CZU: 004:[378.6:63](478-17)

INTEGRATION OF DIGITAL TECHNOLOGIES INTO AGRICULTURAL EDUCATION IN THE NORTHERN DEVELOPMENT REGION OF THE REPUBLIC OF MOLDOVA

Ion BODRUG
ACETI & DIH of Moldova, Balti

Dorin CEBANU ORCID: 0000-0003-0760-394X
National Center of Research and Seeds Production & ACETI, Balti e-mail: mr.cebanu@gmail.com

Sergiu PASCARI ORCID:
ACETI & DIH of Moldova, Balti e-mail: pascariserghei@gmail.com

Mircea PETIC ORCID: 0000-0001-6044-7646
ACETI & DIH of Moldova, Balti e-mail: petic.mircea@aceti.md

Abstract. The article presents the purpose, description of activities, and key achievements of the project "Edu-Tech-Agro-Nord: Agricultural Technological Education for the North," implemented by ACETI in collaboration with the members of the DIH of Moldova. The project aims to integrate digital technologies into agricultural education in the Northern Development Region of the Republic of Moldova. The focus is on familiarizing students with innovative technologies used in agriculture to strengthen their interest in the agricultural field and to develop this sector by preparing young specialists at the level demanded by the market. Another relevant objective is to facilitate relationships between vocational and technical institutions and research institutions in the agricultural field by engaging young people in corresponding activities, with the support of companies providing innovative digital services within the DIH of Moldova.
Keywords: agricultural education, digital technologies, digital transformation, innovative agriculture.

1. Introduction

The agriculture of the Republic of Moldova faces a series of challenges caused by climate change, the increase in the prices of industrial inputs, the degradation of natural resources, the lack of labour, etc. The continuous increase in the prices of non-renewable energy resources used in agriculture and their derivatives, such as mineral fertilizers, pesticides, fuels, etc., imposes the urgent need to rationalize their use. Often the administration of inputs, either in the form of mineral fertilizers or in the form of pesticides, is carried out incorrectly due to the lack of a clear picture regarding some parameters of the agro ecosystem, either with reference to soil fertility or the phytosanitary status of the field. The lack of information implies colossal, unjustified expenses, which are accompanied by harmful effects on the environment and people's health, simultaneously aggravating the problems related to global warming [1].

In order to obtain the necessary information about the state of the fields through the direct method, a multitude of laboratory analyses are needed, for the obtaining of which time, financial resources and labour are consumed. Despite the fact that these results are characterized by high precision, for the characterization of a single field it is necessary to take a very large number of samples due to its heterogeneity. This becomes extremely difficult or even impossible at the state level or even within a single household. That is why a solution would be the involvement and motivation of young people to participate in digital transformation activities of value-added agriculture, the wine sector and tourism, through partnerships between technical vocational education institutions, research institutes and private

companies, but also through the integration these young people in transformational digital activities in the target sectors. Therefore, the goal of the project is to develop the agricultural field both by training high-level specialists and by identifying innovative digital technologies for the formation of this valuable field, mainly in the Northern Development Region of the Republic of Moldova.

Accordingly, the present work is structured as follows: we will start with the project concept and the proposed activities, followed by the description of the project realization and the achieved impact. We will conclude the paper with conclusions and plans for the future.

2. Project concept

Taking into account the actuality of agricultural innovation we came up with a project proposal that was supported to be implemented.

Thus, an effective alternative is proposed by replacing complex classical methods with the use of digital technologies in agriculture. Software solutions such as ERPs and digital video surveillance systems are useful in helping agricultural companies manage resources and optimize operations. In addition, modern technical equipment, including tools and technologies for soil moisture measurement and irrigation management, along with automatic irrigation systems, contribute to the efficiency of agricultural practices. Also, the multispectral drone can address multiple economic, ecological and social challenges by providing comprehensive services, such as streamlining pre-sowing herbicide treatments, spraying crops during the growing season to control weeds, diseases and pests, differential application of foliar fertilizers and desiccants. Their advantage lies in the processing of an enormous set of samples, in a very short time, with minimal expenses and without damaging the plot.

