CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

STATE-OF-THE ART IN AGRICULTURE DIGITAL MANAGEMENT ROMANIA CASE

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https://doi.org/10.34302/crpjfst/2022.14.1.2

Article history:
Received:
28 September 2021
Accepted:
28 December 2021

Keywords:
Management;
Smart Agriculture;
High Tech, Sustainable;
Development;
Saas.

ABSTRACT

Agriculture, animal and plants management are nowadays subject of profound transformations aimed at sustainable development.

The article show up performance of digital agricultural management by implementing appropriate software and hardware elements in areas subject to desertification and beyond. Digitalization and Tele_ transmission both on s&m farms and on large plantations used to forecast and eliminate disasters caused by pests, dryness and nutrient compatibility are already implemented but are still topics of discussions and reluctant on the part of Romanian farmers.

A survey was launched throughout Romania and it was disseminated by National Rural Development Network (NRDN) to find out the weaknesses and threats but also the opportunities and strengths that would determine the implementation of digital methods and infrastructure in Romanian agricultural management, in order to keep pace with the imposed one by the economic, demographic and climatological conditions.

1. Introduction

Agriculture and allied businesses are critical to the economy's long-term development and prosperity. The key difficulties for agricultural production are decision making, crop selection, and supporting systems for enhanced crop output. (Pallathadka, et al., 2021)

But, agricultural habits are changing today and knowledge have to be updated as quick as smart technologies forces the entrance in all fields of activity and even change our life itself. But knowledge that does not change behaviors is useless.

At a time when digitalization, as well as globalization, population ageing and climate changes are elements shaping humankind future, an unseen competition is undergoing between human and machine, between Human Intelligence and Artificial Intelligence. It is, in fact, a kind of race between the verb "have", with all its meanings and the verb "exist".

For the purpose of this study, I look at the extent to which modernization means tackling climate change, desertification and even avoiding a widespread agricultural crisis.

What I find is that Smart Technologies aligning with dedicated software allow a technological revolution on Agriculture (Figure 1). Jobs are reinvented, even at a much faster rate than the ability to train and create new other specializations. In this frame the future jobs in the agriculture, but not only, are and will be reshape, so that humans have to be mates with Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), Drones, machines which are and will be programmed for this. (Channe, et al., 2015).

This reality push agricultural management activities to require nowadays major transforming and to implement "Processes

Remote Control (PRC) and broadly to use Big Data, as well as GPS, ZigBee technology, GPRS network and Internet to monitor and management the fresh agricultural products and the logistics process." (J. Li et al., 2010)

In the same trend the use of "Wireless Sensor Network (WSN) with IP network in Precission Agriculture (PA) would be an added advantage to existing solutions of PA system." (Z. Suryady, et al., 2011)

Another face of digitalization in agriculture is the introduction of radio-frequency identification (RFID) tags in supply chains which "engenders the need for incorporating and utilizing the additional generated data. It is generally assumed that these data, once generated, are complete and rife with necessary information for making decisions." (Yu-Ju, et al., 2011).

Machine Learning, is another stunning digital tool: as long as it accumulates data and experience, it "identifies the challenges in agriculture". ML is in fact a smart software implemented on matched devices, and it is the one that monitors and alerts regarding the necessity or opportunity of the operations such as treating the plantations or harvesting.

The implementation of smart software solutions in agriculture and suitable hardware also, helps increasing the yield of the farm by "making the best use of the resources that the farmers have at hand" and by rising the "level of quality and health of the crops".(Chandhini, et al., 2016).

Thus, technical performance that mankind has gotten, allows the dedicated software and hardware to ensure the management of agricultural operations for multiple plots and lands.

This article done an overview of the most significant and the newest tracks regarding Digitalization and Trends & Technologies used in Agriculture, thus being helpful for informing and rising awareness as much as many stakeholders possible. The main goal of the study actually, is to reveal the attitude of the Romanian farm managers regarding smart technologies implementation and what are their fears and expectations.

2. Materials and methods

The main, up-to-date and relevant scientific literature, reports, notes and statistics was studied in order to be known the state-of-art, as well the latest modern techniques, devices and tools used nowdays in agriculture An analysis was made, in order to highlight the strengths and weaknesses, as well as the opportunities and threats regarding smart technology and its implementation in Romanian agriculture. In this sense, a survey was launched and, thanks to the National Network for Rural Development (NRDN), it was disseminated throughout Romania.

Approaching the problem in a descriptive and easy to understand way, the results of the analysis and the conclusion should substantiate the future economic and agricultural strategies for maintaining the step in Romanian agriculture with the most efficient, effective and green solutions and technologies.

Figure 1. Digital farm management
Source photo: https://industrywired.com/new-age-of-agriculture-state-of-digital-farming-in-2020/

3.Results and discussions

- What is now the state-of art and what is to come?
- What are Strengths and Opportunities of Full Automation of the Farm & Plantation?
- What does Precision Agriculture Applications mean and what departments benefit from digitalized farm?

