ENHANCING THE MANAGEMENT EFFICIENCY IN AGRICULTURE BY CREATING DIGITAL ECOSYSTEMS

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Abstract: *The sustainable development of the agricultural sector is identified as one of the primary strategic priorities of the Republic of Moldova and is crucial for ensuring economic growth. The agricultural sector, as a share of gross domestic product (GDP), ranks second by service sector and comes first in terms of contribution to economic growth. However, the productivity of sector remains at a deficient level, driven by a lack of investment and available loans, with low-yield technologies. For a long time, the agricultural sector was of no interest to the "new generation" of farmers and investors, being characterized by climate risks, lack of automation and innovation, and the application of IT in agriculture was limited to the use of computers for financial management and commercial transactions monitoring. Today, modern technologies have evolved, being intensely introduced into the practice of the agricultural sector; they are offering high-performance and efficient solutions. In the research, the author examines the digitizing prospects of agriculture in the Republic of Moldova and its potential to implement Industry 4.0 products. In the author's vision, the creation of digital ecosystems in the agricultural sector will increase the efficiency of farms management and will propel the Moldovan economy to a new development stage.*

Keywords: *Agriculture, digital ecosystems, Industry 4.0, informational technologies, management efficiency.*

JEL Classification*: O10, O13, O32.*

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1. Introduction

The fourth industrial revolution is driving innovative digital technologies and innovations transforming countries' economies and many sectors of activity, and the food and agriculture sectors are not exempt from this process.

The agricultural sector faces many challenges posed by the impact of climate change, the increased frequency of natural disasters, biodiversity loss and soil erosion, rising food price volatility, inefficient supply chains and other challenges. Agriculture is also becoming more and more knowledge-intensive: farmers have to make increasingly complex decisions about land use, the selection of seeds they plant, the choice of markets and other critical decisions that have an impact on agri-food production, farmers' income and the well-being of entire society. Their information needs are growing, and the information allows them to innovate and therefore adapt to the challenges of survival and a higher standard of living.

The need for national strategies to digitize agriculture has been recognized by many countries around the world that have adopted government policies to promote and finance ICT in the agricultural sector. A valid national e-agriculture strategy streamlines resources (financial and human) and increases the efficiency of the agricultural sector through intra-industrial synergies and sectors of activity.

In the past, it was difficult to obtain information from farmers about their fundamental problems and needs, such as access to agricultural inputs, markets, prices, financing or their learning needs. According to the FAO report, the spread of mobile technologies (smartphones) and, more recently, remote services and distributed computing, open up new opportunities for the integration of small farmers into new digitally driven agri-food systems (Trendov, Varas and Zeng, 2019).

The spread of digital tools is happening very fast. Even among the most deficient 20 percent of developing countries, 70 percent have access to mobile phones (World Bank, 2016). More than 40 percent of the global population has access to the Internet, and there are significant initiatives to connect those who remain, especially in rural areas of developing countries. Over the next ten years, Industry 4.0 will generate dramatic changes in the food system, driven by advanced digital technologies and innovations (blockchain, Internet of Things (IoT), Artificial Intelligence (AI), Virtual Reality), changing consumer preferences and requirements, influence e-commerce on world trade in agri-food products, climate change and other factors.

In order to achieve the United Nations Sustainable Development Goals towards a "zero hunger world" by 2030, FAO emphasizes the need to develop more productive, efficient, sustainable, inclusive, transparent and resilient food systems (FAO, 2017).

2. Methods and methodology

To support scientifically the presented ideas and recommendations, the author made a literature and legal framework review of the publications on the issues of innovation and sustainable development of the agro-industrial sector in the digital era. Also, the analysis of the results about the future development of the agriculture presented in the Evaluation Report of the National Strategy "MOLDOVA 2020", "Agricultural and Rural Development Strategy 2014-2020", the reports of the Food and Agriculture Organization of the United Nations, World Bank reports.

The research uses methods of comparative and systemic analysis, as well as a logical approach to the development trends of agricultural enterprises in the conditions of sustainable development of the Republic Moldova economy.

The authors analyze the path of agriculture sector to accept information technologies and digitization of the agricultural enterprises. The dynamics of agricultural sector development are addressed as an integral part of the country's economy. According to factors that have a situational impact in the current period of activity: trends in agricultural management development, introduction of innovations that positively affect socio-economic indicators development and the environment, increasing employment and income, financing mechanisms for the agricultural sector and the financial results obtained. The analysis of the digitalization level of agricultural enterprises was performed based on data provided by the National Bureau of Statistics of the Republic of Moldova.

