A FEW EXAMPLES OF GOOD PRACTICE FROM BOSNIA AND HERZEGOVINA IN THE FIELD OF DIGITAL AGRICULTURE

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Abstract. *Bosnia and Herzegovina (BiH) is in the early stages of digitalization of agriculture. The digital transformation in the public sector has been largely driven by demands on the road to the EU. Although it has a relatively good strategic framework, digital transformation processes are still slow. This paper focused on the field of digitalization of agriculture in BiH. The research summarizes several previous papers on this topic. In addition, the paper aimed to present several ICT solutions for digital agriculture from Bosnia and Herzegovina. A brief overview of key activities in the field of digitalization of agriculture at the University of East Sarajevo given, which includes research projects and ICT solutions. Three ICT solutions (Web application for cow feeding optimization - Optimilk, LoRa Cattle tracking system and online monitoring and management system for control of greenhouse production - mPlastenik) briefly explained. The key characteristics of the mentioned ICT solutions are presented, such as: major area of work (field), target group (s), suitable for small farms, young people and women, objective and how it does work - development of ICT solution which is used. In the last three years, a large number of activities in the field of digital agriculture have been realized at the University of East Sarajevo. An interdisciplinary research team has been created, several projects have been implemented, and digital agriculture is being included in the educational process. Several ICT solutions used by agricultural producers in BiH have been developed. The needs of small farmers as well as farmers in specific conditions (e.g. hilly and mountainous areas) are in focus.*

Keywords*: ICT solutions, digitalization, innovations, agriculture, Bosnia and Herzegovina*

INTRODUCTION

Agriculture is very important economic sector for BiH. As a subject of many previous assessments and studies, it is evaluated as a sector with the highest employment in the country (with 139,000 employees, either as primary job or additional source of income; BiH Foreign trade chamber). Small farms and plot fragmentation predominate in Bosnia and Herzegovina's agriculture. In 2016, the number of farms in the country was 90.092, whereas the average farm size was 2.96 hectares. Total number of registered agricultural holdings in Farm Registers (entities and Brčko District) is 103,565 in 2019 year. Agriculture sector shares with 18% in total employment where males are 16.4% and females 20.5%. Agriculture generated 7.1 % of total gross domestic value in 2018 (ZUROVAC et al., 2015, MILANOVIC et al, 2018)

Agricultural production, which includes small-scale agriculture with mixed production systems, produces small amounts of market surplus, whereas fragmented production and the lack of mechanization and expertise hinder the agricultural workers' ability to achieve economy of scale in production and produce the amounts needed in some markets, which limits the growth of agriculture. Additional problems are that primary production is unlinked with the processing industry, the share of contracted production is insufficient, as well as the share of added value production and in the total value of agricultural production.

According to the FAO "E-agriculture, nowadays called digital agriculture, is an emerging field focusing on enhancement of agricultural and rural development through improved information and communication processes. It involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs in the rural domain, with a primary focus on agriculture, including fisheries, forestry and livestock. It includes

standards, norms, methodologies, tools, development of individual and institutional capacities, and policy support." Looking beyond the farm, e-agriculture has the potential to contribute to a more economically, environmentally and socially sustainable agriculture that meets the agricultural goals of a country or a region (ITU-FAO, 2020).

There are other definitions of a digital agriculture, such as "digital agriculture as usage of computer and communication technologies to increase profitability and sustainability in agriculture" (SHEN et al., 2010). The use of modern technologies and ICT solutions in agriculture is a conventional practice (MOSKVINS et al., 2008, ILIE AND GHEORGHE, 2016). There is a number of research on digital agriculture, innovation and the involvement of farmers in innovation processes (ROSE, D.C. and CHILVERS, J., 2018, EASTWOOD et al., 2019, BRONSON, 2019, FLOREY, et al., 2020, EBRAHIMI et al., 2021, RIJSWIJK et al., 2021, ROLANDI et al., 2021).

VICO et al. (2021) provides an analysis of the state of digital transformation in the governmental system in the agricultural sector of BiH. The following topics were analysed: Treatment of digital agriculture in strategic framework; digital agriculture in legislation and Level of functionality of information systems in BiH agriculture public sector. The authors have concluded that: "Although BiH has a relatively correct strategic framework for the digital transformation of agriculture in the public sector, as well as relevant legislation, it should be amended in the next planning period in line with the EU acquis. Key issues are implementation activities where many limitations, processes are very slow, very often without any results".

