ANALYSIS OF THE INFLUENCE OF FARM MACHINERY FLEET MONITORING SYSTEMS ON FARM PERFORMANCE

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Abstract

The progress of agriculture is strongly influenced by the shortage of labor and land resources, leading to the transformation of modern agriculture into a highly mechanized and automated form. It has been observed that in recent years the use of intelligent agricultural machinery and agricultural robots has increased significantly in agricultural work. The research carried out aims to highlight the impact of farm equipment fleet monitoring systems on operational management on a farm. By analyzing the various monitoring systems available and evaluating them in terms of efficiency, productivity, and profitability, we can derive an appropriate strategy for the farm. Observation and analysis were the research methods applied to assess the impact of using monitoring systems. Thus, a series of data were monitored and interpreted concerning: agricultural work carried out by a machine, working time, area worked, fuel consumption, how the machine was operated by the mechaniser, etc. The results of the work showed that the implementation of a monitoring system can bring important benefits in cost and resource management, making this investment an efficient and sustainable solution for farmers.

Keywords: monitoring, GPS, IoT, big data, cost control, machine fleet, farm performance, economic efficiency

Innovative technology and knowledge management are essential for the future farmer, due to the structural development of the sector and the expectations from agriculture. Maximizing the productivity of agricultural machinery requires rigorous planning and control of resource use in agriculture. Also, the integration of sensors, actuators, software, onboard networks, and self-steering and guidance technology is rapidly transforming traditional agricultural vehicles into supervised semi-autonomous machines that can traverse fields, steer, and automatically operate farm equipment.

Precision farming involves the use of manual, assisted, or automatic guidance systems, preventing over-fertilization by controlling equipment, applying variable rates according to soil and crop needs, and reducing seed and pesticide consumption by using machinery capable of delivering the right amount to the right place with a minimum amount of wastage or solution recovery.

Current precision agriculture technologies largely focus on smart farming, including soil and plant condition monitoring, pest infestation control, and the use of autonomous tractors (Gupta S. *et al*, 2016).

However, there is little information about Health Monitoring & Diagnostics systems in the field of AgMs (Agricultural Machines) using AI technologies (Zhang Q. *et al*, 2018).

Sustainable development in the agricultural industry can be seen as a key ally in addressing environmental issues, minimizing inequalities, improving food quality, reducing soil deterioration and harmful chemical effects, etc., while taking into account the increasing demand for food production to meet the needs of a growing population.

Specialist Rozelia Laurett and her collaborators take an in-depth look at sustainable agriculture and sustainable development in their 2020 paper, „*Measuring sustainable development, its antecedents, barriers, and consequences in agriculture: An exploratory factor analysis"*. They argue that sustainable development is a concept adopted by a wide variety of organizations, but for some authors, it has become a commonly used and often misunderstood term. It is thus seen by some as a "slogan" open to different interpretations and difficult to apply in reality.

The increasing degree of soil diversity, together with the development of technologies such as microcomputers, geographic information

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systems, and global positioning satellite systems, are the main reasons behind precision farming.

The researcher (Steffen F *et al*., 2019), in the paper "*A comparison of global agricultural monitoring systems and current gaps*", identified several major operational systems that play an important role in regional or global agriculture.

Agricultural technologies are mainly based on the idea of providing enough food to feed a rapidly expanding population. In addition, innovation and its channels are increasingly emphasized, as evidenced by governments adopting them to address significant issues such as poverty and climate change (Christian R. *et al*., a. 2020).

In recent years, technology has advanced significantly in terms of monitoring systems used in agriculture, particularly on farms. These monitoring systems are essential to obtain relevant data and information for effective farm management and to ensure quality production.

The article "*The economic impact of precision agriculture technologies in crop production: a review of the literature*", published in 2021 in the journal Agricultural Economics, analyzed the economic impact of precision agriculture technologies in crop production through a literature review. The authors focused in particular on the impact of monitoring technologies on the economic efficiency of farms, especially on cost reduction and revenue growth.