3. Legal framework review

In the Republic of Moldova, there is no direct strategy for the digitization of the agricultural sector. However, there are several initiatives within the National Strategy for the development of the information society "Digital Moldova 2020" on the development of digital services for agriculture as: Information system for data transmission over time real through web and mobile telephony solutions with the components: PACT (Early Warning and Communication Platform) and SIMA (Agricultural Marketing Information System) (National Strategy, 2013).

The importance of agriculture in the economy of Moldova and the favorable conditions developed by the information society create all the necessary premises for the development and implementation of a national strategy for digitization of agriculture.

In 2012, under the subordination of the Ministry of Agriculture and Food Industry, the Agricultural Information Center (AIC) was created, responsible for implementing the status policy in the agro-industrial field, coordinating activities to implement the "e-Agriculture" principle and consolidating and integrating agricultural information resources to the state digital information. This center became the Single National Operator of all information

systems in the agri-food sector in Moldova with the general goal of developing and implementing the e-Agriculture Strategic Program. One of the digital products operated by the center, according to Law no. 231, art. 3 (Law no 231, 2006) is the Automated Information System "State Register of Animals" (SITA, 2007), to ensure animal traceability, which is implemented in the Republic of Moldova since 2007. The Animal Identification and Traceability System (SITA), is a primary digital ecosystem, integrated in the traceability process of products of animal origin. SITA is presented by a complex of elements and procedures, for the identification and registration of animals and agricultural holdings ensuring compliance with the principle of traceability that is managed by a single operator (Law no 231, 2006). This electronic system aims to ensure the food security of the country, as well as to provide the consumer with healthy agricultural products of animal origin.

E-agriculture program started in 2012 in Moldova, as an initiative of the EU-Moldova Action Plan (Plan no 402, 2005) with promising objectives such as:

- modernization of public services by digitizing operational processes;
- optimization of the activities of entities in the agro-commercial sector through modern technologies;
- streamlining the expansion of digital ecosystems in agriculture;
- developing and monitoring IT policies in agro-business sector.

The expected results from the implementation of the program relate, in particular, to facilitating the process of managing and implementing agri-food development policies and providing the business environment with objective and coherent information that will improve business development in the agricultural sector, and will stimulate ecosystems expansion. The program also contributes to the digitization of public services and operational processes in agriculture, providing an increase of business in agriculture and the professional development of farmers in the IT sector.

4. Prospects of digital ecosystems in Moldovan agriculture

A digital ecosystem is defined as a socio-technical system composed of a set of computer programs with distributed interaction and mutual use by agents in the context of evolutionary self-development (Aletdinova, 2016). Environmental component in the description of these systems (eco-) is associated with attempts to draw analogies of the processes of living nature and the techno sphere, the application of the laws of ecology to the information world (Chang, 2006). W. Brian Arthur notes the properties of the digital economy, which are also suitable for digital ecosystems: they are silent, invisible, vast, autonomous (that is, they do not require constant management by people), self-organizing and self-healing (Brian, 2011).

Although information technologies (access to mobile telephony and Internet) have progressed significantly, the poor technological infrastructure, a low level of electronic skills and digital skills, as well as expensive access to services in urban areas create a significant digital divide between localities. The rural areas have fewer opportunities to benefit from the digital revolution in agriculture.

In the FAO's view, the underlying conditions for the digital transformation in agriculture are Internet access and IT infrastructure in rural areas; the level of education, digital literacy and employment in rural areas and sustainable policies and programs in the field of digitalization of agriculture (Trandov et al., 2019).