Key information regarding the digitalization of agriculture can also be derived based on the Analytical Report (EUROPEAN COMMISSION, 2019) of the European Commission that is communicated to the European Parliament and the Council as an accompanying document to the Commission Opinion on Bosnia and Herzegovina's application for membership of the European Union. In summary, BiH needs to establish administrative structures, fundamental instruments, and institutions required for participating in the Common Agricultural Policy (CAP), to harmonize legislation across the various government levels with the EU acquis, and to set up a number of supporting agricultural information systems in line with the EU framework, which is a very demanding process in terms of planning, preparation and investment. Although some of the required agricultural information systems are existing, their functionality is limited and mostly not at the full capacity as required by legislation.

MIJIĆ et al. (2021) based on the results of the analysis of several aspects of digitalization of agriculture in BiH, they concluded that this process is in an early stage of development. In addition, they pointed that the awareness of the benefits of digital agriculture is raising slowly in BiH, resulting in more people and organizations involved in some kind of work on digitalization of agriculture, on a small or larger scale.

The aim of this paper is to present several ICT solutions in the field of digital agriculture developed at the University of East Sarajevo.

MATERIAL AND METHODS

The methodological approach for this research included a review of relevant references for this topic. The results of our previous research were used in order to briefly present the state of digital transformation in the agriculture sector in BiH. Internal data from the University of East Sarajevo were used to describe key projects and ICT solutions in the agricultural sector. The paper presents three ICT solutions:

1. Web application for cow feeding optimization - Optimilk
2. LoRa Cattle tracking system

3. Online monitoring and management system for control of greenhouse production – mPlastenik

For each included ICT solution, several key characteristics are described: major area of work (field), target group (s), suitable for small farms, young people and women, objective and how it does work - development of ICT solution which is used.

RESULTS AND DISCUSSIONS

In recent years, an interdisciplinary research team composed of experts in the field of agriculture and ICT has been formed at the University of East Sarajevo. The research focus of the team refers to various activities in the field of digitalization of agriculture. Several Research Projects have been implemented or are being implemented by an interdisciplinary research team, as listed below:

1. "Testing and introduction of modern wireless communication technologies in agricultural production". The project suported by the Ministry of for Scientific and Technological Development, Higher Education and Information Society of Republic of Srpska. The project aims to implementing new ICT solutions based on wireless communication technologies in certain sectors of agricultural production. The project includes cooperation with small and medium enterprises in the agri-food sector and the implementation of these solutions.

2. "System for online monitoring and production management in a greenhouse production - Smart Garden –".Supported by the Ministry of Agriculture, Forestry and Water management of Republic of Srpska. The project aimed to developing system for online monitoring as well as management of greenhouse production. The modular system was developed in this project. The key beneficiaries were: agricultural advisory services, greenhouse producers, academia. Trainings for key users were realized.

3. "Digital farm as a platform to strengthen cooperation between HEIs and the real sector". Supported by the Ministry of Agriculture, Forestry and Water management of Republic of Srpska. The Project aimed to introducing ICT solutions in the livestock production. A few solutions were created: GPS animal tracking with LoRaWAN technologies, remote control of light in the barn, sensors, Internet of things.

Three ICT solutions created by the interdisciplinary team are shown below.

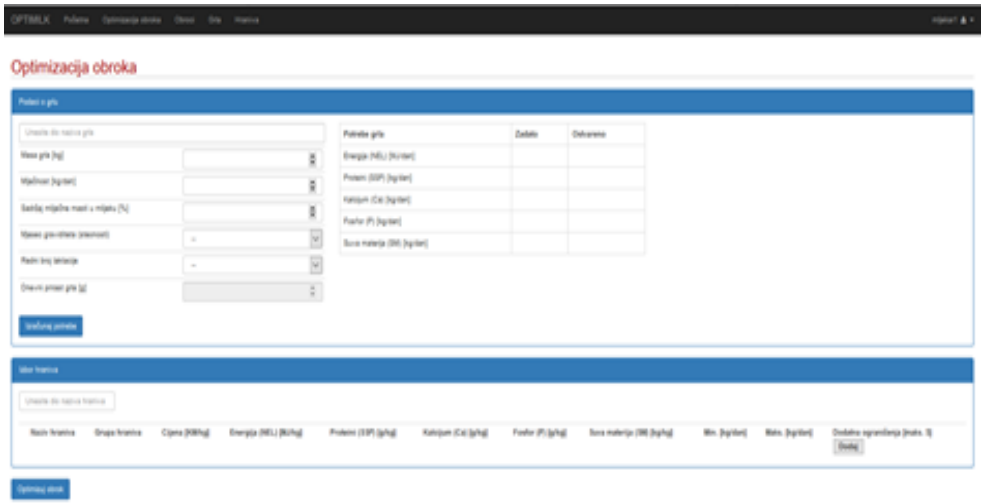
Web application for cow feeding optimization - Optimilk