After analyzing the data collected, the authors concluded that precision farming technologies can have a significant positive impact on agricultural productivity, efficiency, and profitability by reducing costs and increasing yields. In addition, the authors suggested that the implementation of monitoring technologies can be economically justified, especially for large and medium-sized farms, which have a greater need for efficiency and cost reduction (Rastislav K. *et al.,* a. 2021).

Rivera-Padilla argues in his paper, "*Crop Choice, Trade Costs, and Agricultural Productivity*", written in 2020, that agricultural productivities are largely based on the puzzle concept, i.e. farmers typically increase their cost base despite much better labor productivity for agricultural products.

However, one of the main obstacles to implementing these systems on small and medium-sized farms is cost. Initial installation and maintenance costs can be considerable, and many farmers fear that these costs will not pay for themselves adequately. In this paper, we explore in more detail the cost of monitoring systems used on farms and analyze their benefits and cost-effectiveness.

MATERIAL AND METHOD

The present research work aims to follow the influence of farm machinery fleet monitoring systems on the performance of the analyzed farm.

Using data from several perspectives, both technical and economic information is used to examine performance indicators. To facilitate the examination of technical and economic data, figures are provided. These can be found in three different formats: aggregate, relative, and absolute.

In the circumstances of the present work, several methods have been applied respectively:

- Bibliographic study and meta-analysis;
- Economic survey;
- Economic analysis.

For a theoretical approach, I used bibliographic study and meta-analysis as a method, through which I had access to articles and works of writers from around the world.

In addition to the bibliographical study, the economic survey method was also used. In the case of the vegetable farm under study, the survey started by collecting financial data, expenses, and income at the farm level. These data were analyzed to identify trends and fluctuations in income and expenditure.

The economic survey also included the collection of operational data such as input costs, crop production, and resource use efficiency such as land, water, and energy.

Economic analysis is the most widely used in this paper and is also the most heavily weighted, as it is underpinned by a range of methods, tools, techniques, and concepts.

In the case of each phenomenon put under analysis, we have attached great importance to discovering all the components that led to the creation of the indicator, to have a broad and plausible result. In order to make it easier to understand, we give an example of how the unit cost of production analysis is formed, starting from the area of the farm, average production, variable expenditure, fixed expenditure, and going on to the number of employees, seasonal or permanent workers, etc

The analysis of economic indicators and their evaluation criteria was the basis of the theoretical research expressed in the present paper both qualitatively and quantitatively. The data and information used in this study are taken from reliable sources where we can identify information available to the general public. Reliable sources include:

- Accounting of the company under analysis;
- National Institute of Statistics (INSSE);
- Google Scholar;
- ResearchGate;
- Web of Science.

The study on performance indicators was carried out on a benchmark agricultural farm in the North-East Region of Romania. It is a mixed agricultural farm, where the activity in the vegetable sector predominates, having its head office in Cristinești, Botoșani county.

RESULTS AND DISCUSSIONS

On-farm performance indicators can be analyzed through the use of farm machinery fleet monitoring systems. These systems can provide valuable information on the use of farm equipment and help to improve the operational performance of the whole farm.

An advanced management system for monitoring the farm machinery fleet was purchased and implemented on the farm under review. After installing GPS modules on each machine and equipment on the farm, the application installed on IT equipment belonging to the farm engineers collected data on:

- ✓ Date and time the tractor/combine was first started on that day;
- ✓ Which mechaniser used that tractor/harvester;
- ✓ Actual working time;
- ✓ Distance traveled on that day by the tractor or combine harvester;
- ✓ The area worked by a tractor/harvester according to the work process carried out;
- ✓ Amount of fuel consumed by the tractor/combine for the work performed;

The period analyzed for the monitoring indicators on the use of agricultural machinery and equipment on the farm was during the agricultural year 2022-2023.