These are the questions.

In answer to them, is very representative and synthetically showed by Chandhini. K* et al. ,in the International Journal of Innovative Technology and Research, throughout the ”Flow Chart Agricultural Production System” (Figure 2) how the floor farms, are empowered both with Clouds solutions, drone and satellites transmission and Smart ERP platforms& GIS solutions.

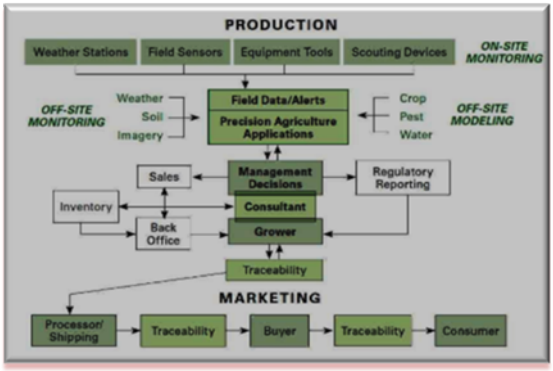


Figure 2. Flow Chart Agricultural Production System

Source; Chandhini. K., et al., (2016).

Thus, the functions generated by digital tools kit for ensuring the implementation of precision agriculture with very great accuracy are:

- monitoring crops
- ensuring financial management
- planning, executing and monitoring of agricultural works
- allocating the necessary resources, forecasting treatments for being applied just-in-time
- real-time alerts, inspections and observations
- devices management
- supply, stocks, sales evidence
- reports for farms, plots, works and activities. (Figure 3)

Agri Digital Management is accomplished based on global scenarios and a system based on AI (https://emerj.com/ai-sector-overviews/ai-agriculture-present-applications-impact/) and Machine Learning. According with description made by software developers, the software for improved agriculture performance incorporated a GIS mapping and geolocation engine so that performance is achieved as the mapped plots and lands are managed by the machine ”according to its own type of plantation soil, treatments and operations that the respective culture requires”.

It is noteworthy that Machine Learning (ML), is able to learn as it accumulates data and experience. Machine learning (ML) is fast becoming a powerful tool for increasing agricultural production, for instance, ML predicts weather and yield through satellite images. (Fan, et al., 2020)

The machine is able to send alerts identifying the optimal time for harvesting, spraying or treating plantations. All needed information are collected from the sensors of IoT devices installed in weather stations, on the land, in ”electrical tanks”, to correlate and monitor activities and operations, for launching alerts in real time and indicating treatments and operations that the respective culture requires”.

System based on AI and ML allow the identification of plant diseases and application of solutions just-in-time.

Due to conception, AI and ML has the ability to connect to multiple weather stations for providing real-time weather information.

All above mentioned features are affordable, being available even for mobile devices for farmers around the world and very pervasiveness. (https://emerj.com/ai-sector-overviews/ai-agriculture-present-applications-impact/)

Figure 3. High Tech Agriculture Management

All functions and capabilities mentioned above are STRENGTHS related with digital tools kit, ensuring the implementation of precision agriculture with very great accuracy.

Predictive Analytics for Process Automation and Mechanization (PAM), for innovative approach towards Automation &Technological Development (ATD), for New Business Models (NBM) indicates the rise of global agricultural production with 69% between 2010 and 2050. Technological innovation in farming is coming to support world's population increase at 9.7 billion by 2050.
(http://publications.tno.nl/publication/34636797/vmt66M/TNO-2020-R11009.pdf).

Drone Fly, a leading DJI Enterprise, FLIR infrared UAV, estimates that drones can spray fertilizer 40 to 60 times faster than doing so by hand.
Business Insider Intelligence projects there to be around 12 M agricultural sensors installed globally by 2023 (https://www.dronefly.com/).

Already tractors has begun connecting to the Internet and was created a method to display data about farmers' crop yields, even on phones and an undergoing project is about self-driving tractors.

Meanwhile, when smart machines will be spread the field, agricultural farm managers would be free up to perform other tasks with more efficiency.

Statistics demonstrated that the management provided by the AI and ML has made it feasible to produce more plants than ever before, according with vHT-agri system develop by Maharashtra State Agricultural with ”the same or a lower input of raw materials” (Satoshi N., et al., 2018).
As AI, ML, IoT are integrated into conventional agriculture, income from the agri sectors will go up.

The outcome of using digital technology is that the input ratio fall accordingly. The composition ratio of conventional input materials such as fertilizer and agricultural chemicals decrease. This is OPPORTUNITY agreeing with the green deal policies.

High Tech Agri Management based on Artificial Intelligence and Machine Learning allows easily planning, monitoring and carrying on analyses regarding all the activities of the farm.

