterprises, stimulating investment in agriculture (Kiselev et al., 2016; Stratila & Țurcan, 2021), as evidenced to some extent by data on the dynamics of allocation of capital to tangible durable assets (Figure 3B).

Figure 3. Dynamics of growth rates of prices and allocation of capital to tangible durable assets in the agricultural sector



A) Growth rate of prices for agricultural products, % | B) Investments in fixed assets in Agriculture, million lei

Source: developed by the authors based on information from Biroul Național de Statistică al Republicii Moldova, 2022b).

For the period from 2015 to 2022, there was a steady growth in the volume of investments in agriculture, reaching a significant increase in 2022 to 4655,1 million lei. The increase in investment indicates positive trends in the national economy, stimulating the development of the production base as well as modernization of agricultural enterprises, the expansion of agricultural production and, as a result, an increase in the demand for fertilizers.

A key point to highlight is that investment and the utilization of fertilizers in agriculture are interrelated, as both contribute to increasing production and increasing yields. Mineral and organic fertilizers not only contribute to increasing yields, but also improve soil fertility with proper application, which contributes to the steady progress of enterprises over the long run. Thus, the use of fertilizers is an integral part of modern agriculture (Table 2).

Table 2. Mineral and organic fertilizers used in agricultural enterprises and in farms

Indicators	2015	2020	2021	2022
Mineral fertilizers (active substance) – total, thou. tonnes	40.1	100.9	104.7	67.9
Share of area fertilized with mineral fertilizers, %	64.9	80.5	82.7	79.9
Organic fertilizers, thou. tonnes	56.2	105.4	129.8	82.6
Share of area fertilized with mineral fertilizers, %	0.92	0.64	1.10	1.70

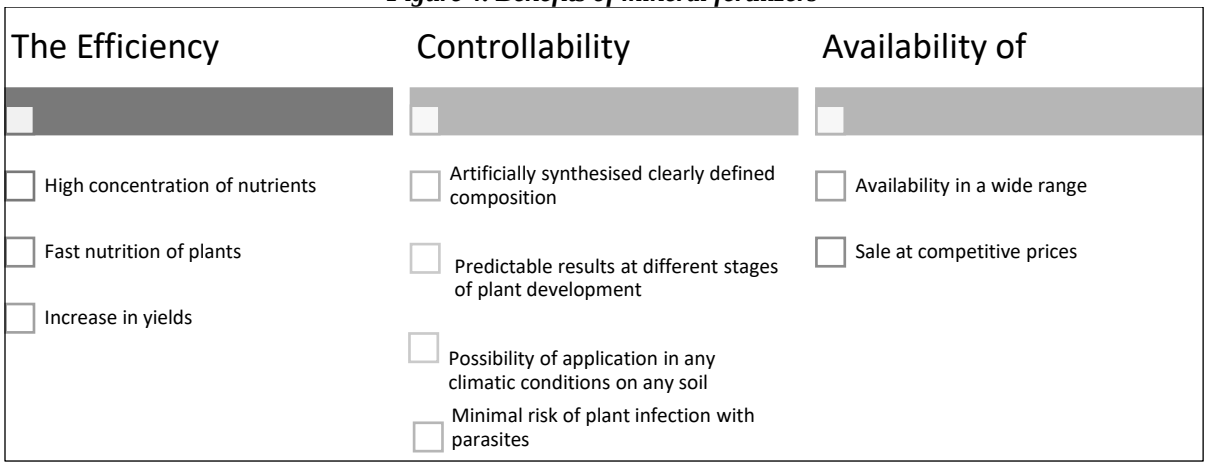
Source: developed by the authors based on information from Biroul Național de Statistică al Republicii Moldova, Anuarul Statistic al Republicii Moldova, Editions 2002-2023, 2022.

Over the period under consideration, the total utilization of mineral fertilizers significantly elevated from 40.1 thousand tons in 2015 to 104.7 thousand tons in 2021, but in 2022 there was a slight decrease to 67.9 thousand tons. The share of the territory treated with mineral fertilizers also increased from 64.9 % in 2015 to 82.7 % in 2021, but in 2022 there was an insignificant decline to 79.9 %. The prevalence and significance of the use of mineral fertilizers in agriculture is obvious.

The use of organic fertilizers also showed an upward trend, exceeding 100 thousand tons in 2020 and 2021, but in 2022 there was a decrease to 82.6 thousand tons. This may be due to changes in farmers' preferences or the availability of organic fertilizers. The share of area fertilized by organic fertilizers also increased between 2015 and 2022, although much slower than the proportion of land fertilized by mineral fertilizers. At the same time, the share of use of organic fertilizers remains low during the period under review compared to mineral fertilizers.

The advantages of mineral fertilizers over organic ones are illustrated in Figure 4.

Figure 4. Benefits of mineral fertilizers



Source: developed by the authors based on information from Agrofirma Partner, 2022.

Derived from an extensive analysis of the present state of agriculture, key trends in the development of the industry can be identified.

Agriculture encompasses various types of ownership and management structures, including enterprises, farmers, and households. The costs of operating activities of agricultural enterprises are significant, for every 1 lei of sales income comes about 0.90 lei of costs and expenses, so to provide stable evolution of the industry it is important to ensure regular rationalization of their level. The structure of agricultural products is dominated by plant production (about 3/4). Ahead of the growth rate of prices for plant production over the growth rate of prices for animal products indicates an increased demand for these products. The widespread use of mineral fertilizers in agriculture is a common practice.

