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DIGITAL INNOVATIONS IN CATTLE-BREEDING - OPPORTUNITIES AND CHALLENGES FOR SUSTAINABLE DEVELOPMENT OF THE RURAL AREAS IN BULGARIA

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Abstract

The article explores the transformative effect of the digital innovations in the agrarian sector (in particular ruminant breeding) by tracking both the opportunities, and the challenges, which they represent for the sustainable development of the modern agriculture. Integration of digital technologies in cattle-breeding becomes more and more common, offering potential solutions for increasing of the efficiency, productivity and ecological sustainability. The change towards digitalization brings different challenges, varying from problems related to accessibility to concerns, related to data security and ethical consequences. Based on the existing literature and empirical evidence, this research provides complete analysis of the current conjuncture of the digital innovations in livestock industry, assesses the potential benefits from them and explores the barriers preventing their broad acceptance. The conclusions contribute to nuanced understanding of the role, which the digital technologies play in shaping the future of the sustainable agriculture and the rural areas in Bulgaria. The implemented retrospective analysis shows that the problematic agricultural holdings can be encompassed by digitalization only if serious financial investments are made.

Key words**:** *digitalization, cattle breeding, sustainable development, innovations, rural area*

INTRODUCTION

The modern agricultural sector experienced deep transformation, characterised by comprehensive digital revolution, which fundamentally changed the traditional agricultural methodologies. The technological progress became integral part of this change of the paradigm, serving as a catalyst for innovations in different aspects of the agricultural practices. Among the sectors, significantly affected by this technological coup is ruminant breeding, which is fundamental component of agricultural industry and which stands out with significant adaptation of digital innovations. The research tries to enter the details of this digital metamorphosis in cattle breeding, aiming at the same time to comprehensively analyse both the opportunities, and the challenges, stemming from integration of the digital technologies. The main focus of this research is outlining the consequences of digital innovations in cattle-breeding aiming at sustainable development in agriculture.

The digitalization in agriculture is a multilateral phenomenon, comprising different technologies such as sensors, analysis of data and taking of informed decisions. Cattle-breeding, being one of the most complex components in agriculture uses these digital instruments in different occasions in its practices. This includes precision livestock farming, decision making, based on data and application of ecologically sustainable practices. Integration of such technologies is expected not only to revolutionize the operative aspects in cattle breeding, but also to contribute significantly to the broader goals for sustainability in agricultural sector.

The increase of the digital innovations in the cattle-breeding sector is accompanied by numerous potential opportunities, which require analysing. Internet of Things (IoT) is combination of technological moments and

conditions, which form the future of mankind. Its concept is based on identified, connected devices, which gather data and store it in an information cloud, which is processed by smart algorithms [16]. The Precise Livestock Farming (PLF) uses a set of digital instruments, such as sensors and GPS technology for observation of specific animals, providing the farmers with information in real time about the animal health and behaviour [5].

This level of precision facilitates the optimized strategies for feeding, early detection of health problems and improved overall management of the herd, which results in efficiency and productivity. Decision making, based on data, is another main aspect, which provides farmers with the opportunity to gather, analyse and interpret huge quantities of data for taking of informed decisions [26]. Such based on data approaches allow optimization of resources, prevention of diseases and improved overall management of the cattle breeding agricultural holdings.

The inclusion of digital technologies promises to encourage ecological sustainability. Monitoring and real-time control, facilitated by these technologies, can contribute to decrease in the loss of resources, optimization of the efficiency of the fodder diet and minimization of greenhouse gas emissions, related to farming large ruminant cattle [5].

Since agriculture fights with the imperatives for sustainability, the digital innovations in cattle-breeding are outlined as a potential solution for bringing the sector in conformity with the goals for environment management.

Nevertheless, despite these promising opportunities, the integration of digital technologies in the sector of cattle-breeding is not challenge-free. The access and the financial opportunity are the main problems, especially in the developing regions, where financial limitations and poor infrastructure hinder the wide acceptance of digital solutions. The considerable preliminary expenses related to acquiring and implementation of these technologies, impose barriers, which can increase the existing inequalities between the farmers.

Moreover, the increased usage of digital instruments creates concerns about data security and personal privacy. Collecting and storing of huge and sensitive data about the individual animals and agricultural practices impose strict measures for cyber security to protect this information from unauthorised access and potential abuse [14]. The ethical consequences of digital innovations in livestock farming are expected to be significant, too, and they will comprise questions such as humane treatment of animals, preservation of biological diversity and potential displacement of the traditional agricultural practices.