With the help of *Figure 1* below, we can better understand how the monitoring system works:

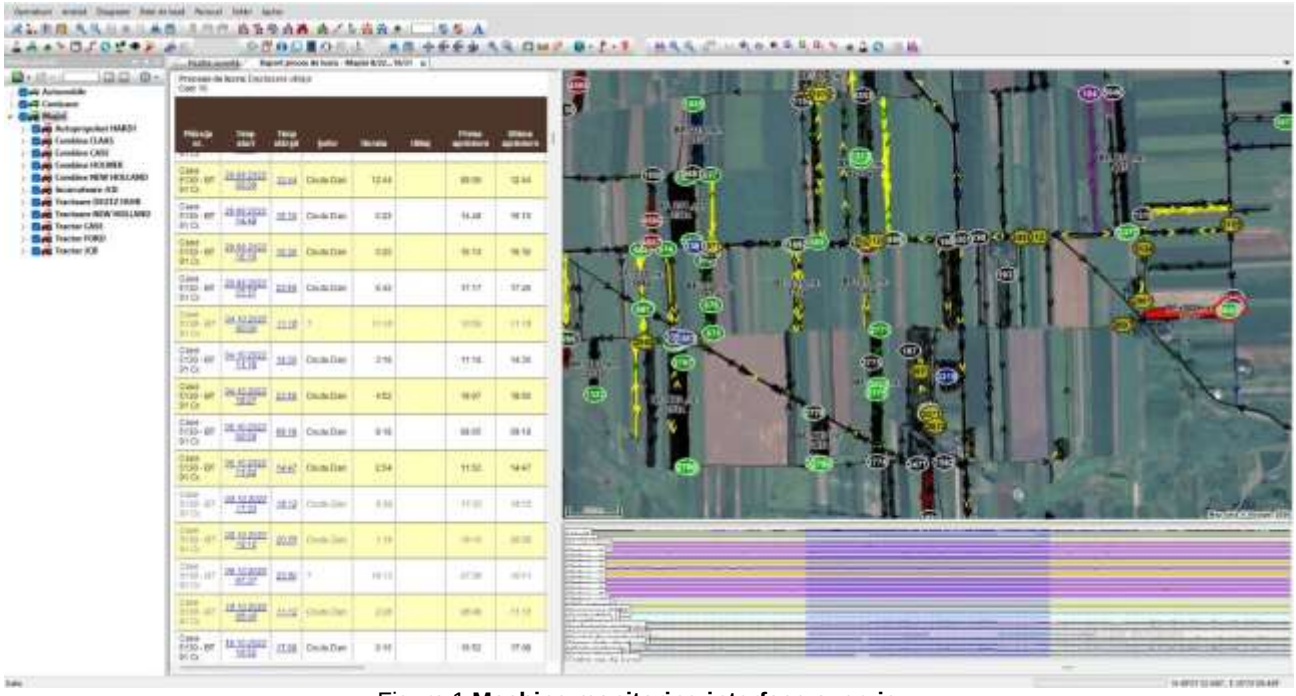

Figure 1 **Machine monitoring interface overview**

Assessing the performance of a business is entirely based on the use of tools, such as examining expenditure and, of course, the associated costs. On an agricultural farm, various types of expenditures are encountered, such as financial or operating expenditures. Operating costs represent the most significant part of the total expenses of a business, which requires detailed analysis to identify new approaches and strategies to reduce them.

In this study, we have developed two different approaches to examining fixed and variable expenses, as follows.

I. FIXED COST ANALYSIS

Fixed costs are a category of costs that remain unchanged throughout the financial year, regardless of the volume of production. These include, for example, promotion costs, overheads, and administrative costs. When the fixed cost is related to production, in terms of lei/kg, it decreases as production increases.

To highlight the impact of the purchase of the machinery fleet monitoring system by the farmer, two variants of fixed expenses were developed: the value of fixed expenses before the installation of the monitoring system and the value of fixed expenses after the installation of the

monitoring system. Results from the examination of fixed expenditure per hectare can be seen with the help of *figure* 2.

