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INFORMATION SYSTEMS MANAGEMENT IN AGRITECH FOR FOOD SECURITY

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A B S T R A C T

In this paper, we considered and characterised the features of information systems management of agricultural production processes, which are based on agricultural technologies to support and increase food security in the domestic and external markets. We revealed management models in this category, which are used in the agrarian sector of Canada and Vietnam. Differences between these two models are connected with several factors, including socioeconomic development, quality of arable land, availability of resources and their cost, level of labour resources' readiness to the implementation of new ICT, and farms' adopting the necessity of transition to precise farming. The revealed advantages and problems of implementing Agritech at the level of the two countries demonstrate that the focus on sustainable and precise farming has become a new trend in this sphere.

The goal of this paper was to establish the features of the formation of approaches to information systems management in Agritech to ensure the food security of countries that produce agricultural products.

The scientific novelty of this paper lies in the determination of approaches to the implementation and management of information systems in the considered category, which facilitate the creation of conditions for the growth of efficiency of agricultural productions under the influence of threats of climate change.

1. INTRODUCTION

Food security is the indicator of the country's ability to support standards in ensuring the necessary quality and quantity of food for the population. The government performs the role of regulator and guarantor for this indicator for the population and countries that import food. This responsibility concerns the strategic level. Participants in the agrarian market (companies growing crops and companies dealing with their processing) support the stability and growth of food security. A separate role is found in the quality of labour resources, which are involved in this sphere. If the employees of farms and companies in the food industry of the country demonstrate good knowledge in the sphere of agrarian technologies (Agritech), there are prospects for effective economic growth. Modern Agritech is connected with the digitalization of key processes. It is usually based on information systems management in the sphere of crop production and regulation of crop research. An increase

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in the volumes of domestic food production with a simultaneous increase in the level of labour resources' well-being predetermines the necessity of general economic growth and change in the model of the national economy (gradual transition from the category of rapidly developing economy to developed economy). Such opportunities are peculiar to countries with high level of labour resources' readiness for digital transformations and rich experience of adaptation to new information systems that are based on Agritech.

Productiveness of sectors that are involved in food security depends on many factors, including quality of planting material, availability of agricultural technologies, the level of digital readiness of personnel, etc. Agricultural technologies and the level of digital readiness of personnel are closely interconnected. Agricultural technologies are selected, purchased, and implemented by the initiative of the government and companies in the agrarian sector (farms, large corporations). The direction for training personnel in the context of information systems management, created with the use of Agritech, is the sphere of competence of the government, business, science, education, and population.

The objective of this paper was to identify the features of the formation of approaches to information systems management in Agritech for the food security of countries that produce agricultural products. Therefore, we tried to reach the following tasks: revealing countries with the highest level of digital readiness of labour resources to the implementation and constant upgrade of agricultural technologies and large contribution to global food security; describing characteristics of the approaches to the management in the studied category.

2. EXPERIMENTAL SECTION

In this research, we elaborated on the implementation of agricultural technologies in countries that produce agricultural products for domestic and external markets. We studied the experience of Canada and Vietnam, because of their contribution to food security and focus on the application of Agritech in the management of information systems.

To achieve the designated research tasks, we used a range of methods. Systematisation enables us to generalise information on the implementation of Agritech in companies of the agrarian sector, involved with the cultivation of crops, and establish approaches to this process. Content analysis allows revealing a list of agrarian technologies that are used in the management of information systems in food market companies. The method of comparison was used to compare transformations that took place in food security due to the implementation of Agritech. Statistical analysis allowed the collection of official data on the state of the considered objects and indicators.

We determined key approaches to information systems management in Agritech to ensure food security using the provisions of theoretical and empirical scientific materials.

Carmichael et al. (2023) presented provisions of complex research connected with farmers' assessing the necessity, factual results, and problems of the sustainable development of agriculture in various provinces and territories of Canada. The empirical analysis demonstrated that, in most cases, Canadian farms are oriented towards sustainable economic activities; there is no general agreement that to achieve the necessary indicators in the sphere of climate change it is necessary to implement serious reforms in the organisation of agricultural production.

Grigorieva and Shulga (2018) dwelt on the features and types of agrarian clusters in Canada, with special attention to the relevance of the creation of innovative sectoral superclusters. The authors demonstrated advantages for all interested parties and established that production frameworks of these integration structures can be a large-scale basis for implementing innovative agricultural technologies.