In this sense, the platform built by the Digital Innovation Hub of Moldova is useful, which includes digital providers of innovative services, but also educational institutions in particular with a technical professional profile in agriculture that cannot afford to purchase such digital tools. At the same time, the use of current technologies has an important effect not only on the real results in concrete agricultural situations, but also on the motivation of the students of technical vocational education institutions in the Northern Region of the Republic of Moldova (which are part of the DIH of Moldova) for the activity in the agricultural field through the use of technologies current.

Within the project, we facilitate both the relationship between professional technical institutions and the agricultural research environment by attracting young people to the appropriate activities, but also with the business environment, together with innovative digital service providers that will create a sustainable and competitive ecosystem. Accordingly, we consider it important to attract providers of innovative digital services with existing concrete examples of software solutions to help agricultural companies, technical tools for modern agriculture, but also the multispectral drone. Thus, for a competitive agriculture it is necessary not only the availability of such technologies, but also the training of appropriate skills. For technical professional education institutions in Bălți, Râșcani, Soroca, Grinăuți, Ungheni and Țaul, it is important to collaborate with various institutions and organizations that can offer innovative technological news and training to motivate students and disseminate the experience of young people passionate about agriculture and the possibilities of using technologies digital in this field. Starting from the intention to have a more systemic character, we planned the initiation of the creation of AgTech clubs, with the participation of about 10 students from each vocational technical education institution, but also with an interest in innovative technologies in the field of agriculture from each institution targeted.

In this sense, the activities to strengthen the ecosystem of digital transformation in agriculture among local actors (IT and agricultural companies, educational and agricultural research institutions but also associative entities) will contribute to motivating the young generation to get involved in studying and exploiting the possibilities digital in agriculture to catalyse the evolution of results.

3. Activities

Taking into account the above, ACETI aimed to contribute to the development of the high-value agricultural sector, both by increasing the number of high-level specialists in the field, and by promoting the use of innovative digital technologies, carrying out the following activities:

- **Regional forums** to bring together student members of AGTech clubs, teachers, AgTech companies, media representatives, ACETI members, local and international partners, representatives of academia and the private sector, thus creating a platform for the exchange of ideas, the promotion of innovations in agriculture and the strengthening strategic partnerships.
- **Acquisition of multispectral drones for training** and obtaining necessary authorizations for use in research, agricultural missions and educational processes, as training in research and educational institutions.
- **Seminars, study visits, master classes** with the participation of practicing specialists in the field of innovative agricultural digital technologies who have managed to implement several digital innovation projects in agriculture. These activities facilitate dialogue between students and professionals in the field to better understand how digital technologies are used in agriculture and to solicit ideas for future innovations.
- **The practical demonstration of the multispectral drone** on the research plots of the NCRSP Selectia sector, on the fields of the agricultural colleges, of the producers of fruits, vegetables, berries, medicinal plants and cereal crops, including those grown in the ecological system, produced in the Northern Region of the Republic of Moldova.
- **The development of a guide on the operation of the drone,** which would describe all the specific moments essential for piloting them.

Thus, the implementation of these activities involves capitalizing on the collaboration network that was formed by the ACETI partner group and their partners to contribute to the digital transformation in agriculture.

4. Achievements and impact

So far, several activities have been carried out within this project. We note the forums, master classes and study visits that aroused a keen interest in the process of innovation and digitization of agriculture from all participants, especially from the younger generation, budding specialists in the field of agriculture. These activities laid the foundations of the AgTech clubs from professional and technical institutions in the agricultural field in Ungheni, Țaul, Grinăuți and Soroca, by establishing direct dialogues with digital service providers in the agricultural field, namely with those who operate drones, install sensors, manage platforms digital agriculture, but also modern technological lines.

Based on the project, drones were procured and transmitted for research activities in agricultural missions and educational training processes at three agricultural colleges in the north of the Republic of Moldova and at the National Centre of Research and Seeds Production. Thus, these institutions received drones and other innovative equipment to conduct research and develop the professional skills of students. Thus, the National Centre of Research and Seeds Production Selectia sector, will be able to use in its research activities a high-performance multispectral drone, accompanied by a D-RTK station, which will increase the precision of research.

