PERSPECTIVES OF AGRICULTURAL SECTOR DEVELOPMENT THROUGH IMPLEMENTATION OF SMART TECHNOLOGIES (REPUBLIC OF MOLDOVA CASE)

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Abstract: *Digitalization of agriculture aims at optimizing the IT knowledge and technologies in order to achieve long-term stability of agricultural production, environmental protection and consumer security. Sustainable agriculture can be achieved through management strategies that assist the producers in selecting hybrids and varieties, soil conservation practices, biodiversity conservation, and pest management systems. In other words, the purpose of digital agriculture is to minimize the negative impact on the environment by producing a stable level of production and profit. The objective of this research is to analyze the state of affairs of the agricultural sector in the Republic of Moldova and to examine digital technologies as effective solutions for the sustainable development of the agriculture.*

Key words: *Precision farming, Smart agriculture, sustainable development, simulation models, tele-detection, Information Systems for data collection and processing (GPS), System Decision Support.*
JEL Classification: *R11.*

1. Introduction

Humankind lives and develops progressively in the presence and with the help of information technologies. In the evolution towards the "Gigabit Society" of the next decade, the challenges that we have to face are great: the development of human capital, the integration of digital technologies in business and the public services sector are the main priorities.

The growth of the world population, according to the European Commission estimates, will determine an increase of food demand by 70% towards 2050. Another persistent challenge is to meet the demand for healthy foods and with an optimal food supply for the consumption needs of the population.

The increasing lack of availability of agricultural land, ecological losses and environmental degradation, water shortage, growing needs for energy, as well as the emergence of new harmful organisms and new diseases exert considerable pressure on the environment, and for farmers it is more and more difficult to produce food in a sustainable way.

Digital technologies constitute the future of agriculture, and the attempts to ignore them are preventing the development of this sector.

The Internet of Things, Robotics, Artificial Intelligence and large volumes of data are applied by farmers around the world and make an essential contribution to streamline the processes efficiency.

Technological innovation in agriculture represents an essential part of the solution. Agricultural technologies, in particular, have the potential to increase the productivity and sustainability of agriculture. Research in the field considers digital technology – the only realistic way to meet current challenges.

Worldwide, about 805 million people suffer from chronic malnutrition. Although global food and ecological security concerns have recently brought public sector research and development into focus, the agriculture is still lagging behind.

The digitization of agriculture improves the working conditions for farmers, reduces the negative impact of agriculture on the environment, but also ensures a much higher profitability of the enterprise.

Digital agriculture will take the place of the traditional one, with producers realizing that by investing in technology, they can achieve efficient results, such as saving planting material, fertilizers, herbicides, pesticides and fuels.

2. Material and analysis method

In order to carry out research in the field of implementing information technologies in the agricultural sector, the data of the National Bureau of Statistics, the National Strategy for Agricultural and Rural Development 2014-2020 of the Republic of Moldova, the reports of the Agency for Interventions and Payments in Agriculture, the data provided by the Ministry of Agriculture, Regional Development and Environment were examined. The data from the financial statements and the experience offered by the agricultural enterprises and associations from the Northern region of the Republic of Moldova were examined. Also, the advantages of IT implementation in agriculture have been generalized by studying the European and international practice.

3. Analysis of the agri-food sector

The large flow of foreign investments in recent years in the field of automotive industry development, currently this industry holds a 3% share of the national economy, and the rapid growth of fiber and cable production (43% in 2019 compared to 2018) has not changed the vector of the development of the country's economy, oriented towards the development of agriculture and agri-food production. Agriculture remains an important sector in the economy of the Republic of Moldova, although its contribution to GDP (gross domestic product) is in a continuous decline.

Thus, according to the data of the National Bureau of Statistics in 2015, the contribution of agriculture to the formation of GDP constituted 12.1%, compared to those over 30% registered a decade ago, and in 2018 this share constituted only 10.2%.

The negative dynamics of global agricultural production in GDP was determined by the development of the service sector. This trend is observed in developing countries, where the service sector plays an increasingly important role in the national economy, and the agricultural sector is in decline.