In this context, the purpose of this study is to evaluate the current status of implementation of the digital technologies in animal farming in Bulgaria and EU and their relation with sustainable agricultural development.

MATERIALS AND METHODS

The research is based on scientific developments, related to precision digital technologies, both invasive, and non-invasive; biological and biometric sensors; and block-chain technologies, aiming at control of specific technological processes in the sphere of livestock farming, focusing on breeding of different cattle categories. General scientific research methods (including information-logical analysis of scientific and technical information) were used and applied. In order to implement complex analysis of the technological tendencies in cattle-breeding materials for market research and implementation of smart and precision technologies were applied. Descriptive and retrospective analyses were applied to consider the different aspects of application of digital technologies in cattle-breeding. For this purpose different data for the period 2016-2022 was considered and explored, which included information from Bulgarian, European and global cattle-breeding. Structured and systematized information is extracted mainly from publications, official scientific articles, reports and abstracts. The results of the analysis provide summarised concept for application of digital technologies

in the veterinary practice and cattle-breeding. The technological tendencies, challenges and opportunities, as well as the market reaction were analysed in comparison with the global and the national tendencies in the respective period. Since the research is based on already published and accessible data additional ethical approvals were not required. All used sources are adequately cited in conformity with the requirements for ethical scientific practice.

Limitations of the research include limitation to the accessible information and time period. Nevertheless, the used methods allow trustworthy analysis of the existing tendencies and opportunities in the sphere of digital technologies in cattle-breeding. This methodology provides a frame for analysis of the questions, related to implementation of digital technologies in cattle-breeding, as well as objective and complex approach towards this dynamic sector of agricultural activity.

The main aim of this research is to examine the current condition of implementation of the digital technologies among the farmers and the agricultural producers-cattle breeders in Bulgaria and EU and their relation with sustainable agricultural development.

The research provides answers to the following **key questions**:

-What opportunities exist for using digitalization for increasing the efficiency and sustainability of breeding ruminants?

-Which are the main challenges which hinder the vast entry of digital technologies in this segment in the agrarian sector?

-What is the current level of implementation of digital technologies in the Bulgarian cattle-breeding?

To achieve these goals we used research approach with miscellaneous methods, including: quantitative researches for measurement of the degree of acceptance of digital technologies; quality interviews and observations on the spot for differentiation of the nuances in the challenges in front of farmers, as well as the perceived opportunities in the sector.

The article quotes abstracts of research works of Bulgarian and foreign authors. Summarizations and conclusions were done. Parts of the results are shown with the help of figures and tables.

RESULTS AND DISCUSSIONS

For the implementation of the set tasks we direct our attention towards the opportunities, which digitalization offers for increasing the efficiency and sustainability of breeding ruminants. Then we examine the main challenges of broad introduction of digital technologies in front of this segment in the agrarian sector. Finally, we analyse the current level of implementation of the digital technologies in the Bulgarian cattle-breeding.

Digital technologies in cattle-breeding

The digital technologies change the sector for cattle breeding by introducing revolutionary changes in the traditional methods of work. This transformation comprises numerous aspects - from health care of the animals to resource management and it is based on the following key technologies and innovations: RFID (radio frequency identification) tags; GPS technology; IoT (Internet of Things) sensors; Automatic milking systems; Precision livestock farming (PLF); Block-chain technology; Drones and analysis of data and farm management software (Figure 1).

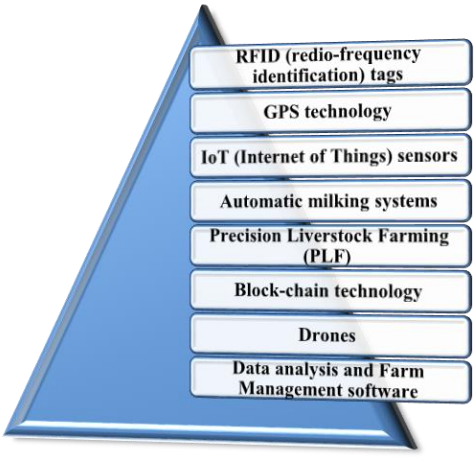

Fig. 1. Digital innovations in cattle-breeding
Source: the authors' conception.

RFID tags, attached to the cattle ears are devices, containing unique identification information. Biometric sensors successfully observe cattle water consumption. A research done by [27], using RFID tags and

accelerometers, shows with 95% precision the correct classification of the cattle behaviour models during water consumption. The applications of RFID technology in cattle-breeding are diverse. It is mainly used for tracing different cattle categories, which allows the farmers to observe the location and the behaviour of the individual animals. Moreover, RFID tags facilitate health monitoring by allowing collection of data in real time for each animal. They are applied in the equipment and inventory management and contribute to the efficient arrangement of data related to cattle [26].