Belated plant protection affects 20-40% of the global yield every year. Artificial Intelligence and Machine Learning for High Tech Management being equipped with alarm algorithms for detecting harmful insects and diseases can prevent for the risk of harmful insects or diseases.
Land cultivation, planting, crop protection, fertilization, irrigation, harvesting and all other activities are managed through a friendly interface. The HT interface allow to ”track the quantities used at the entrance, the costs and the working hours for each activity”(Agrivi booklet).

3.1. Romania agriculture and high technology- case study

At the beginning of 2021, a questionnaire was launched on the Romanian market, disseminated through the National Rural Development Network, for this article purpose with the aim of identifying the conditionalities and interest regarding digital technologies in farm management, by Development Regions.

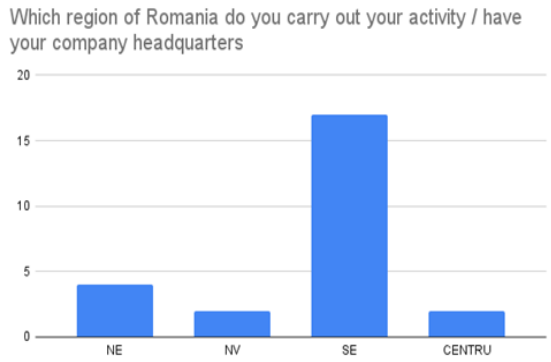


Figure 4. Q1_applied questionnaires: Which region of Romania do you carry out your activity / have your company headquarters.

The number of respondents was relatively small, this aspect being a subject for another analysis.

Those who were interested in answering the questions were mostly from the SE region: (Tabel 1)

Table 1 Distribution of answers by Romanian regions

REGION	NW	CENTRER	SE	SW OLTENIA	SUD-MUNTENIA	NE
Respon-dents %	3.8 %	7,7 %	76.9 %	7.7 %	0%	3,8 %

The next two questions sought to identify the legal form of organization in order to have an image on the degree of coagulation of the Romanian agricultural properties. It is already proven that small properties can only ensure a subsistence production, the return obtained being insufficient for digital management implementation and smart devices controlled activities.

Because 64% of owners land are not organized as societies, reveal a weak force representing the interests of farmers which are spread in small entities without juridical personality (Figure 6).

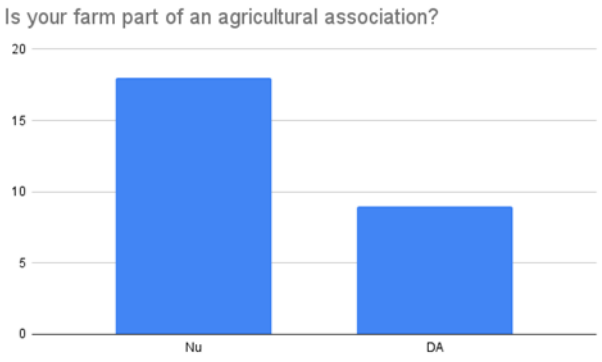


Figure 5. Q2_applied questionnaire: Is your farm part of an agricultural association?

In a majority of (28%) of the total respondents, farmers are owners of SMEs, as a legal form organization and (4%) are Agriculture societies and 4% are Research centers.(Figure 6)

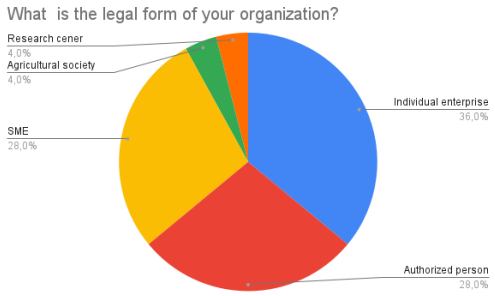
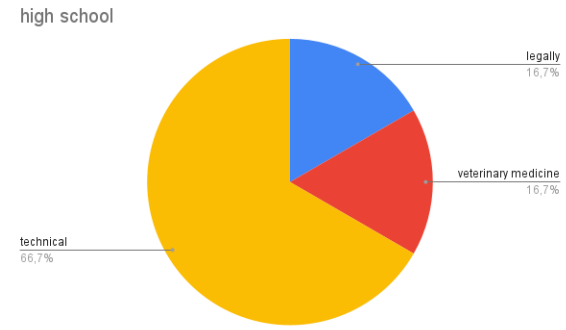


Figure 6. Q3_applied questionnaire: What is the legal form of organization ?