Three other drones will be used in the educational process by the Centre of Excellence in Horticulture and Agricultural Technologies from Țaul, the Agricultural Technical College from Soroca and the Gheorghe Răducan Agro industrial College from Grinăuți.

Another deliverable of the project was the creation of a guide on drone operation at the level of professional technical institutions. It contains a concise and informative description of the need to use agricultural drones, as well as specifying their advantage over conventional technologies.

In this endeavour, drones can be extremely useful and cost-effective. Accordingly, the guide developed within the project contains information about the types of drones and their applicability in society, an overview of agricultural drones and the possibilities of their use, but also useful information on how to select and register a drone correctly, including legislative aspects, those of the environment, safety and security. Analysing all these activities, it is important to know the opinion of those who deliver technologies to be known by the beneficiaries of the project. That's why, following the activities carried out so far, we questioned the companies that, being benevolent, demonstrated the possible technological innovations in the field to the participants of the activities. Respectively, the representatives of the 6 companies involved highly appreciated the activities carried out. If we refer to what they noticed, the representatives of the companies emphasized the good format of the events, the attitude of the organizers, the quality of the presentations of digital solutions, technologies and techniques for digitized agriculture, but also the interest of new generations towards new technologies in agriculture.In terms of possible improvements they would like to see at future events, many of the speakers noted the desire for such events to have lists of attendees willing to see how a technology or technique works in the field, with a stronger stake on the practical side. Several of the respondents mentioned that they would like to see more agricultural producers at such events. In addition, the vast majority agree to participate in other similar activities. Moreover, we note that the given project has a direct impact on the digital agricultural ecosystem created in the Northern Region. We note the establishment of collaborative relationships between the companies involved with technical vocational education institutions in the realization of direct projects that boost the interest of the young generation in both the agricultural and digital technologies fields.

5. Future activities

In the future, other forums, master classes and study visits will be held that will stimulate the interest of the young generation, of budding specialists in the field of agriculture, for the process of innovation and digitization of agriculture. The use of the multispectral drone within the National Centre of Research and Seeds Production Selectia sector, represents a major step in optimizing the quality of research and accelerating the data collection and analysis process, contributing at the same time to increasing the accuracy and observational details (Fig. 1). This advanced technology allows the monitoring of the state of agricultural crops in different phases of growth and development through the normalized vegetation index NDVI (Normalized Difference Vegetation Index), an essential tool in the assessment of plant health [2].

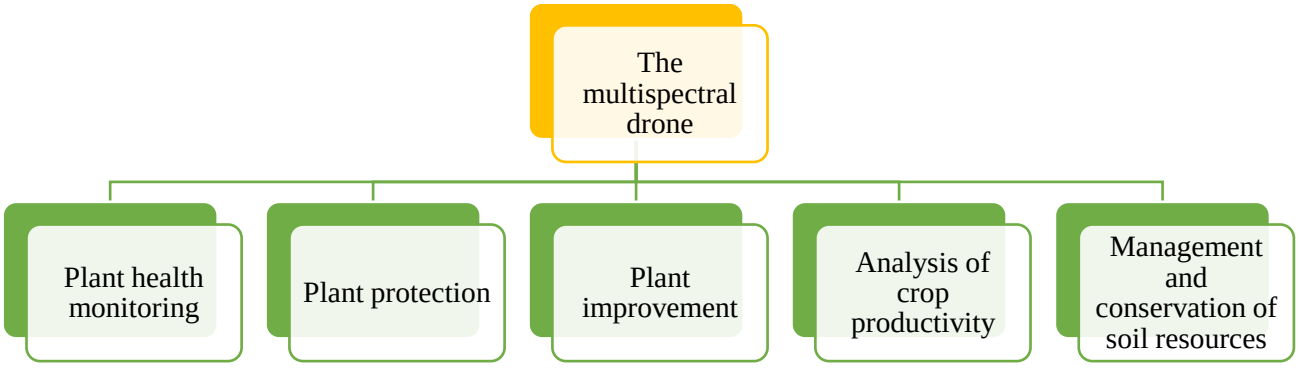


Fig. 1 Multispectral drone usage directions at NCRSP

The information obtained through NDVI will allow us to evaluate the reaction of plants to various technologies and agricultural systems, ensuring their adaptation to the pedoclimatic conditions specific to our area.