Optimilk is unique web-oriented application for ration optimization of dairy cows in the Western Balkan Countries. The feeding costs share with more than 50 % in total costs of dairy production. The dairy farmers should to optimize dairy cows ration to achieve better economic production performance. It needs a very complex mathematical calculation with Simplex algorithm (Linear programming method). In other hand, there are many small dairy farms in Bosnia and Herzegovina, without feeding experts. They do not have the necessary knowledge to optimize the ration of dairy cows and they need simple and user-friendly solutions. OPTIMILK is a multi-user web application developed according to the latest web standards and good practices in web development. It provides user-friendly interface and easy access to the application from different kind of internet connected devices (mobile phones, tablets, desktop computers).

Table 1

An overview of the Optimilk

Major area of work (field)	Feeding management
Type of ICT/Digital solution	Web-based application
Target group(s)	Dairy farmers
Suitable for small farms, young people and women	Extremely useful for smallholders, because they are not able to buy a desktop application for meal optimization.
Objective	A web-based application with dual purpose: • optimization (cost minimization) ration of dairy cows and • rooster of experts – helps farmers in finding experts for support in preparation of projects
How does it work – development of ICT used	User friendly application for wider range of dairy producers (big and small). It has two aims: 1. To balance meal for cows. Users can choose a nutrient from the database, can change parameters, enter a new nutrient, share their optimal meal with other users. The application provides the ability to plan needs for a period of time. 2. To help farmers to find experts in project management and preparation. Bosnia and Herzegovina started with use of pre-accession funds of EU. Farmers still have problems to find appropriate experts. One part of this application has list of experts. Farmers can see if the expert is available and his contacts. Expert can change his availability.



Picture 1. Screenshot of the Optimilk

LoRa Cattle tracking system

The aim of the system is to monitor the movement of cattle in a free breeding system with the use of modern information and communication technologies that allow monitoring of movements in a large geographical area with minimal communication costs. The advantages of using LoRaWAN technology are the possibility of use in devices with limited power supply (battery power), and lower communication costs compared to solutions based on the use of the GSM network. The system has the following functionalities:

User management – Enable application user management. Define two types of users: administrator and operator. Functionalities available only to administrators are specifically marked below.

Animal records (administrator) - Record basic information about the animal (ear tag number, animal name, possibly additional information.)

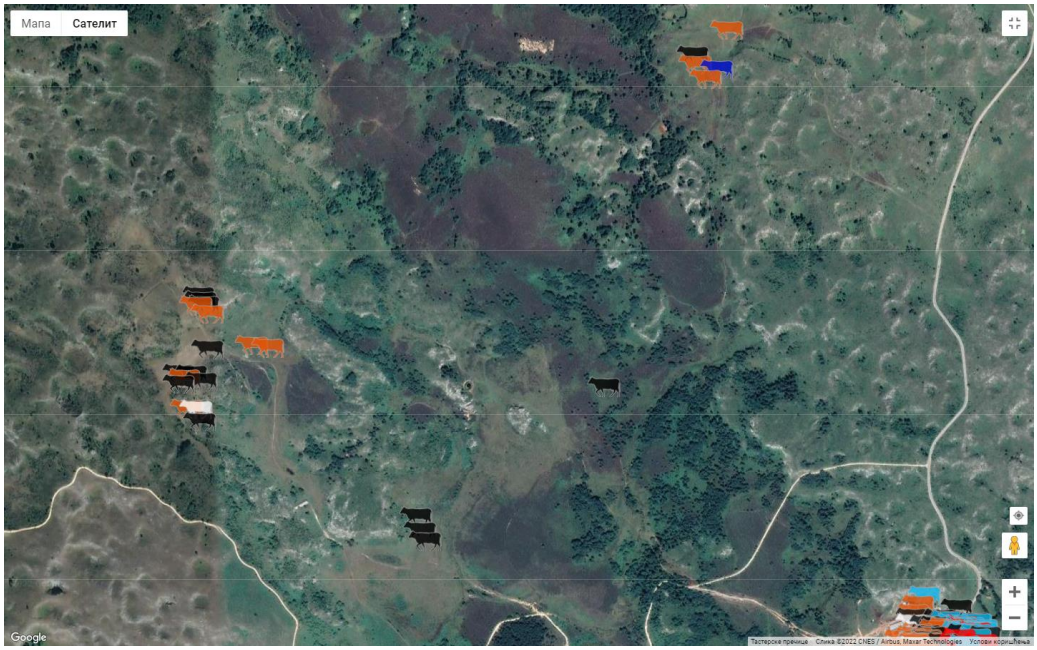
Records of sensors / devices for monitoring the movement of animals (administrator) - Record animal movement monitoring devices (name, type, serial number, additional identifiers if necessary) and enable their allocation to animals.