I also wanted to know the degree of training and the initial field of education of the interviewed farm managers. The dominance of the share of managers with a technical profile, as managers of farms and plantations (67,7% HS, 33,3% Univ Degree, 37,8% MD,) it is explained, in my opinion, by the industrial sector dereliction after 1989. So that, engineers, almost regardless of their specialization, invested time, training, finances in inherited or leased land. (Figure 7)



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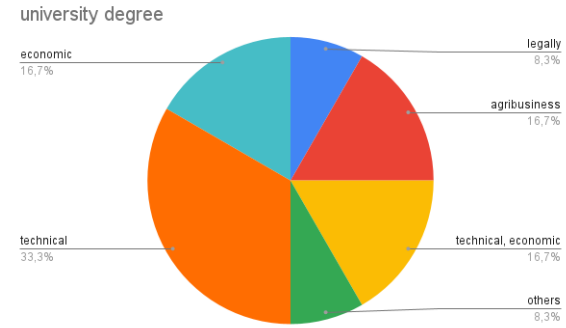

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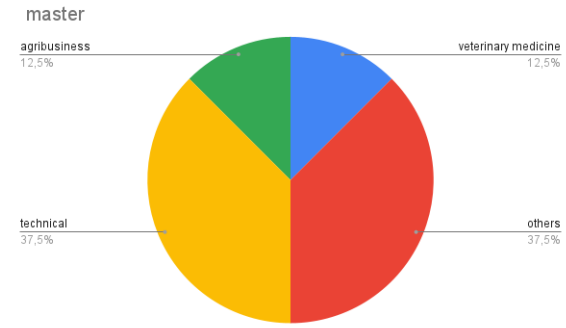

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Figure 7.(A,B,C) Q4_applied questionnaire: What is the qualification level of the company manager?

As reveals the chart bellow, 66,7% of legal entities, with economic activity in agriculture are micro-enterprises, with up to 9 workers, being not known the value of other resources like financial, material and the surface of the land. These are followed by societies (25,9%) with 10-50 employees (Figure 8)

The most significant problems the managers confront with, appear in the graph represented in Figure 9: (19,2%) are too old workers, (23.1%) have no proper skills and almost (50%) have a kind of seasonal activity and are not very involved in the workplace.

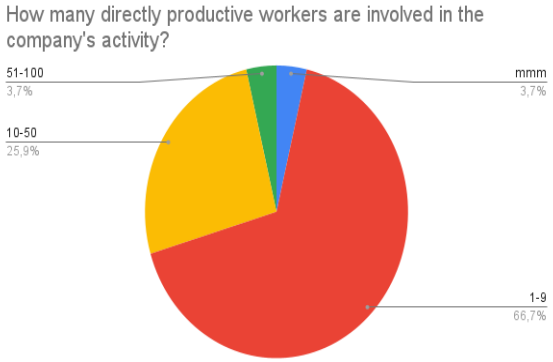


Figure 8. Q6_applied questionnaire: How many directly productive workers are involved in the company's activity

The state of the art regarding the lack of efficiency and / or the rarity of a motivated and well-trained workforce should be a trigger for farm manager, to move on for implementing new technologies in agriculture.

Unfortunately, this aspect will have the consequence of removing workers from some jobs, this implying their retraining and mastering the skills regarding new technologies, where it is possible and for whom it is possible. Not all current agricultural workers can acquire the skills and knowledge thus to become a mate with digital machines.

Additionally, surveyed managers think more than half of the number of workers create troubles, cause damage, even theft and are difficult to retain. Maybe, all before, because small wages and earnings?

Last but not least are poorly trained. (Figure 9)

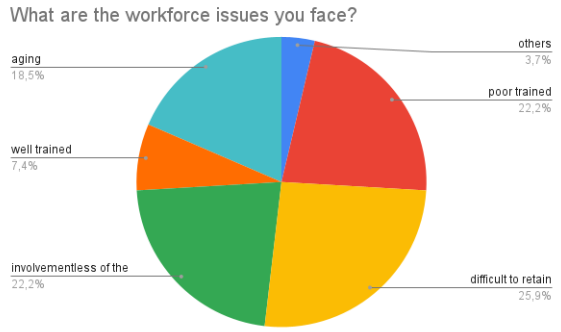


Figure 9. Q7_applied questionnaire: What are the workforce issues you face?

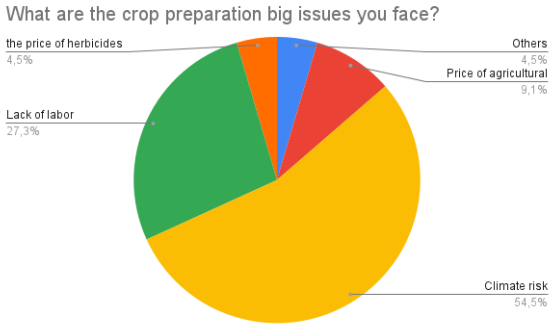


Figure 10. Q8_applied questionnaire: What are the crop preparation big issues you face?

Not only the labor force raises concerns for Romanian agricultural farms managers.

It seems that the major fear, (54.5%), is the climate risk followed by lack of labor and skilled workers (27.3%), the price of agri works 9.1% and the price of seeds and herbicides, (4 %) (Figure 10).

So what should be done, now in the 21st century, when precision agriculture is already an answer? Let's see further what are the weaknesses and threats but also the opportunities and strengths of Romanian farmers.