GPS technology

Application of the technology of the global positioning system (GPS) in the breeding and control of horned cattle is significant progress in animal-breeding science, providing new vision for the behaviour of the animals and their interaction with the environment. A research conducted by the Animal Research Centre of the University of Kentucky uses GPS for tracing of the location of the animals in different pasture zones, and in this way it improves the understanding of the behaviour of both domestic and wild animals in extensive pasture environment [6]. GPS tracking and detection of movement improve the option of conducting researches and to control herds in vast and cross pastures [4].

In addition to the observation and the welfare, the GPS technology further contributes to the efficiency of breeding programmes. By analysing the movement and interaction models of the cattle, the farmers can obtain information about the behaviour and the preferences of pairing in the herd. Such information is precious for optimization of the strategies for breeding for improvement of the genetic qualities and increasing of the productivity [20].

IoT (Internet of Things) sensors

The concept for Internet of Things as collection of innovative technologies is based on identified, interconnected devices (sensors, computer configurations, communication devices, etc.), capable of collecting data and storing it in the cloud of information, which is processed by smart algorithms. IoT helps the livestock breeders to observe different processes in agricultural holdings by means of sensors, capable of measuring the solar radiation, the atmospheric pressure, the physiological growth, the changes in the internal environment of the body, the temperature, etc., helping at the same time for obtaining of correct technological solutions [28].

Automatic milking systems

The automated systems for milking represent a significant change in the approach towards milk production. Introduced at the beginning of 90-s of the previous century, these systems made revolution in dairy industry by automation of the milking process, decreasing in this way the labour costs and increasing the efficiency of milking. The sensor technologies have the ability to provide certain autonomy by replacing some of the technological tasks, and this is observed mainly in the robotized systems for milking of cows. The robotized systems for milking use specific sensors, which record the behaviour of the cow during milking and feeding [16].

Precision Livestock Farming (PLF)

Precision Livestock Farming (PLF) includes integration of modern technologies such as sensors, robotics and data analysis for precise observation and management of cattle. This approach comprises different technological variants of cattle-breeding, including feeding, breeding and health management. Large set of data shall be applied, followed by error checks and quality control, to guarantee the quality of the technological process. Precision technologies become more and more popular in the dairy industry, because they apply remote monitoring of cows' health and allow timely pathogen response [14].

[22] examined the automated detection and recording of cows' vocalizations in the herd, with reported and analysed sensitivity in 87% of them and characteristic specificity in 94% of them, as a potentially important method for monitoring and analysis of proestrus and oestrus of individual animals. Feeding and energy balance are important for the efficient milk production by specialized milk breeds. The circulating levels of non-esterified fatty acids (NEFA) show negative energy balance and can be symptom of considerable risks for

health, which must be examined. Biosensors, monitored by NEFA, are in a process of development and have the potential to be extremely useful in dairy agricultural holdings [23].

Block-chain technology

The block-chain technologies present milk cattle-breeding as transparent, stable and predictable in the eyes of the client. They are a decentralized, preliminary encrypted transaction book, where every transaction creates a „node“. The nodes are arranged in records, known as "blocks", and they are related to hemcodes and form a "chain". The block-chain technology has four basic characteristics – it is distributed, transparent, unchanging and democratic [21].

Data transfers in block-chain are implemented between machines and the data is automatically updated. In cattle-breeding this is done because every animal receives unique, individual identification. This identification number will remain valid for the animal during its whole life aiming at data collection in the farm or the holding, where it lives and was bred, it will register its transportation to the slaughterhouse, it will be used in the after-slaughterhouse examination, control of the meat products transport, reliability of the packing and characteristics of the retailer. Block-chain technologies are still at an early stage of their development. They present farmers and agricultural producers as transparent and responsible in front of the consumer for the way their products reach the market. Block-chain technology is particularly useful for observation of the food quality or use of antibiotics via the available scanning devices for creation of history of the animals [18].

Drones

Using drones for tracing the herds slowly gains popularity in different countries. Australia and Israel already use drones at a large extent for observation of the herds. The drones can be used for tracking and determining the number of the animals. They can fly fast around stables or over the pasture at any time and take pictures or video clips. These pictures can help easy detection or visualization of cattle, their number or any other activity in the farm [25]. For observation and tracking the drones can use built-in technology for thermal detection, which can find any animal using its body temperature. The drones provide clear thermal images, which easily differentiate between one animal and another. Flying is done at 90-270 feet over the herd. Such drones use pointing down stereo cameras for tracking of movement. They can be used to determine the location and orientation of the cattle [3].