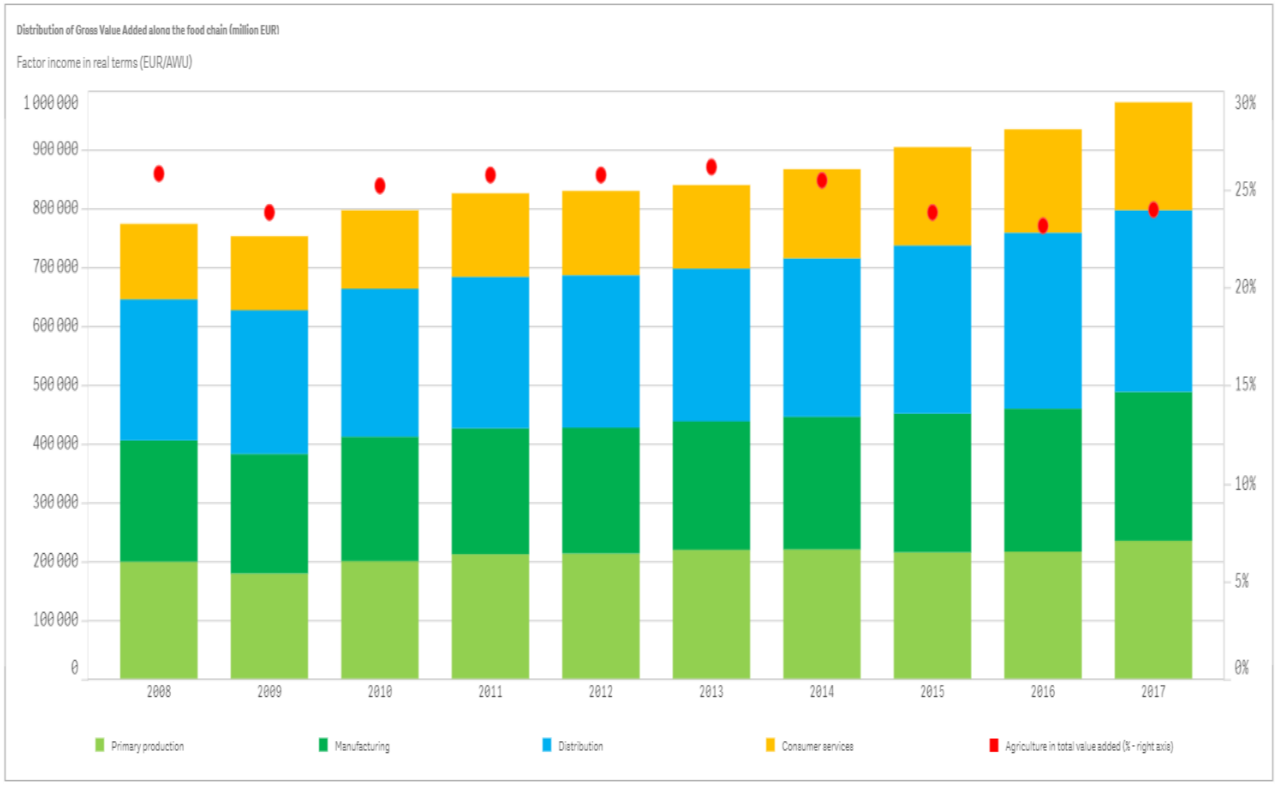
According to the data of the *Eurostat* portal, the gross added value from agriculture by economic branches in the European Union entirely is decreasing in 2017 (23% of GDP) compared to 2010 (28%). At the same time, agriculture plays a vital role in the Eastern European economies, its contribution accounting for about 10% of GDP in the last decade. In this regard, it is important to mention the gap between different areas of Europe, where, in 2018, the contribution of agriculture to GDP was 10% in Eastern Europe and 28% in the European Union.

The employment rate in Moldovan agriculture is still important, but it also registers a decline, both in absolute terms and in relative terms.

In 2019 the economically active population of the Republic of Moldova constituted 1,407 million people, increasing by 7.6% compared to 2018, and the share of economically active persons from the rural area was higher than that of the urban area: 58.6% correspondingly and 41.4%, according to data presented by the National Bureau of Statistics (NBS).

From the distribution of the employed persons by economic activities follows that in the agricultural sector 556 thousand persons worked or 40.4% of the total employed persons. Of these, 51% constitutes the individuals employed with the production of agricultural products, exclusively for their own consumption.

Chart nr.1 Gross added value from agriculture by economic branches



Source: EUROSTAT 2017, https://agridata.ec.europa.eu/extensions/DashboardIndicators/AddingValue.html

As far as the Republic of Moldova is concerned, the employment rate in agriculture has decreased by almost half in a decade, but compared to other regions of Europe, it is still high.