Dang et al. (2023) described the specifics of agrarian sector management in the Mekong Valley (Vietnam) in the context of the use of Agritech and the problems of local farmers' transition to more productive methods and approaches to agricultural production. The authors listed important socioeconomic and environmental problems of this territory, caused by the influence of climate change on the low yield of rice. Climate fluctuations led to a decrease in farmers' and local population's income and excessive use of nitrogen which pollutes the environment. The research also listed agricultural technologies used by local farms, which are aimed at the temporary preservation of business.

Shumka et al. (2021) presented an analysis of the financial and technical advantages of implementing projects in the sphere of recycling and reuse of biomass in industry. According to the authors, this direction has particular effectiveness in countries with developed agrarian sectors. This direction is relevant for farms that use agrarian technologies to create cyclic agricultural productions.

Joffre et al. (2020) substantiated the advantages of creating farm clusters in regions with low socioeconomic activities and problems with the implementation of innovative technologies due to the absence of finances and knowledge. Empirical analysis of the results of cluster functioning of aquaculture farms in Vietnam demonstrated the effectiveness of this practice compared to traditional farms that work

individually and have no advantages of network structures. The authors showed that, in the conditions of network interaction, partners implement standards of product competitiveness, an important place among which belongs to eco-friendliness. It is achieved due to robotized technologies of water purification and the use of eco-friendly food.

3. RESULTS

The indicator of society's digital readiness for the implementation of agricultural technologies can be assessed through the lens of the level of digital competitiveness, calculated annually within the IMD ranking (IMD, 2024).

Let us consider the specifics of the approach to information systems management in Agritech in Canada.

An important component of the implementation of information systems in Agritech is the government's active participation in its development and financing. At the national and regional levels, favourable financial and technological conditions for the improvement of sustainability and energy efficiency in the agrarian sector and food industry are ensured. The measures peculiar to the modern stage of the implementation of innovative approaches to information systems management are as follows:
1) Investments in project financing of agriculture and agro-industrial products. There is the programme Sustainable CAP for 2023 - 2028, which involves expenditures of USD 3.5 billion, including USD 1 billion for programmes of improvement of products' competitiveness through energy efficiency and other agricultural technologies in the food industry; mandatory expenditures of USD 2.5 billion for support of agricultural technologies.

Development and realisation of the programme Sustainable CAP is connected with the fact that, despite the high digitalization of processes in agriculture, there is no agreement among farms regarding the need for reforming approaches and methods of management that would facilitate an increase in sustainability (Carmichael et al., 2023).

Analytical materials do not provide precise information on the distribution of these investments in the implementation of Agritech and other directions, but this article is present within two sub-programmes. Responsibilities in the realisation of this programme are assigned to the Agricultural Adaptation Council. This body regulates interaction with farms and companies in the context of investments in innovative technologies. According to this programme, support is divided into two categories: for projects of the implementation of agricultural technologies or innovative technologies in the agro-industrial sector which are worth less than USD 100,000 there is a possibility of grants from federal funds (50 %); projects worth more than USD 100,000 can receive financing at the level of 35 % of total expenditures (Canada.ca, 2023a). This support is aimed at an increase in the level of quality (including consumer qualities) of agricultural products due to the use of ICT, including information systems management. In this case, the government stimulates long-term sustainable development of the agrarian sector, which ensures food security.

The Sustainable CAP programme contains five targeted directions: increase in sustainability and public trust; increase in the level of development of trade and food market; improvement of the level of science and implementation of innovations and research in the agrarian; environment and climate change; increase in the level of competitiveness, economic growth, and improvement of the agrarian sector's potential (Canada.ca, 2023b).

Special attention should be paid to stable support from the government for the initiatives on implementing agricultural technologies to raise the sustainability of agricultural landscapes during precise farming projects. This involves the protection of soils and the environment from the impact of polluting emissions and waste from agricultural production. The total volume of financing in this sphere equals USD 250 million. The government presents offers on ICT that are based on the management of information systems in the context of soil probing, diagnostics of air and water, and assessment of the norms of the use of chemical fertilisers (Canada.ca, 2023b). These ICTs are adapted to agriculture's needs. Their development and commercialisation are conducted by universities and R&D organisations. The system of the government's participation in projects on the financing of these ICT is rather simple and accessible for companies in the agrarian market. If a farm is to implement agricultural technologies of this category, it makes an application within this programme and substantiates the needs and expectations of possible innovations. Then, the Agricultural Adaptation Council considers the application and the applicant receives a notification about the decision.