Analysis of data and farm management software

Integration of analysis of data and farm management software in animal-breeding facilitate efficient agricultural operations, improve decision- making processes and contribute to sustainable agricultural practices. Software applications for farm management comprise an extensive set of instruments, intended to manage all aspects of the farm processes. They include record keeping, financial management, inventory management, cattle tracing and crops monitoring. They often provide opportunities for data collection, analysis and visualization, which allows the farmers to comprehend the models and the tendencies in their holding [19]. In the future, the farm management software will probably increase the integration of advanced technologies such as artificial intelligence (AI), machine training and Internet of Things (IoT). These technologies could allow automated and smart systems for decision making as further improvement of the efficiency and the sustainability of agricultural practices [15].

These technological innovations show us that the future of the livestock farming is in the sphere of smart and connected solutions, which optimize the production processes, improve the welfare of the animals and facilitate the management of agricultural holdings. With their help the livestock breeding sector can not only increase its productivity, but also develop in a way, which is sustainable and in harmony with the environment and the social requirements of the modern world.

Challenges in front of the digital cattle-breeding

While the digital technologies offer numerous advantages in cattle breeding, their acceptance and integration comes with different challenges. Some of these basic challenges include: Implementation costs, Literacy of the farmers; Lack of integration between the systems; Data management; Limited connectivity in the rural areas; Ethical considerations (Figure 2).

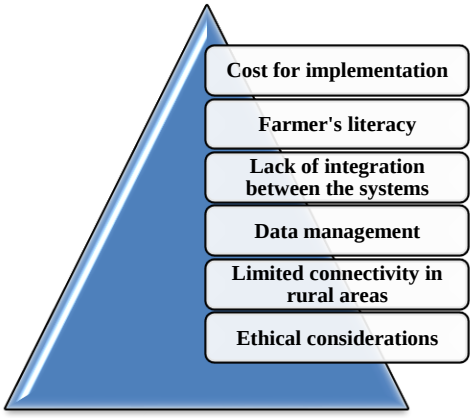

Fig. 2. Challenges in front of digital cattle-breeding
Source: the authors' conception.

Implementation costs

The implementation costs for digitalization in livestock farming are a multilateral question, which includes initial investment, current operating cost and potential long-term savings or rate of return. The integration of digital technologies, including RFID tags, IoT sensors and automated systems, represents a considerable barrier, due to the necessary considerable initial investment. This financial barrier is a challenge, especially for small farmers, who can encounter limitations, hindering their ability to accept these technologies efficiently [26].

Literacy of the farmers

The educational level among the farmers is one of the greatest challenges for application of the new technologies. The necessary knowledge include educational and technical abilities for management of the instruments. Training increases the ability of the farmers to process information and this way to take decisions, using technologies for smart agriculture [11]. The farmers in the developing countries are predominantly uneducated and unqualified, due to lack of desire to obtain knowledge or any other new technological cognition [13]. Quite often this is the reason for the farmers to prefer the traditional agriculture to smart agriculture [12]. Farmers must be digitally literate to increase the advantages of the technologies for smart agriculture and at the same time the agro-technological companies should guarantee that the farmers easily understand the limitations of the technology [10].

Lack of integration between the systems

The integration of systems in technologies for smart agriculture is a critical area, which requires additional refinement to efficiently comprise production, management and instruments for decision making. The state of affairs of the smart agriculture often demonstrates incoherent approach, in which the different systems diverge with one another, which results in inefficiency and not optimal data usage. One of the main challenges in this area is the lack of interoperability between the different technological systems. This results in a scenario, where the data, collected from different sources, cannot be efficiently consolidated or analysed in a uniform way, which in this way limits the opportunities for complete decision making [26]. For example – a system, collecting data for soil moisture, may not integrate in a problem-free way with another system, monitoring the meteorological models, despite the obvious correlation of these factors during taking of agricultural decisions. Moreover, the gap between agricultural and information sciences aggravates this problem. There is urgent necessity of increased communication and cooperation between academic circles and interdisciplinary groups for development of integrated solutions in livestock farming [1]. Such cooperation can lead to development of more holistic systems, which will efficiently combine agricultural knowledge with cutting-edge information technologies.

Data management

Farmers encounter problems with data organization and analyses, obtained from sensors. A major part of them does not know how to use the information and how to systemize data in a more accessible form. To a larger extent this is related to the lack of

integration between the different systems, as well as the insufficient level of literacy. Agricultural producers, consultants, etc., participating in the production process, shall provide greater accessibility to data and information in order to improve the exchange of experience and knowledge among them. Such data type is beneficial for both the other farmers, and for the end users.