The system also has other functionalities such as: Display of data on the current location of the animal; View detailed data on the history of animal movements and the Virtual Fence.

Table 2

An overview of the LoRa Cattle tracking system

Major area of work (field)	Livestock (pasturing)
Type of ICT/Digital solution	IoT, web-based application
Target group(s)	Farms with cattle production (cow-calf, pasturing system)
Suitable for small farms, young people and women	It is suitable for all farmers regardless sex, age and farm size.
Objective	Provide real time data on animal position.
How does it work – development of ICT used	Ensure efficient and cheap GPS system with LoRaWAN without GSM modules.



Picture 2. Screenshot of the LoRa Cattle tracking system

mPlastenik

mPlastenik is a system structured from a hardware and software component, intended for monitoring and control of production in a protected area. It is a modular system that results in better growing conditions in the greenhouse, as well as more efficiently working force and better-input management.

The system allows the following:

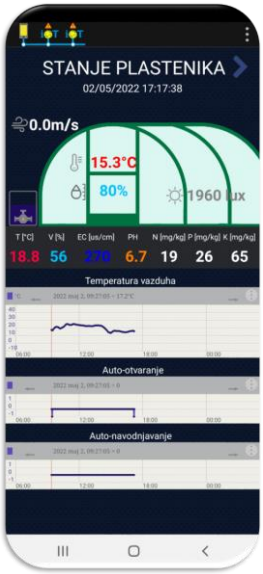
• Real-time online monitoring of key air and soil meteorological parameters

• Real-time online monitoring of key soil chemical composition parameters
• Online irrigation control
• Online control of the opening and closing system
• Online control of the ventilation system (fans)
• Data storage on a remote server
• Easier insight into data history through a user-friendly interface
• Flexible configuration by setting the limit values of individual parameters in order to manage individual system components.

Table 3

An overview of the mPlastenik

Major area of work (field)	Greenhouse production
Type of ICT/Digital solution	IoT/Sensors/LoRaWAN/WiFi/Mobile app
Target group(s)	Small Greenhouse vegetable producers
Suitable for small farms, young people and women	Yes.
Objective	There are many women engaged in agricultural production in greenhouses. They are mostly small producers as well.
How does it work – development of ICT used	Better (remote) monitoring and control of conditions for greenhouse vegetable production



Picture 3. Screenshot of the mPlastenik (monitoring module)

Picture 4. Screenshot of the mPlastenik (management module)

CONCLUSIONS

BiH is in the early stages of digitalization of agriculture. The digital transformation in the public sector has been largely driven by demands on the road to the EU. Although it has a relatively good strategic framework, digital transformation processes are still slow. In the last two to three years, there has been a more intensive use of ICT solutions in the private sector. The COVID 19 pandemic has accelerated digital transformation in all sectors in BiH, including agriculture. In the last three years, a large number of activities in the field of digital agriculture

have been realized at the University of East Sarajevo. An interdisciplinary research team has been created, several projects have been implemented, and digital agriculture is being included in the educational process. Several ICT solutions used by agricultural producers in BiH have been developed. The needs of small farmers as well as farmers in specific conditions (e.g. hilly and mountainous areas) are in focus.

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