2) Investments in start-ups in the sphere of Agritech. This involves the direct participation of the government in financing start-ups and government's attracting investors to create and develop agricultural technologies for sustainable development. Start-ups that support the effectiveness of Canadian farms and positively influence the level of ecology include the following (Singh, 2023; Semios, 2023; AgFunderNews, 2019):
- Resson – information systems management in the sphere of forecast modelling of the indicators of crop yield and quality of agricultural products. This solution is aimed at large agricultural holdings and clusters of agrarian companies. The latter are numerous in Canada;

they have pilot projects on innovative digital solutions for the improvement of the quality and productiveness of goods based on precise multivariant modelling (Grigorieva and Shulga, 2018). The start-up's cost was USD 27.7 million;

- Ostara – agricultural technology of purification of wastewater used in agricultural production and the use of food waste to produce eco-friendly fertilisers. The technology, which lies in the basis of equipment for automatic collection and recycling of farms' waste, ensures the prevention of movement of crop research waste in the environment. This start-up's cost was USD 56.7 million. The company that developed this start-up (Ostara Nutrient Recovery Technologies Inc.) merged with Multiform Harvest (a company dealing with the technological emission of phosphorus from biomass) (AgFunderNews, 2019). This move allowed for the development and mass promotion among farms of the technology of phosphorus capture, to prevent water pollution. There are government programmes for purchasing phosphorus from farms for market prices, without any intermediaries. The direction of capture and reuse of agricultural products processing waste has become more popular in the world practice due to its environmental and economic advantages (Shumka et al., 2021);
- Concentric Agriculture – digital instructions for production of organic products, used for soil recovery and an increase in the level of crop yield. This digital solution facilitates the growth of productiveness and food security. The investments in this start-up amounted to USD 73 million. The government supported this project as an alternative to the system of using traditional fertilisers and pesticides;
- Terramera – digital information project for production support and the use of eco-friendly fertilisers and pesticide replacements, made of synthetic products. The cost of this start-up was USD 82.8 million. This solution is based on the management of information systems, which include AI and machine learning technologies (to develop the formulae of "green" chemistry); a chatbot for consultations regarding the use of the products for crop management. The goal of the creation and implementation of this start-up was to use agricultural technologies for the ecologization of agricultural production, improvement of the population's health, and growth of accessibility of eco-friendly products. This start-up is used by national and foreign farms (the interface is available in several languages) and has in-built databases for various regions of the world. Farms that utilise this digital solution manufacture environmentally friendly materials for plant care;
- Farmers Edge – a digital app based on the management of information systems, which contain large databases on criteria and indicators of precise farming management. The principle of work of this app is as follows: the farmer (manager of the agrarian company) inputs initial data on the plant and geolocation of the farm; the system determines precise parameters of crops for the given plant given climate and environmental data of the territory; the use of innovative methods of sowing and crop management is offered additionally (if it is acceptable for the farm and possible in the given location; this could be a recommendation on the depth of planting, which allows raising yield and protecting soil from corrosion, or refusal from fertilisers). This digital app also allows calculating expenditures for growing crops on the offered territory given the application of the agricultural technologies of precise farming. This start-up cost USD 103.6 million;
- Semios – digital solution in the sphere of precise farming. It is an information system that ensures crop management, with the main focus on continuous control over the use of pesticides and their influence on plants and the environment. Due to in-built agrarian technologies, farmers receive a precise picture of the level of pesticides in plants and soil. This information allows regulating the application of pesticides, preventing their excess, saving money on excessive pesticides, and supporting high quality of agricultural products due to strict control of the use of pesticides. The cost of the project was USD 112 million. In 2023, Semios was modified: additions in the context of types of crops, climate, and the need for additional information and monitoring configurations were added. Additional capabilities included crop management under the risk of frosts; precise assessment and forecasting of plant diseases; smart management of plant pests; and management of climate features (Semios, 2023).

The business environment and the research sector are an important component in the development of information systems management. Due to the activities of investors and companies in the agrarian sector, as well as establishments and organisations of the scientific and technical sphere, information and communication technologies, which are based on the management of information systems, are integrated with various agrarian technologies.

Canada's human resources have high digital readiness for constant changes in ICT. In the world rankings, Canada is placed 17th (Cisco, 2024). Accordingly, the implementation of new agricultural technologies in information systems management in agricultural production is at a rather high level due to the knowledge and potential of the country's labour resources.