According to the analyzed answers, histograms reveals (Figure 11) there are many managers (Green bar) who know and have documented themselves about new technologies (IoT, Clouds, SaaS, Drone). But only few managers implement digital technology and do precision agriculture in Romania (Mauve bar).

There are only very few who are not interested regarding this issue (Blue bar). Could it be a cause for concern? Probably yes, considering that there is a predictable and predicted food crisis added to a global competition and Romanian agriculture would not stay aside.

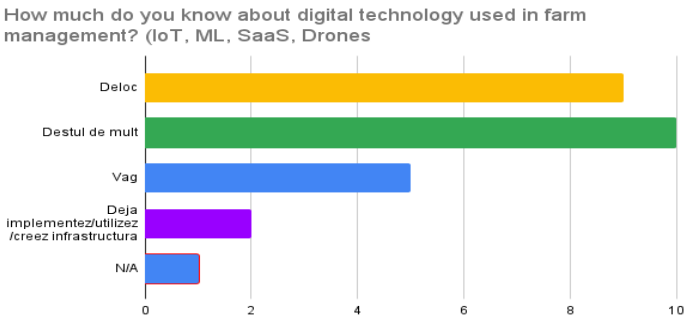


Figure 11. Q9_applied questionnaire: How much do you know about digital technology used in farm management?

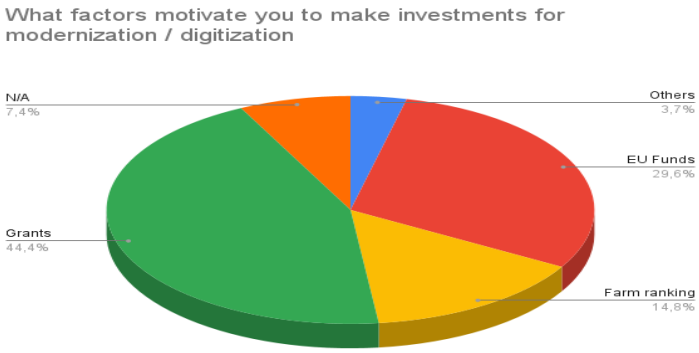


Figure 12. Q10_applied questionnaire: What factors motivate you to make investments for modernization / digitization

Going forward (Figure 12) hope seems to be reborn. All managers are much and very much interested in implementing digital agriculture, being highly motivated by competition for Grants (44,4%), EU funds (29,6%) and by the aim of bringing the own farm to a leading competitive position (14,8%). Asking for possible causes as major weakness on moving to digital agriculture (Figure 13 A,B), most managers (40,7%) responded as being "less true" the lack of access to documentation. Regarding the "fear of theft of the digital infrastructure" (55.5%) responded as being "very true" and "true". Fear of failure followed by the impossibility of reimbursement of the loan was another significant weakness regarding the digital agriculture.

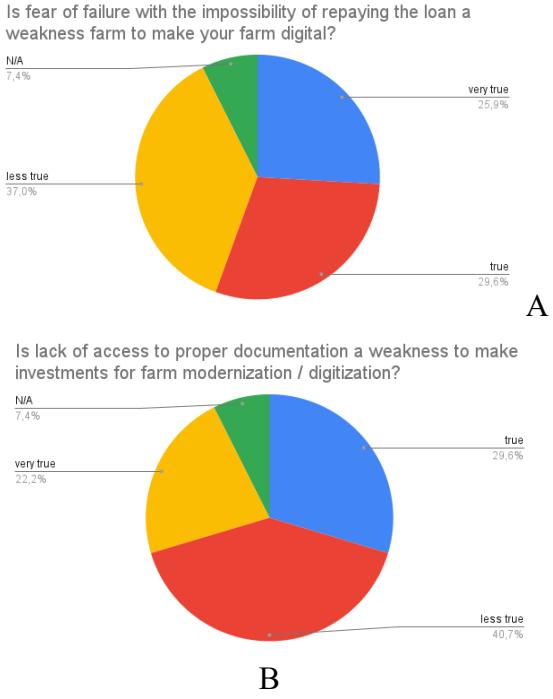
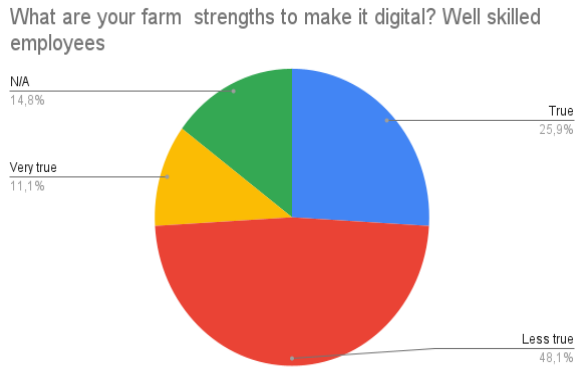


Figure 13.(A,B) Q11_applied questionnaire: What are the farm weakness to make investments for modernization / digitization?