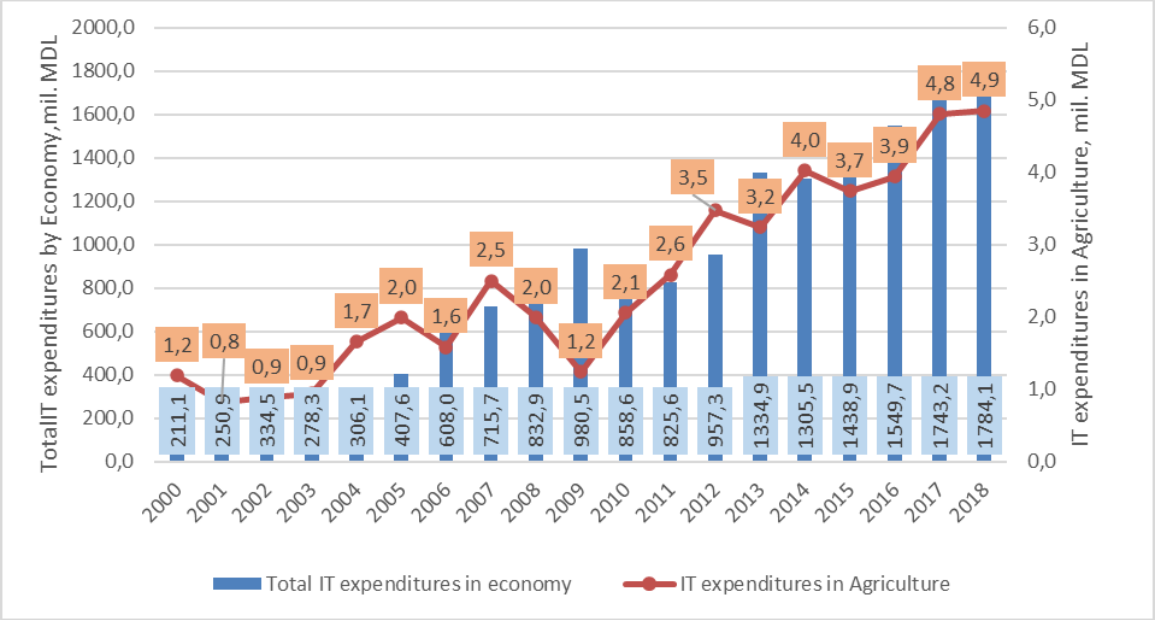
According to National Strategy for the Development of the Information Society "Digital Moldova 2020", the Republic of Moldova is ranked among the top 20 countries in the world in terms of Internet access speed. At the same time, broadband connectivity is not at the necessary speeds throughout the country to meet the current and potential needs of users. The substantial discrepancy between access to urban and rural localities (almost 30%

of rural localities do not yet have broadband access (National Strategy, 2013) distorts ICT infrastructure.

Although there is a coverage of 98-99% of rural localities with mobile telephony and the Internet, we can attest a poorly developed level of IT infrastructure. The agricultural holdings investments in IT products are non-essential to trends and figures from other areas of activity.

In 2018, the share of these total expenditures on the economy was only 0.27%, which directly determines the quality of IT infrastructure in rural areas.

Figure 1. Expenditure dynamics for information technologies in agriculture and in total by economy, in the period 2000-2018 (thous. MDL)

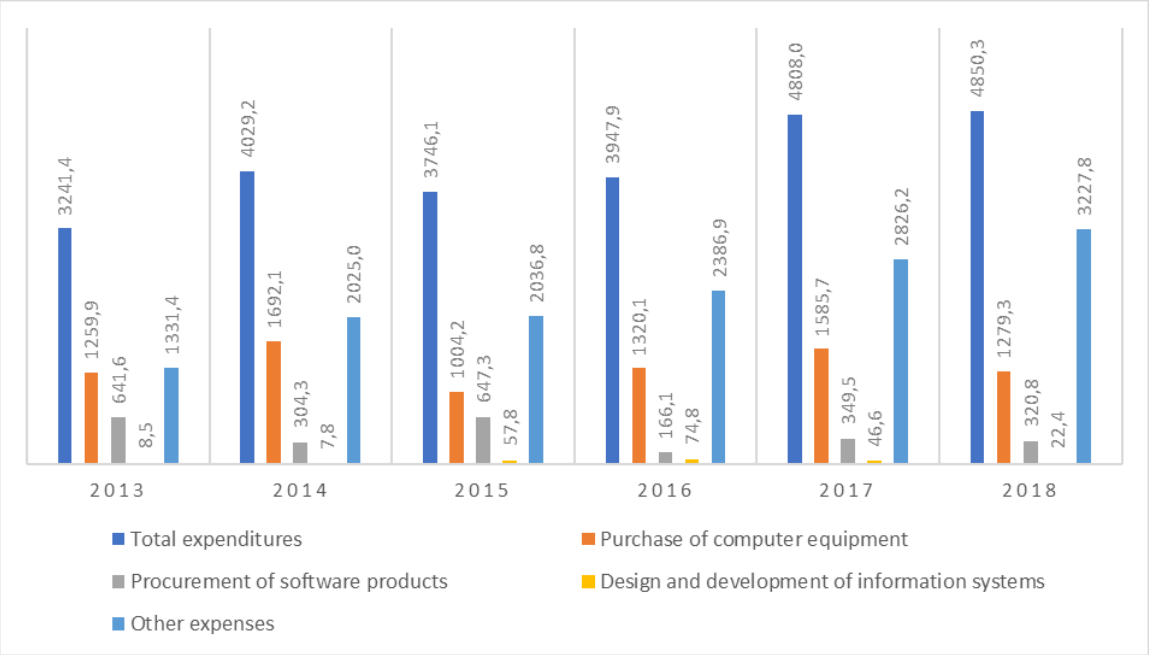


Source: developed by the author based on National Bureau of Statistics (NBS) data

The detailed analysis of IT expenditures shows a considerable increase in the last decade: from 980,5 mil. MDL lei in 2009 to 1784,1 mil. MDL in 2018 (by 54.96 percentage points). At the same time, the dynamics of IT expenditures share in agriculture grew from 0.13% in 2009 to 0.27% in 2018.