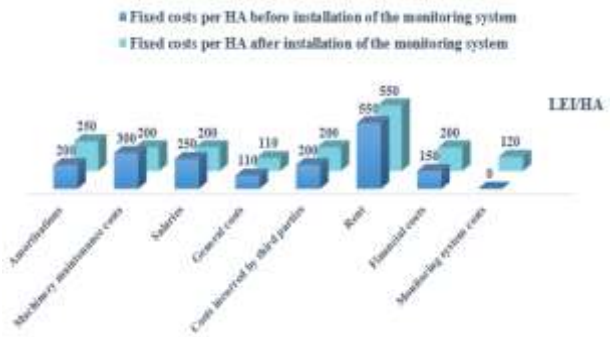

Figure 2 **Fixed costs at HA before and after installation of the monitoring system**

Therefore, looking at Figure 2, the total fixed costs increased from 1,760 lei/ha before the installation of the monitoring system to 1,830 lei/ha after its installation. However, a decrease can be observed in the maintenance and running costs of machinery and salaries, which may indicate an increase in operational efficiency. Increases in financial expenses and depreciation may be related to the investment in the monitoring system.

II. VARIABLE COST ANALYSIS

The variable costs of a farm are those costs that can be changed according to the dynamics of production. Expenditure for this group falls into two categories: direct and indirect. Specific costs are those variable costs that do not change over time and are indicated per unit or per product, e.g. lei/kg.

Since they can take many forms, depending on how the product or goods are generated, variable costs are often also referred to as direct costs.

The analysis of variable expenditure was carried out for the following crops: common winter wheat, maize, and sunflower.

a. WHEAT crop

Looking at *Figure* 3, it can be seen that the use of a monitoring system in the common winter wheat crop brings significant savings in variable costs. Comparing the two tables, total variable costs are reduced by 255,00 lei/ha when using a monitoring system. These savings are the result of optimized processes and more efficient use of resources in all cost categories mentioned above. In addition, the use of a monitoring system can also contribute to more sustainable crop management, reducing the environmental impact through more selective use of fertilizers, herbicides, insecticides, and fungicides.

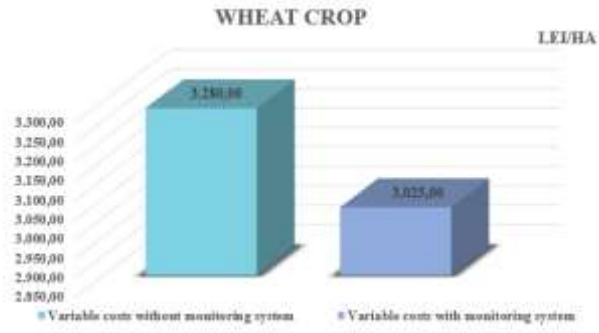

Figure 3 **Variable cost of wheat with and without monitoring system**

b. CORN crop

Comparing the total variable costs for corn cultivation (*Figure* 4), we see that without monitoring the costs are 3,892 Lei/ha, while with monitoring they decrease to 3,650 Lei/ha. This means a total saving of 242 Lei/ha when using a monitoring system.

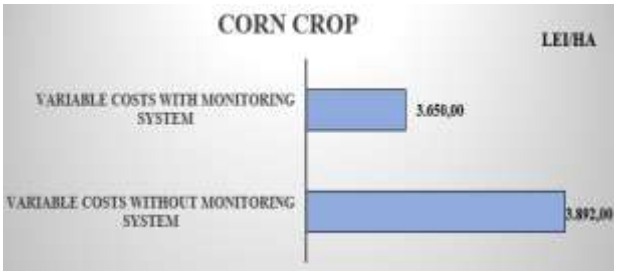

Figure 4 **Variable cost on corn with and without monitoring system**

Therefore, implementing a monitoring system in maize cultivation can have a significant positive impact on variable costs. By optimizing the use of resources such as diesel, seed, herbicides, insecticides, fungicides, and fertilizers, the monitoring system can reduce costs per hectare, allowing farmers to save money and improve their farming efficiency. This can help increase the profitability of the maize crop while facilitating a more sustainable and responsible approach to farming. In the long term, the use of monitoring systems can have a positive impact on the environment and the economic performance of farms.

c. SUNFLOWER crop

Sunflower cultivation can bring significant benefits in terms of reducing variable costs and optimizing crop management. Analyzing Figure 5 below, we can see that if a monitoring system is used, the total variable costs are 3,140 lei/ha, while if a monitoring system is not used, they are 3,370 lei/ha. This means a saving of 230 lei/ha due to the use of the monitoring system.