The strengths of the company identified by the interviewed managers were ranked as follows: with a majority share was the option

The analyzed issues exposed by survey (Figure 14 A,B,C) were as follows:

- The company has well-skilled employees, 48,1%"less true" ;
- the company provides motivating salaries to employees, so that they get involved with enthusiasm.
- The company has partnerships / financial resources that allow it to invest in a digital infrastructure : 66,7%"less true";
- The company has budgeted / is willing to budget expenditures for the implementation of precision agriculture: 66,7%"less true".



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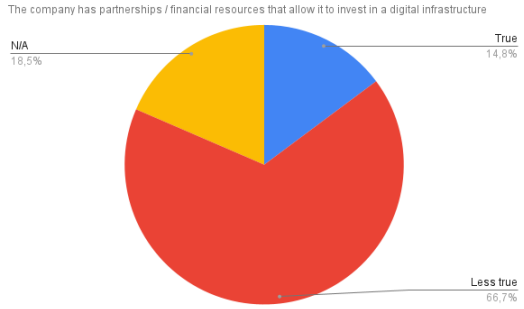

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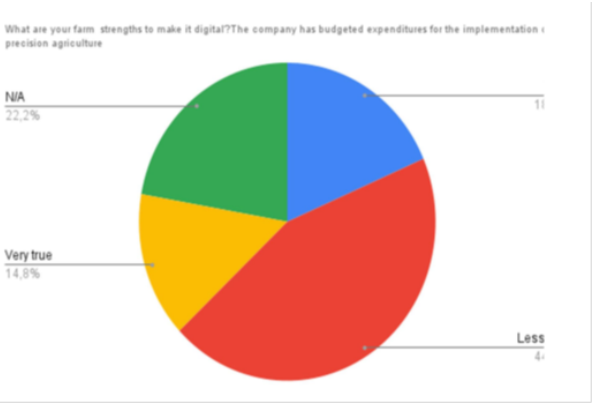

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Figure 14 (A,B,C). Q12_applied questionnaire: What are your farm strengths to make it digital?

Regarding threats, the respondents consider the biggest one the prices charged for digital technology implementation, services and very high rents for SaaS.

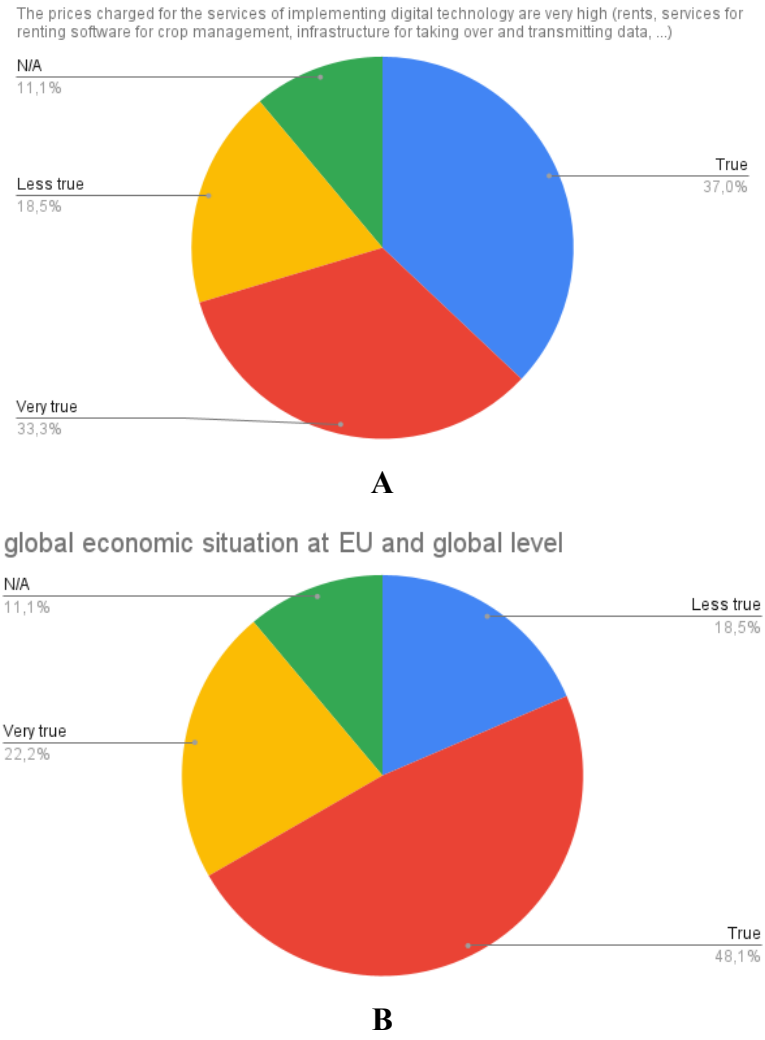

Figure 15. (A,B). Q13_applied questionnaire: What are your farm threats to make investments for modernization / digitization?

for crop management, infrastructure for taking over and transmitting data: ”true” and ”very true” represents (70,1%), (Figure 15A).