According to National Bureau of Statistics data, in the period 2013-2018, the expenditures of agricultural holdings for software products, designs and information systems creation are non-essential from 0,6 mil. MDL and 0,01mil. MDL in 2013 to 1,3 mil. MDL and 0,02 mil. MDL respective in the year 2018 (see figure 2).

Figure 2. Expenditures of agricultural holdings for information technologies by categories of expenditure, in period 2013-2018 (in thousands MDL)

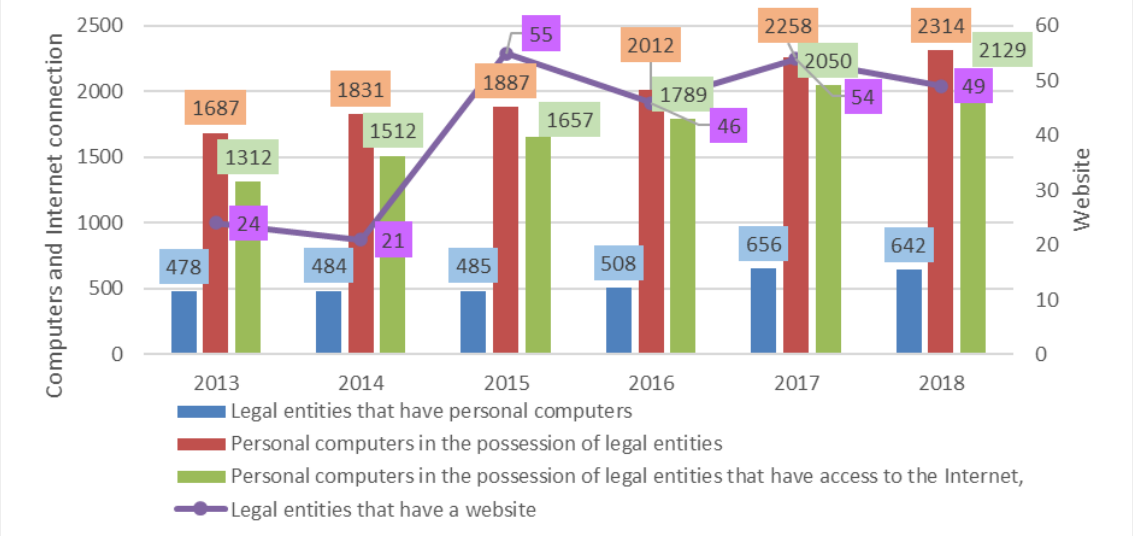


Source: developed by the author based on NBS data

The highest expenses were directed for mobile telephony and Internet services, included in the category of other expenses, 1,3 mil. MDL in 2013 and 3,2 mil MDL in 2018.

The degree of endowment of agricultural holdings with computers, Internet access and website is shown in Figure 3.

Figure 3. Providing agricultural holdings with computers, Internet access and website



Source: developed by the author based on NBS data

According to statistical data, the number of agricultural holdings that have computers and Internet access is increasing in 2018 in comparison with past ages. The number of holdings with computers increased in 2018 by 34% compared to 2013, personal computers number grew up by 37% and those connected to the Internet by 62%, and the number of

agricultural holdings that have a website has doubled. At the same time, the level of endowment of the sector with IT products is very modest the total number of agricultural holdings (only 1.16% of agricultural holdings have a website to promote the activity and market products).

Another aspect examined as a factor in determining the digitalization potential of agriculture is digital literacy and skills that affect the use of digital innovations. The level of education and income are determinants of how the Internet is used. Studies show that people with a higher level of education tend to use more advanced services, such as e-commerce and online financial and government services. Users with lower education tend to use the Internet, mainly for communication and entertainment.

According to FAO findings, in rural areas, where education and literacy rates are generally lower, and mobile phones tend to be used mainly for communication and socialization. The level of IT literacy is a challenge for the introduction of digital farming applications that require more advanced digital skills (Trendov et al., 2019).