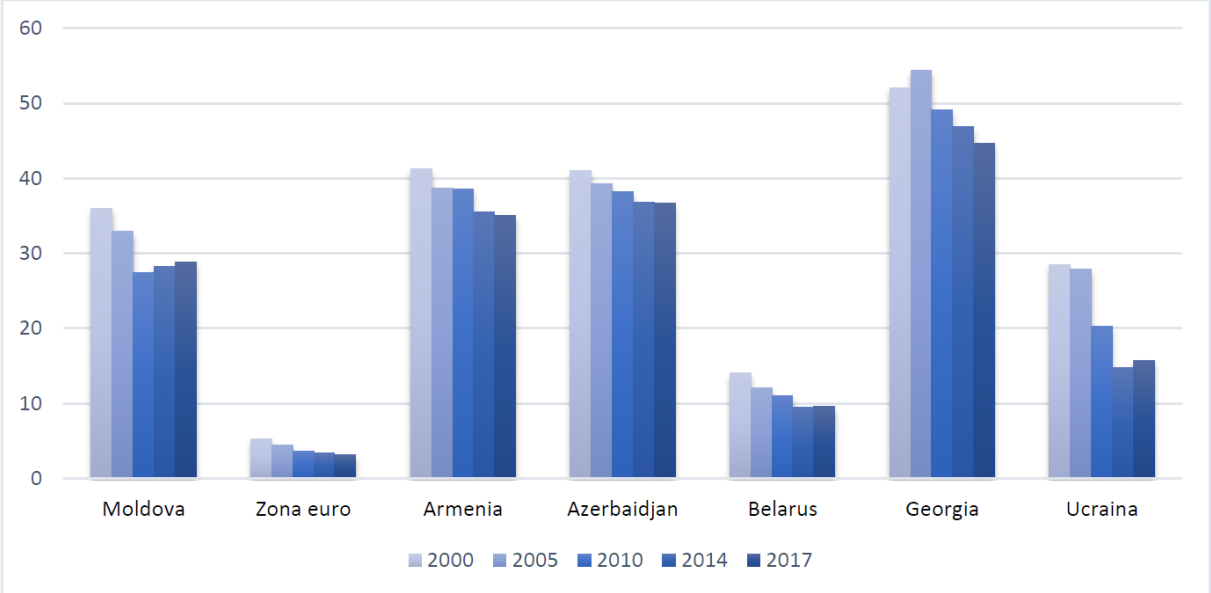
Rapid structural changes in the country's economy have led to the emergence of new employment opportunities in sectors other than agriculture, thus conditioning the migration of population from rural areas and employment in other industries, which are not traditional for the national economy. Although the rate of employment in agriculture is declining, the agricultural sector continues to play an important socio-economic role. Obviously, agriculture remains one of the most important employers in the economy. The decrease of the employment rate in agriculture together with the increase of the production of the sector led to the increase of the labor productivity in the agriculture of the Republic of Moldova. However, compared to other countries in the region, the index remains at a significantly low level.

In Eastern Europe, the employment rate in agriculture continues to be high, but is declining. While in the EU about 3% of the working population is employed in agriculture, in the countries of the former Soviet Union from this region, the employment rate in agriculture in 2017 was 30% (Chart nr. 2). In the case of the Republic of Moldova, the employment rate in agriculture has decreased by almost half in a decade, but compared to other regions of Europe, it is still high.

The agricultural sector of the Republic of Moldova is dominated by vegetable production, while the zootechnical sector plays a less important, but stable, role in production, which suggests a potentially low level of competitiveness. In the years 2000-2017, the crop production accounted for 60-70% of total agricultural production, being largely represented by the raw material exported in bulk to the CIS and the EU.

According to statistical data, 8% of US farmers are processing about 65% of tillable land, and in Europe 5% of farmers are processing more than half of the land. This is achieved through automation. The digitization makes it possible to remotely measure the state of the soil, ensures a better water management of the entire farm and a better crop monitoring using phones, tablets, field sensors, drones and satellites at hand.

Chart nr. 2. Employment in agriculture as a share of total employment in EU countries and some Eastern European countries, 2000–2017 (%)



Source: Eurostat (2018)

In addition, digitization can improve the working conditions for farmers and reduce the negative impact of agriculture on the environment. At the same time, the flows of improved agricultural data throughout the agri-food chain generate many benefits for those involved, including farmers and other stakeholders from the distribution and retail sector.

Agriculture can make many contributions to the economic growth. It may have a contribution to smart, sustainable growth, favorable to the inclusion. We cannot talk about a rational and efficient use of natural resources without thinking about agriculture and the way it is managed.