The general economic situation involving the impossibility of recovering expenses on a volatile global market, populated by customers having low purchasing power was ranking as follows: ”true” and ”very true” represents 70,3% (Figure 15B).

Asked about the company's opportunities in terms of digitalization, managers consider the interest of importers for Romanian agricultural products, given for export is (48.1%) "true" (Figure 16 A) and European policies on this matter are (44.4%)"very true" (Figure 16 B).

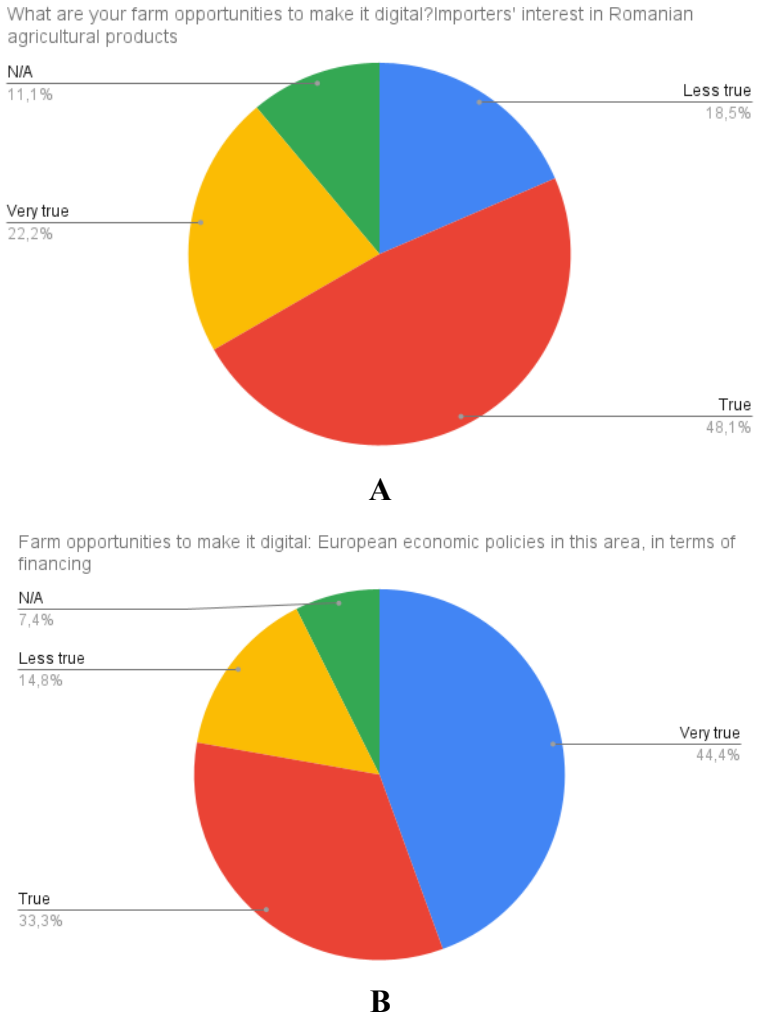

Figure 16. (A,B) Q14_applied questionnaire: What are your farm opportunities to make investments for modernization /digitization?

Was noticed an interest of managers for implementing digital technology. They estimated investments to be realized as follows:

Regarding infrastructure and sensors for collecting data on temperature, humidity and NPK, (33,3%) consider time for implementation over 1 year **(**Figure 17A).

Regarding drone (s) (33,3%) answered that time for implementation is 1-3 years and (22,2%) consider 3-5 % **(**Figure 17B).

Regarding dedicated software, SaaS and pest monitoring systems, 29,6% estimated 1-3 years and others 22,2% consider over 10 years will be necessary for implementation **(**Figure 17C).