In the last decade, the Republic of Moldova, like many EU countries, is facing a growing shortage of IT skills. The low level of digital literacy is felt, especially in rural areas of the country. The benefits of the information society are not sufficiently exploited, and most agricultural producers are excluded from society and the ICT-based economy. They do not have the opportunity to capitalize on opportunities to participate in the global digital economy.

The education system ensures digital literacy of the population by adjusting the curriculum to the needs of the knowledge-based economy, teachers trained in the application of ICT, digital educational content, including "lifelong learning" in the field of ICT.

According to the findings presented in the National Strategy "Digital Moldova 2020", graduates of educational institutions of all levels do not possess sufficient practical skills to work in an information society. At the same time, uncompetitive salaries determine the lack of competent teachers in teaching ICT, lack of a system of motivation and professional growth, the exodus of specialists in the field to international companies (National Strategy, 2013).

The low overall ownership of smartphones in rural areas, combined with the high cost of the internet, also presents challenges in using mobile farming applications and limits the scope of social networks such as Facebook to facilitate agriculture and information flows between farmers. The availability of information could help farmers make better decisions in agriculture, which could help increase yields, reduce environmental impact and improve livelihoods.

The diversity of available technologies and the lack of standardization and compatibility between them, the adaptability of technologies is limited, and it is often not possible to integrate equipment of different brands. Hence, farmers have to decide in which brand to invest. There are no independent advisory services to support farmers in making these decisions.

The need to digitize agriculture creates demand for digital skills and people competent in the use of digital devices, understanding the results and developing programs and applications. It requires not only basic IT literacy, but also data management and communication skills.

In addition to technology investments, there is, therefore, a growing need for investment in the development of multidisciplinary digital skills and knowledge -this is true in both developed and developing countries. Another critical aspect for the digitalization of agriculture is the automation of operational processes. Automation in the field of industry has revolutionized the manufacture of semi-finished and finished products. Although better

known in industrial environments, automation solutions are also gaining popularity in other sectors, such as agriculture.

For example, "M2M" solutions offered by mobile and Internet companies allow remote monitoring of production machinery and equipment by alerting the contractor in the event of their malfunction. The automated transfer of data for the collection of useful information and critical information is a digital product designed to streamline operational management, which allow real-time adaptation to market demands.

Existing ICT solutions in the agricultural sector allow farmers to monitor production processes remotely; monitoring products in production for more efficient planning; remote diagnostics, which allows real-time technical support to production equipment; protection of personnel in the technological process; raw material supply alert system; optimization of the delivery and distribution process; development of additional services based on manufactured products. Implementing "M2M" type solutions in the field of agriculture, the manufacturer can benefit from applications for various processes in agriculture such as: collect data on the condition of agricultural equipment; monitor and locate equipment, animals, transport units; benefit from weather forecast alert tools; develop tools for crop protection based on warning signals.

5. Conclusion and recommendations

In the agricultural sector, the digital transformation will change the structure of the labor market and the nature of labor. It will redefine the role of farmers and agricultural entrepreneurs and change the skills needed in this sector. It can also change the way and where people work and can affect female and male workers differently, due to differences in digital skills and the use of technology. Rural areas, in particular, lag in the process of acquiring digital skills. There is a need to develop a digital skills training model geared towards farmers so that they can learn to assess and implement best practices and technologies for their agricultural business.

The agricultural sector is currently facing significant challenges. The digital ecosystem requires not only the introduction of information and communication technologies (ICT) in all areas of activity, the electronic management of documents and mutual settlements, the digital interaction of all subsystems and production processes, but also:

- development of digital information and communication structures;
- elaboration of new forms of electronic interaction;
- information resources;
- knowledgebase;
- expanding the number of platforms for business, government and social integration;
- digital environment;
- staff able to work in cyberspace.

As a consequence, each participant in the network interaction will be able to act simultaneously as a client and as a server, thus forming the architecture of the digital ecosystem. The ecosystem architecture will ensure the digitization of all physical assets, debts and transactions and their integration into digital ecosystems. The primary function of the ecosystem is to provide and use digital services; electronic processing of all types of information; supporting informational interaction; the use of business intelligence based on the use of artificial intelligence; support for various needs; control of technological processes; strengthening cross-sectoral interaction and involvement.

Digital agrarian ecosystems can be created within complex agro-industrial groups, both state and interstate.

In conclusion, in order to strengthen the digitalization potential of the agricultural sector in the Republic of Moldova, it is necessary:

1. Improving connectivity and network access in rural areas (Infrastructure and access).
2. Promoting digital content and services in rural areas (among farmers).
3. Strengthen digital skills and literacy to stimulate the use of IT technologies in agriculture and create the necessary innovation climate.
4. Attracting investment and subsidizing the development of digital services in the agricultural sector.

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