Limited connectivity in the rural areas

Many rural areas, where ruminant breeding predominates, may have limited access to high-speed internet and connectivity. This lack of infrastructure presents a challenge, especially for the digital technologies, relying on constant data transfer. Functionality in real time can be interrupted, which will affect the efficiency of certain technologies in these regions [26].

Ethical considerations

The main ethical problem in digitalization in livestock farming is the risk for increase of unemployment. Since machines and automated systems replace manual labour, this leads to decrease of the number of workplaces for agricultural employees. This change can lead to considerable social-economic challenges, especially in rural areas, where agriculture is the main employment source [7]. Introduction of advanced technologies, such as drones and sensors, creates ethical considerations, especially related to animal welfare and data privacy. Achieving balance between the technological progress and ethical considerations is crucial for the sustainable acceptance of digital innovations. Farmers shall orient themselves in the ethical dimensions of implementation of technologies, which directly affect the welfare of personnel and animals.

A balance between the technological progress and its social, economic and ethical consequences is of key importance for the sustainable development of the sector. Partnerships among farmers, technological companies, academic institutions and governments can play an important role in overcoming these challenges and encouragement of innovative and efficient solutions in the sphere of breeding ruminants.

Condition and perspectives of the digital environment in Bulgaria

Searching for opportunities for increasing the degree of sustainability in Bulgarian agriculture, respectively the rural areas, we analyse the place of Bulgaria in the European Union.

Bulgaria occupies the second to last place among the 27 EU Member States in the European Commission Digital Economy and Society Index (DESI) in 2022. Bulgaria's DESI score grew at an annual average of 9% over the past five years, but this is not sufficient to catch up with the other EU Member States.

On digital skills Bulgaria remains significantly below the EU average, having a score of 32,6 versus the EU average of 45,7. In order to reach the EU target until 2030, the country needs to step up efforts, as more than two thirds of its population lack basic digital skills. Bulgaria also underperforms on the proportion of ICT specialists in comparison with the average indicator in the EU.

On Connectivity, Bulgaria score very well on Fibre to the premises coverage (85% of households), which significantly exceeds the average indicator in the EU of 50%. Despite the low prices, both fixed and mobile broadband take-up remains low.

On the business side, the adoption of digital technologies by small and medium enterprises remains almost half the EU average. Only 6% of Bulgarian firms use big data, 10% - cloud services and 3% - artificial intelligence (AI), which is considerably below the EU 2030 targets of 75% for each technology. To support business digitalisation, Bulgaria is making use of European Digital Innovation Hubs [9].

The components of the European Commission Digital Economy and Society Index (DESI) are: human capital, connectivity, integration of digital technology and digital public services (Figure 3).

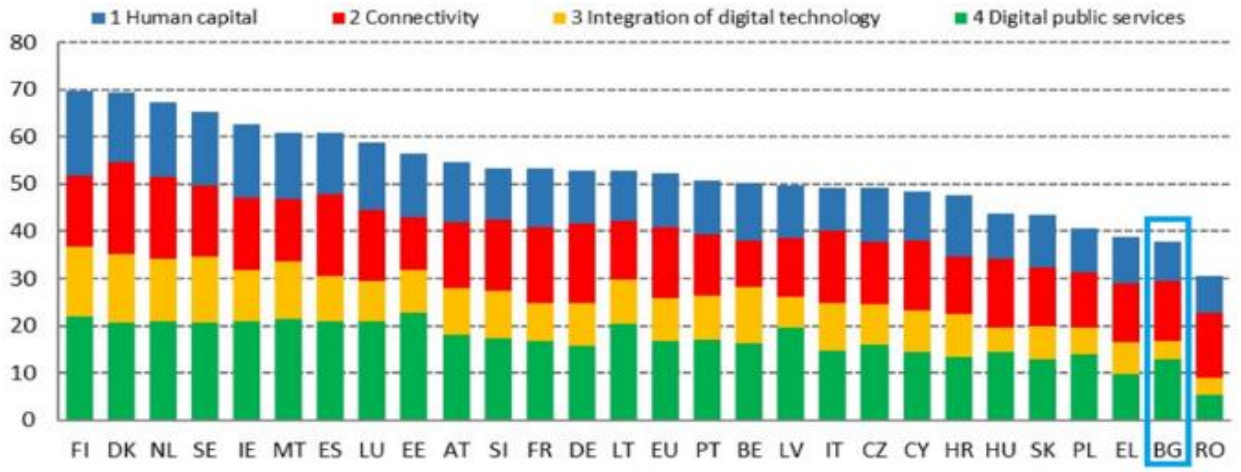

Fig. 3. Ranking according to the index for introduction of digital technology in the economy and the society (DESI) for 2022.
Source: DESI, report for Bulgaria 2022 [9].