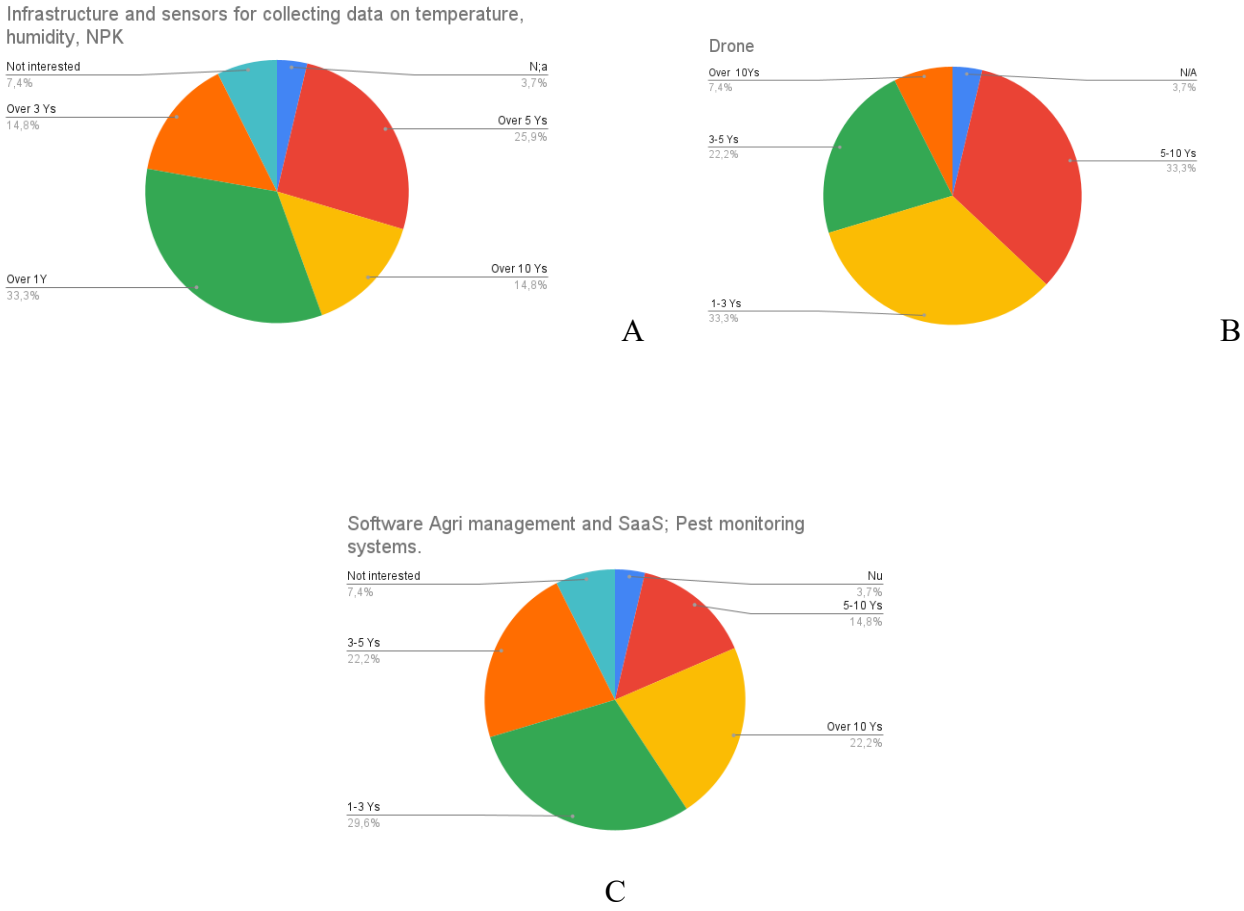

Figure 17.(A,B,C) Q15_applied questionnaire: What are the digital equipment your farm will be equipped with?

4.Conclusions

The agricultural progress has been a crucial factor in worldwide social and economic change. (Salunke, et al., 2015)

Romanian farmers are open and aware regarding the added value of farm management through the implementation of digital technologies. However, the high costs of the digital infrastructure, as well as the lack of financing resources, maybe also the blockages created in the economic policies by the current sanitary problem, all of these make the Romanian farms to be under digitized. The result of the analysis should not take us by surprise, because most of the answers came from small and very small companies, which still cannot afford to implement digitalization in farm management in order to be efficient, in a competitive way, and to keep pace with the great transformations in agriculture.

On the other hand, the large farms are already applied top technologies.

A well-known example is Agricost Insula Mare a Brailei, the largest farm in Romania, but also a very important one in Europe, which has 80 tractors with Trimble automatic guidance. Crop development monitoring is done at the Agricost with up to 29 weather stations which are and will be integrated in the coming time to monitor air temperature and humidity, precipitation, wind speed, humidity and soil temperature, to receive alerts on the possible occurrence of diseases in agricultural crops.

This means that while some farmers will be able to expand their operations, others will be severely challenged in their efforts to compete

in the sector and meet the stringent food quality and safety standards required by processors and retailers.
(https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf, pp 4), accede on 05112021.

Crop management on difficult meteorological conditions as well as just-in-time treatments against diseases and pests, and transmissions with drones of field information, and AI faster added decisions for reducing and simplifying field work, applying the appropriate treatments only when necessary and in the required quantities, obtaining rich crops and healthy agricultural products throughout agricultural chain, are aspects with robust interest for farmers.

Application of digitalization for agriculture still remains "a formidable task, since integration of diverse domains for online monitoring of agricultural supply chain and management of complex agro ecosystems require concerted and collaborative efforts in a structured manner." (Patil, et al., 2012).

All above have to be envisage by the Romanian forward thinking educational and agricultural policies makers, for creating robust support for sustainable Romanian agricultural.

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