In this regard, it is interesting to evaluate the effect of some aspects of the activity on the operational performance of agricultural enterprises, which are the main players in the industry and can actively increase investment, as well as dictate new development trends by applying a reasonable approach to the use of mineral fertilizers.

4.2. Correlation analysis of net profit of agricultural enterprises

The data set used to construct the multifactorial correlation model is outlined in the table below (Table 3).

The net profit of agricultural enterprises is taken as an effective indicator. As factors of influence on net profit are accepted:

- X1 – Income from sales of agricultural enterprises, million lei;
- X2 – Share of plant production in agricultural production, %
- X3 – Mineral fertilizers (active substance)
- t – is a factor of time, years.

The period of analysis is 2015-2022, except for 2020, when enterprises recorded net losses. Experts point to several factors, such as the drought, Covid 19, the lack of adequate government policies and the uncompetitive exchange rate, which in 2020 caused the deepest agricultural crisis in the last 30 years (Balakhnova, 2021).

Table 3. Input data for correlation analysis

Years	Net profit, million lei **(Y)**	Incomes from the sales, million lei **(x1)**	Share of plant production in agricultural production, % **(x2)**	Mineral fertilizers (active substance), thou. tonnes **(x3)**	Time, years **(t)**
2015	37.09	11835.5	58.0	40.1	1
2016	1153.64	14421.4	72.2	44.6	2
2017	2264.11	15983.8	73.6	65.6	3
2018	1461.66	17215.6	73.7	77.4	4
2019	1445.70	17501.7	72.6	94.3	5
2021	5787.60	24713.5	81.1	104.7	7
2022	3780.27	27900.14	72.1	67.9	8

Source: developed by the authors.

The multiple correlation is shown in the following equation:

$$\boldsymbol{Y = -15.5186 + 1.2119 \times x1 + 0.0075 \times x2 + 0.0849 \times x3 - 2.6016 \times t.} \quad (1)$$

The analysis of regression coefficients using Student's t-test confirmed their significance, as the computed reliability of the correlation coefficient exceeded the critical tabulated threshold (Table 4).

The economic interpretation of the derived regression coefficients indicates:

- b1 - increase of incomes from sales by 1 million lei will result in a rise in net profit of agricultural enterprises by 1.2 million lei;
- b2 - an increase of 1% in the proportion of plant production within the overall agricultural output will result in increasing of net profit by 7.5 million lei;
- b3 - increase of mineral fertilizers applied in agricultural businesses and in farms by 1 thousand tons will increase net profit by 84,9 million lei;
- t - each year net profit of agricultural enterprises decreases by an average of 2601.6 million lei (for this set of factors).

Table 4. Regression coefficients according to Student's test

Parameter	Coefficient	Critical value of Student's T-test	Calculated T-test result
Intercept	-15.5186	3.0796	-5.0392
b 1	1.2119	0.2780	4.3594
b 2	0.0075	0.0517	0.1460
b 3	0.0849	0.0255	3.3235
t	-2.6016	0.7117	-3.6554

Source: developed by the authors.

The coefficient of determination achieved (0.9802) suggests a strong relationship within the equation. The factors integrated into the mathematical model have an impact on around 98.02% of the fluctuations observed in the net profit of agricultural enterprises. Moreover, the correlation coefficient stands at 0.9900. The assessment of these findings using Fisher's standard test indicates the significance of the multiple measurement, as the calculated F-value (24.735) exceeds the tabulated F-value (19.4) (Novyi semestr, 2022). This is supported by the degrees of freedom (f1=7, f2=2, with a significance level of q=0.05).

Thus, correlation analysis facilitates identifying the strength as well as direction of impact of various factors on key parameters of efficiency of agricultural enterprises.

Conclusions

Agriculture is an industry with a special structure of producers, including both legal and natural persons, which determines its diversity and specificity. The analysis of key indicators of agricultural enterprises showed a steady increase in their number, a steady increase in income from sales of agricultural products.

Moldova’s agriculture is largely dependent on natural conditions and external factors, which creates instability in financial results (net profit) and requires constant attention and support.

To create a favorable investment environment, it is essential to ensure economic and legal stability, progress of human capital, as well as developed business infrastructure and other factors. The growth of allocation of capital to tangible durable assets is an indicator of investor confidence in the prospects of economic development and contributes to increasing the competitiveness of businesses in the world market. This trend underscores the need to further support and stimulate investment activity in agriculture to ensure sustainable business development and prosperity of the country.

The study of soil mineralization and the development of effective management strategies play a crucial importance in ensuring the sustainable progress of agriculture of the Republic of Moldova. Mineralization management has a direct impact on land fertility, crop quality and plant health, which in turn can improve production performance, economic sustainability and have a favorable effect on infrastructure and social development. Thus, understanding and effective management of the mineralization process are important aspects of the strategy of stable progress of the economy.

The application of the correlation model, taking into account various aspects of the activities of agricultural enterprises, allows to predict the expected financial indicators of these enterprises in the conditions of modern economic challenges.

Further research can be aimed at in-depth study of the impact of investment activities of agricultural enterprises on their financial results.

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