Human capital

In the Human capital dimension, Bulgaria ranks 26th out of the 27 EU countries. Only 8% of individuals have above basic digital skills, which is considerably below the 26% EU average, and only 31% of the population have at least basic digital skills (versus the 54% EU average). Only 7% of enterprises provided ICT training to their staff in 2020, significantly below the EU average of 20%. However, Bulgaria scores well on female ICT specialists (representing 28% of all ICT specialists versus an EU average of 19%). Moreover, the proportion of ICT higher education graduates is also high in Bulgaria. (Table 1).

Table 1. Human capital 2020-2022

Human capital	Bulgaria			EU
	2020	2021	2022	2022
At least basic digital skills % individuals	No data	No data	31	54
Above basic digital skills % individuals	No data	No data	8	26
At least basic digital content creation skills % individuals	No data	No data	44	66
ICT specialists % individuals in employment aged 15-74	3.1	3.3	3.5	4.5
Female ICT specialists	28	28	28	19
Enterprises providing ICT training	10	7	7	20
ICT graduates	3.8	4.0	4.6	3.9

Source: DESI, report for Bulgaria 2022 [9].

The Bulgarian Recovery and Resilience Plan includes measures that are entirely or partially linked to digital skills. They have a total digital budget of about EUR 299 million. The measures mainly address challenges linked to education and digital skills training for adults.

Connectivity

In 2021, Bulgaria exceeded the average values of the EU concerning high speed next generation broadband access (93% against 90% in the EU) and the coverage of the fixed very high capacity networks (85% against 70% in the EU), using technology for fiber-optic lines to the buildings. Using this technology, coverage increased from 75% in 2020 to 85% in 2021, and it increased from 49% to 61% in the rural areas but Bulgaria remains significantly behind the EU in terms of distribution of the fixed broadband internet (63% of the households against 78% in the EU) and of the fixed broadband access with speeds at least 100 Mbps (22% against 41% in the EU). Distribution of broadband access

with speeds of 1 Gbps is extremely low (0.42%).

Regarding the mobile broadband access, the parameters are also below the average level for the EU. Only 25% of the radio frequency spectrum for 5G is distributed (in comparison with 56% in the EU), and the 5G network coverage comprises 40% of the populated regions (against 66% in the EU). Using mobile broadband internet on the part of the population is 73%, in comparison with 87% in the EU. Despite the low level of distribution of the fixed and the mobile internet, prices of broadband internet access in Bulgaria are relatively low, and the country is ranked 5th in the index of prices of broadband access (Table 2).

Table 2. Connectivity 2020-2022

Connectivity	Bulgaria			EU
	2020	2021	2022	2022
Overall supply of the fixed broadband internet access-% households	58	59	63	78
Supply of the fixed broadband internet access with speed at least 100 Mbps-% households	11	15	22	41
Supply of internet with speed at least1 Gbps-% households	0,26	0,27	0,42	7,58
Next generation high-speed broadband access coverage -% households	84	88	93	90
Coverage of fixed very high capacity networks (VHCN)- % households	65	75	85	70
Fiber-optic lines to the buildings coverage -% households	65	75	85	50
Radio frequency spectrum for 5G - supplied spectrum as % of the total harmonised radio frequency spectrum for 5G	0	25	25	56
5G network coverage -% populated places	No data	0	40	66
Supply of mobile broadband internet access-% people	60	60	73	87
Index for the price of the broadband internet access-Result (0—100)	72	78	86	73

Source: DESI, report for Bulgaria 2022 [9].

Bulgaria's Recovery and Resilience Plan includes considerable measures concerning the digital connectivity.

The total budget in this area amounts to around 272 million Euro.

The measures are oriented mainly towards the challenges, related to the efficacious use of radio frequency spectrum and efficient political and regulatory frame [9].

Implementation of digital technologies

Integration of digital technologies in the business processes continues to be a problem for Bulgaria, which is ranked 26th of the EU Member States.

Use of cloud services (10%), artificial intelligence (3%) and big data (6%) on the part of the businesses in Bulgaria is one of the lowest in the EU. Only 25% of the small and medium enterprises (SME) have basic level of digital intensity, and they also lag behind in the online sales, where merely 10% of the SME carry out online sales – around half of the average for the EU (Table 3).