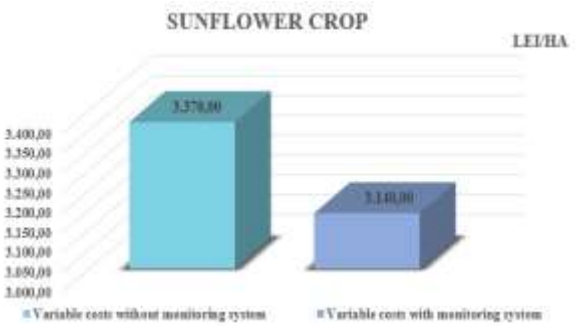

Figure 5 **Variable cost in sunflower cultivation with and without monitoring system**

These savings come from different cost categories such as diesel consumption, seed, herbicide, insecticide, fungicide, and solid and foliar chemical fertilizers. By implementing a monitoring system, farmers can identify and address crop-specific problems in a more efficient and targeted way, leading to better use of resources and reduced costs.

In addition to the financial benefits, the use of a monitoring system can also have environmental benefits as it can reduce the excessive use of fertilizers and pesticides, which helps to protect the environment and biodiversity.

CONCLUSIONS

The demands of the agricultural sector are focused on productivity and increased efficiency today. Lowering costs, minimizing labour time, and ensuring control over all agricultural activities are crucial to profitability and competitiveness, both nationally and internationally.

On a farm, the assessment of performance indicators can be achieved through farm equipment fleet monitoring systems. These systems can provide important data on machinery utilization and help optimize the operational performance of the whole farm.

The use of GPS technology in agriculture helps to increase productivity, effectively manage input costs (such as herbicides, plant protection products, chemical fertilizers, seeds, and fuel), and maximize profit. GPS systems eliminate the need to use milestones to indicate directions in the field, reducing labour costs. Chemical application is accurate, eliminating overlap errors. This leads to savings in fuel and inputs because rows are parallel, regardless of their shape (straight, curved, round, etc.).

Analyzing the total fixed costs, they increased from 1,760 lei/ha before the installation of the monitoring system to 1,830 lei/ha after its installation. However, a decrease can be observed in the maintenance and running costs of machinery and salaries, which may indicate an increase in operational efficiency. Increases in financial expenses and depreciation may be linked to the investment in the monitoring system.

As can be seen from the results, the use of a monitoring system in the common winter wheat crop brings significant savings in variable costs. Comparing the two tables, total variable costs are reduced by 255.00 lei/ha when using a monitoring system. These savings are the result of optimized processes and more efficient use of resources in all cost categories mentioned above.

In maize cultivation, comparing the total variable costs, we see that without monitoring the costs are 3,892 lei/ha, while with monitoring they decrease to 3,650 lei/ha. This means a total saving of 242 lei/ha when using a monitoring system.

Sunflower cultivation can offer considerable advantages in terms of reducing variable costs and improving crop management. If a monitoring system is used, the total variable costs are 3,140 lei/ha compared to 3,370 lei/ha without monitoring. This indicates a saving of 230 lei/ha due to the application of the monitoring system.

The savings come from various categories of expenditure such as fuel consumption, seeds, herbicides, insecticides, fungicides, and solid and foliar chemical fertilizers. By implementing a monitoring system, farmers can identify and address specific crop problems in a more efficient and focused way, leading to better resource management and lower costs.

In addition to the financial benefits, implementing a monitoring system can also bring environmental benefits as it can limit the excessive use of fertilizers and pesticides, thus contributing to the conservation of the environment and biodiversity.

In conclusion, the implementation of a monitoring system can bring important cost and resource management benefits, making this investment an efficient and sustainable solution for farmers.

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