4. Considerations regarding the implementation of IT technologies for the development of the agricultural sector

In the specialized literature two new concepts are formulated "Precision agriculture" and "Smart Farming".

Therefore, precision agriculture, which originated at the beginning of the 90's of the last century, with the advent of the geographical positioning systems (GPS), is inscribed as a new methodology (a new agricultural system), which could be the key to solving many current problems. This agricultural methodology aims to optimize the use of soil, water and chemical inputs resources (fertilizers and pesticides) on specific local bases. Its basic objectives being the following:

- obtaining large quantities and quality products;
- optimizing the economic profits;
- carrying out the integrated protection of the environment;

- increasing the sustainability of agricultural systems.

Precision agriculture constitutes the use of information and communication technologies, together with the best agricultural practices for the acquisition, transmission and processing of large amounts of data from agricultural fields in order to increase productivity and environmental protection (Hopkins, 2015, p. 28).

The emergence and development of precision agriculture was favored by a number of factors such as:

- the ability to understand the complexity of agricultural systems (systemic and holistic approach);
- the ability to monitor phenomena and processes (automation of data acquisition);
- the achievements in computing techniques (hardware, software and databases);
- the improvement of the calculation and interpretation methods (statistics, modeling, simulation, decision support systems);
- the development of geographical information systems (GIS);
- the emergence and development of the analysis of spatial statistics (geo-statistics);
- the progress in space techniques (tele-detection, GPS);
- the technical achievements in agricultural machinery improvement (VRT).

In the Republic of Moldova, the promotion of precision agriculture is justified by the following hazards pointed out by the agricultural associations and farmers:

1. Use of plant varieties not adapted to the specific conditions of our country
2. Elimination of the specialized units in plant culture
3. Deregulation of the national seed production system
4. Use, by private producers, in a significant proportion, of non-certified seed material
5. High level of prices for agricultural inputs (fertilizers, pesticides, fuels, equipment, agricultural equipment, high bank interest rates)
6. The producers do not finance the culture for economically optimal productions
7. The recent climate change in our country
8. Disregarding the spatial variation of climate and soil resources in agricultural crop zoning
9. Passing the crop culture, in a proportion of 94%, to non-specialized private producers

The use of geospatial and information technologies allows the fields, their productivity and populations of pests to be properly assessed and mapped. These possibilities offer essential advantages in scientific research and the implementation of results.

Precision management in agriculture (precision agriculture) includes the use of three basic elements:

a. Simulation Models, Decision Support Systems and the Geographic Information System (GIS)

A Geographic Information System (GIS) consists of data and computer programs intended for spatial analysis. This system is particularly used to create, store, analyze and process spatially distributed information through a computerized process. The GIS technology can be used in various scientific fields such as: the resource management, environmental impact studies, mapping, route planning.

In the case of Precision Agriculture, the computer programs are intended to obtain results regarding the size and quality of the crop and the factors that affect the development of the plants. These factors include the soil fertility, the disease control, the pests and weeds control, the precipitation distribution, the temperature, the altitude etc. Furthermore,

the GIS technology ensures the planning of the actions necessary to eliminate the factors that may limit the use, number or quantity of chemical materials in agriculture, first of all, of pesticides, by preventing their use, when it is not needed.

b. Tele-detection (TD) and Information Systems for Data Collection and Processing (GPS)

Tele-detection images have been identified as the most appropriate data sources for Precision Agriculture requirements. TD is an observation on a non-contact object. It consists of the measurement and recording of the electromagnetic energy, which is reflected from the surface of the earth, using the sensors attached to airplanes or satellites. The identification of the information regarding the state of the atmosphere is made based on the observations obtained from the sensors. Usually, the digital data is further analyzed using specialized software (Gameda, Dumanski and Acton, 2007, p. 38).

The research carried out in recent years has shown that the Global Positioning System (GPS) best meets the needs of Precision Agriculture in terms of capabilities, price and economic effect. GPS is a location system that provides extremely accurate data for any point on the planet, at any time or weather conditions. The Global Positioning System is a set of global radio navigation based on a set of 24 high altitude orbital satellites.

Nowadays, most of the agricultural land is manually tested, farmers manually collect samples from the pre-set locations, which are sent to the laboratories for analysis. Then, the agronomist engineer creates an appropriate map of the fertilizers recommended for each area designed to optimize the production. Afterwards, a GPS fertilizer distributor applies the selected amount of nutrients to each location.

c. Decision Support System (DSS)

The management of agricultural land today means the management of the sustainable use of the land, and the sustainable use must solve problems of productivity, security, protection of the potential of the land and prevention of the degradation of the quality of the land and the environment, (economic) viability and(social) acceptability (Vlad, 2001, p. 4).