The plan includes a number of measures, which purpose is to help the enterprises in adapting their work to the digital environment, and some of these measures are improvement of the quality of the scientific researches and the innovations, investments for implementation of the modern technologies, like for example, creation of quantum platform (0.5 million Euro).

Digital public services

Bulgaria's indicators in the sphere of the digital public services are low as it ranks 25th in the EU. Barely 34% of the internet users use the electronic services of the government.

The country scored 58 points out of 100 possible for the amount of data, filled-in automatically online in the public service forms, which is below the average indicator for the EU of 64 points. Regarding the access to the digital public services for citizens, Bulgaria has a result of 59 points, while for the enterprises - 76 points, and both are below the average level for the EU. Use of open data in Bulgaria is also slightly below the EU average (Table 4).

Table 3. Implementation of the digital technologies 2020-2022

Implementation of digital technologies	Bulgaria			EU
	2020	2021	2022	2022
SME with at least basic level of digital intensity-% SME	No data	No data	25	55
Electronic data sharing -% enterprises-% enterprises	23	23	22	38
Social media -% enterprises	10	10	13	29
Big data-% enterprises	7	6	6	14
Computer services in the cloud-% enterprises	No data	No data	10	34
Artificial intelligence-% enterprises	No data	No data	3	8
ICT for ecological sustainability-% enterprises with average/high intensity of ecological measures using ICT	No data	68	68	66
Electronic invoices-% enterprises	13	10	10	32
SME, doing online sales -% SME	7	8	10	18
Turnover from e-commerce-% turnover SME	2	3	4	12
Trans-border sales online-% SME	3	3	4	9

Source: DESI, report for Bulgaria 2022 [9].

Table 4. Digital public services

Digital public services	Bulgaria			EU
	2020	2021	2022	2022
Users of services of the electronic government -% internet users	36	36	34	65
Pre-filling of forms - Result (from 0 to 100)	No data	No data	58	64
Digital public services for citizens- Result (from 0 to 100)	No data	No data	59	75
Digital public services for enterprises- Result (from 0 to 100)	No data	No data	76	82
Open data % of the maximum result	No data	No data	78	81

Source: DESI, report for Bulgaria 2022 [9].

Bulgaria's Recovery and Resilience Plan includes measures, related to the electronic management and the digital public services. The total budget in this area amounts to around 985 million Euro. The measures are oriented towards the digitalization of the public administration, as well as of the forms in the judicial sphere and of the court orders. Furthermore, improvement of the electronic health care and of the digital innovations in the health care are supported [9].

Smart livestock farming in Bulgaria

Smart Livestock Farming Programme provides for creation of innovative methods and instruments for smart and efficient development of the livestock farming with reduced human resources and reduced impact upon the environment. Research workers and livestock breeders will have an easy and controlled online access to instruments, resources and cooperation related to high performance computation information and communication technologies. They will be able to connect and to store data, as well as have access to virtual, research work eco-systems and customers' networks [24].

International factors, pre-conditioning the development of digitalization in cattle-breeding are:

-Pan-European network of centres for digital services;

-EU strategy of the for building up of European market;

-EC's proposal for digitalization in different spheres.

The Smart Livestock Farming Programme in Bulgaria needs to develop scientific methodology, systems and instruments for modelling of the main processes in the livestock farming, and namely: breeding, feeding, milking and cleaning in the livestock farming, monitoring of the physiological condition of the animals, effect of the climate, environment, etc. Another important goal of the Programme is to develop a „methodology for the genetics and reproduction in the livestock farming".

The Programme includes a total of 12 basic panels: Robotized milking systems; Robotized systems for animals and agricultural holdings; Smart systems for genetic progress; Smart systems for monitoring and analysis of productivity of pastures and meadows; Cyber-physical systems for monitoring; Cyber-physical systems for smart management of livestock breeding complexes; Unmanned aerial vehicles; Service robots and drones for storage and/or delivery of ready products;

Stock management; ICT technologies in the financial, economic and accounting activities; Digital teaching technologies, working with young talents and special target groups; Smart waste management as part of the circular economy (Figure 4).