These data are essential for adjusting agricultural practices to maximize yields in the context of climate change and seasonal variability. We also plan to develop research directions in integrated plant protection. The multispectral drone will be used for early identification of the degree of weeding, monitoring the dynamics of pest populations and rapid diagnosis of diseases. Through spectral analysis, we will be able to determine the areas affected by biotic stress, which will allow precise and effective interventions in phytosanitary management [3].

Plant breeding is a long-term process, it takes about 8-12 years to create a high-performing wheat variety. The use of multispectral drone would allow the rapid selection of the best plants based on observable phenotypic characteristics such as height, resistance to falling, adaptability to abiotic stress, etc. Thus, promising phenotypes could be identified more efficiently, speeding up the process of selection and genetic improvement [4].

In field trials, the multispectral drone provides a detailed picture of plant evolution, allowing monitoring of key aspects such as leaf development, water stress and water use efficiency. The resulting images can be analysed to assess plant vigour and identify nutrient deficiencies through detailed analysis of the spectrum reflected by leaves and other plant parts. This information is valuable for optimizing fertilizer application and adjusting cultivation methods according to the specific needs of each type of crop [5]. A no less important aspect in agricultural research is the management and conservation of soil resources, which can also be achieved with the help of UAVs. Thus, operations such as land mapping and identification of areas at risk of soil degradation can be easily carried out. The multispectral drone is an innovative and indispensable tool for NCRSP research, bringing more precision and efficiency to crop management and monitoring, as well as to the plant breeding process, thus supporting modern agriculture in a sustainable and adaptive way.

6. Conclusions

All written above confirms that the approach brings a new breath to the way of doing agriculture and learning agricultural science in the northern part of the country. By carrying out this project, we contribute to the development of the agricultural sector, both by training high-level specialists and by identifying innovative digital technologies for the formation of the high-value agricultural field. We like to believe that these young college students, who are now familiar with innovative technologies in agriculture thanks to our project, will be, in the near or a little more distant future, those farmers who will use them actively in their daily activities and , why not, those who will be able to develop even newer, more efficient technologies, which today seem impossible to us, and the researchers who today receive new opportunities to do science, including with our contribution, will put their shoulders to these achievements.

Bibliographical sources:

1. DENT, D., BOINCEAN, B. Regenerative agriculture: What's missing? What do we still Needle to do you know? In Regenerative Agriculture, 2021, pp. 1-12. Springer. Available at: https://doi.org/101007/-978-3-030-72224-1.

2. VÉLEZ, S., MARTÍNEZ-PEÑA, R., CASTRILLO, D. *Beyond Vegetation: A Review Unveiling Additional Insights into Agriculture and Forestry through the Application of Vegetation Indices*. *J*, 6(3), 2023, pp. 421-436. Available at: https://doi.org/10.3390/j6030028.

3. MAHLEIN, A.K., KUSKA, M., BEHMANN, J. *Past and Future of Plant Stress Detection: An Overview From Remote Sensing to Positron Emission Tomography*. Frontiers in Plant Science, 10, 21, 2019. Available at: https://www.frontiersin.org/articles/10.3389/fpls.2019.00021/full.

4. CHIVASA, W., MUTANGA, O., BIRADAR, C. *UAV-Based Multispectral Phenotyping for Disease Resistance to Accelerate Crop Improvement under Changing Climate Conditions*. Remote Sensing, 12(15), 2445, 2020. Available at**:** https://doi.org/10.3390/rs12152445.

Acknowledgment. The work was carried out within the project “Edu - Tech - Agro - North - Agricultural Technological Education for the North" funded by the United States Agency for International Development through the Competitiveness and Rural Resilience Project in Moldova and is implemented by ACETI, in collaboration with development partners.