A Decision Support System is a computer tool (a computer program and database system) that supports the decision-making activity in poorly-structured problems, in which it is not possible, for a fully automated system, to carry out the entire decision-making process.

Precision agriculture refers to the "differential" approach of the field versus the "uniform" approach on which traditional management systems in agriculture are based. The precision management of agricultural lands takes into account the natural, specific variation of the soils and not their administrative division.

Therefore, based on the above, we can conclude that precision agriculture:

1. ensures the strategy of sustainable development in agriculture;
2. uses geospatial and information technologies in order to use the specific data of the given place in the direction of making decisions related to agricultural production;
3. presents a set of modern technologies for a sustainable agriculture.

Precision agriculture constitutes a management approach for the entire household, using the information technology, the positioning data (GNSS), the tele-detection and close data collection. These technologies aim to optimize the efficiency of inputs while reducing their negative impact on the environment.

The measurement of the different working parameters by sensors, the analysis of the information received through the specific software and the sending of orders for the modification of other parameters on tractors and agricultural machines created the "Smart farming" system.

For the Republic of Moldova this is a new technology of soil processing, which is used only by some agricultural enterprises for some years.

According to the experts in the field, the economic effect of the technologies of precision agriculture, would be: the reduction of the expenses by minimum 10% -15% and the increase of the productivity in adverse weather conditions of the season by 20-25% (Timofti, 2020, p. 4).

With the use of GPS, the application, development and extension of the *E-Agriculture* concept becomes more and more modern, this being a relatively new term used in the field of agriculture. The concept of *E-Agriculture* describes an emerging domain focused on consolidating this field through the best communication and information processes. E-Agriculture is a smart investment in the agricultural sector, using the ICT domain. This will allow the modification and improvement of the sanitary-veterinary, phytosanitary and food sectors, both at operational level and at managerial level, acting directly and indirectly for the benefit of farmers and the business environment in the agricultural sector.

The aim of *E-Agriculture* is:

- streamlining the development and implementation of sectoral policies;
- focused subsidization;
- optimizing the farmers' activity by digitizing the public services;
- monitoring the sectoral policies.

Agricultural producers, practicing such a kind of agriculture, have modern management technologies that provide them with real-time detailed information on the crops they manage.

These management systems provide considerable financial benefits to farmers as well as significant environmental benefits, including reversing soil degradation, reducing river pollution, increasing carbon sequestration, and reducing greenhouse gas emissions (Hedley, 2015, p. 17).

Based on the analysis of the experience of several countries, the stages of implementation of precision agriculture can be:

1. Use of the concept of specific local management in agriculture. Accepting the condition, that the fields, other management units, which were considered as an integrated unit, further must be divided into smaller units (plots), homogeneous, which will be processed according to the individual needs.

2. Definition of small units. Highlighting the particularities, based on which the fields can be divided into smaller units. Topography and the soil type can serve as a basis for the subdivisions. Field mapping according to the requirements of precision agriculture.

3. Obtaining information on the productivity of small field units. Most important is the size and quality of the crop for each plot. Harvest mapping.

4. Identification of restriction factors. The analysis of each plot on the main factors that influence the size and the quality of the crop. By superimposing the obtained maps, you will get a performance map, which can detect under what conditions the worst results will be obtained.

5. Appropriate response. Applying corrected actions only as required.

6. Evaluation of results. Economic and ecological effect of applying the elements of Precision Agriculture (Hopkins, 2015, p.13).

Increasing the productivity of agriculture through process mechanization and technical management have become important factors in maintaining the balance between the production of agricultural products and the needs of the population. At the same time, the application of nutrients and combating harmful organisms will continue to be a critical link between the production of food resources and the sustainability of agriculture.

Coupled with the needs of increasing productivity, farmers are forced to produce more food products with minimal effect on the environment, in parallel with reducing the application of polluting substances. Farmers face the dilemma of raising productivity and, at the same time, reducing costs and ensuring the protection of the environment.

In this context, the strategic activities at the country level must be coordinated in the aspect of agricultural land resource management, land use planning, including evaluation and interpretation of soil information, land use, integral with agroclimatic resources, crop needs and other environmental factors, which influences the production potential, in order to determine the limits and the potential of agricultural production.

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