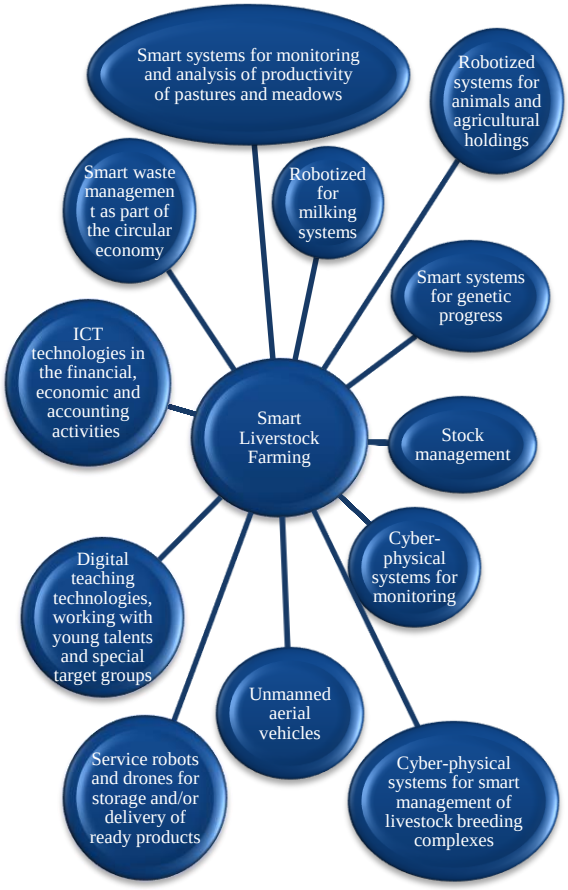

Fig. 4. Smart livestock farming
Source: Vasileva, 2022.

The National Strategic Plan for Agriculture and Rural Development 2023-2027 aims at encouraging the sharing of knowledge and innovations. To further expand the Agriculture Knowledge and Innovation Systems (AKIS) a coordination body will be created on a national level. Information seminars will be organised in order to introduce the farmers to the opportunities provided by the CAP Strategic Plan. The plan supports activities, related to education and training of farmers, through sharing of knowledge, training and provision of consultancy services. 290,000 people are expected to make use of this. Increasing the broadband internet is also provided for in this plan.

Based on data from the agrostatistics in 2016, in Bulgaria we had 98,033 agricultural holdings and farms, but in 2022, they were reduced to 71,947, or the reduction amounts to 28,086agricultural holdings for the period of 6 y ears. These agricultural holdings and farms till a total of 3 million and 959 thousands of hectares of land of the territory of our country [2].

According to a Bulgarian scientist, the farmers, agricultural producers and managers of large livestock breeding structures in Bulgaria fear mainly of the cost they are to incur for the implementation of digital technologies. On the basis of an inquiry in Bulgaria it was found that there are farms and agricultural holdings, which use and flexibly apply the digital technologies. They are around 14-16% of all holdings and they implemented mainly GPS navigation systems. A small number of municipalities in Bulgaria developed strategies for implementation and deployment of digital technologies. This process continues although with some delays. Our country is ranks last but one together with Greece for 2021 in the Integral Digital Economy and Society Index -DESI. Only Romania is ranked after us [17].

The Smart Livestock Farming Programme is a pioneering approach to the modernisation of the livestock breeding sector, and it focuses on the implementation of innovative technologies and methods for efficient management of resource, reduction of the influence on the environment and optimization of the production process with reduced use of human resources. To speed up this process of digitalization and to guarantee its successful implementation, national specifics and institutional environment are to be taken into consideration and appropriate strategies must be developed on a local level. In this context, the efforts of the EU and the national bodies for elaboration and application of strategies for digitalization and innovations in the rural areas are of crucial importance for the future of the smart livestock farming in Bulgaria and Europe.

CONCLUSIONS

Cattle-breeding in Bulgaria is the main sub-sector of the livestock farming for introduction of technological novelties and applications. These technologies facilitate the precision livestock farming, and allow real time monitoring of health and behaviour, improve the management of the resources and the overall management of the farm. The digital innovations contribute also to the sustainability of the environment through optimization of the resource use and reduction of greenhouse gas emissions.

Adoption of digital technologies is faced before considerable challenges, including high implementation cost, lack of literacy of the farmers, problems with the integration between different systems and complex data management. These barriers are particularly well manifested in the developing regions, where financial and infrastructural limitations exist.

Position of Bulgaria in the European Digital Economy and Society Index (DESI) shows the need of improved digital skills and ICT infrastructure, which will bring it in line with the standards of the EU. The country faces challenges when achieving the goals of the EU for digital transition among the SME and the population, as a whole. Overcoming these challenges requires coordinated efforts, including financial investments, educational initiatives and cooperation between sectors. This approach will contribute to the guarantee that the benefits of digitalization in livestock farming will be implemented in a sustainable and fair way. Findings reveal a promising future for the digital innovations in the livestock farming, with an emphasis on the smart, connected solutions, which optimize the production processes, improve the animal welfare and are brought in conformity with the ecological and social requirements of the modern world.

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