Let us also analyse the approach to information systems management in Agritech in Vietnam.

We chose this country for the analysis because of its transformations in the economic sphere on the whole and in the context of reforms of the agrarian sector (including the use of modern agricultural technologies).
The quick economic growth of Vietnam after the 1980 reform allowed it to transform from a country with big problems with food into a country that is a large

exporter of rice, peanuts, coffee, pepper, and other products (Nguyen, 2024). Climate change, faced by Vietnam, influenced the implementation of digital agricultural technologies.

Special attention in this direction was paid to agrarian technologies, used by farms that produce rice in the Mekong Valley. Over 2018-2024, there were fluctuations in rice production in Vietnam: in 2019-2020, this indicator reduced by 1.9 % compared to 2018-2019; grew by 0.08 % in 2020-2021 compared to 2019-2020l reduced by 4.12 % in 2021-2022 compared to 2020-2021; grew by 0.8% in 2022-2023 compared to 2021-2022; and grew by 0.46 % in 2023-2024 compared to 2022-2023 (Statista, 2024b).

Because of the appearance of salt water in rice fields, farmers lose crops. The Vietnamese government used a complex approach to the sustainable development of territories in 2020's, and it started measures for the transition from rice production to the production of other crops, which are less dependent on climate change (Relifweb, 2024). There were programmes for local farmers' transition to gardening and sustainable crop research, which does not require particular soil qualities. As for digital solutions, one example is the technology of imitation modelling, which is presented in digital applications for information systems management in production processes (Dang, et al., 2023). Farms' data and geolocation are used within an information system for the modelling of forecast variants of crop yield; dates of sowing and recommendations for crop management given climate change; date of harvesting; and expected calculation of resources' expenditure.

An important factor in the current management of information systems in rice production in Vietnam is the government's policy for the improvement of digital and professional readiness of employees who work in agriculture. Analysis of the legal and programme regulation of personnel training in Vietnam's agro-industrial complex shows that it is mainly aimed at the general training of agricultural employees and does not involve teaching them skills in modern ICT and is not aimed at an increase in digital knowledge. One problem is that the wages of Vietnam's agricultural employees are the lowest in Asia. This indicator is 12 times lower compared to Malaysia, 2.1 times – compared to Thailand, and 1.8 times compared to the Phillippines (Nguyen, 2023).

The low digitalization of Vietnam's agrarian sector is predetermined by different reasons, including the focus on a cheap workforce and traditional methods of agriculture. 21 million people were employed in the agro-food sector of Vietnam in 2021; of them, 18 million were employed in agricultural production, and 3 million – in food and beverage production (Statista, 2024a). As of 2022, there were only 48 agrotechnological companies in the country that dealt with Agritech in information systems management (Innolab.asia, 2023). Medium and small farms do not focus on digitalization or realisation of the leading agricultural technologies, which would stimulate an increase in productiveness, revenues, and satisfaction of new demands from the able-bodied population.

Given the relevance of raising agricultural productiveness, there are programmes – at the level of business and public-private partnership – to improve the quality of digital and technological readiness of the agrarian sector. These projects include the following:
1) Programme for improvement of digital knowledge of farmers, organised in cooperation with the Union of Farmers of Vietnam and Google. This programme involved hiring specialists for support services, for teaching farmers and managers in nine provinces of the country. This programme allows farmers to use ICT more effectively and transfer new knowledge to their employees. As of now, the programme has 500 specialists from support services and 40 specialists who instruct farmers directly;
2) Programme of motivation for implementing agrarian technologies. The country has twelve territories in which agrarian technologies are actively developed. Participants of the bank pool (the central bank and a range of commercial banks) started a programme of support for farms that perform transfer to precise farming. The total cost of this package is USD 4.4 billion.

Vietnam's approach was formed based on the factual state of digital and professional readiness of labour resources, practices of farms, and capabilities of budgets of different levels in supporting precise farming. Since there are many small farms, especially in rice production, their activities do not involve strategic management. This influences the government's ability to form certain aspects of support in this sphere. The cluster approach, which is used in aquaculture in the Mekong Valley, allows for effective interaction between small farms (shrimp production) in the context of ICT (Joffre, et al., 2020). Cooperation in such clusters is built around trust, new opportunities for synergy, etc. This network experience of farmers in the Mekong Valley may be a model for adaptation for local rice producers.

4. DISCUSSION

Analysis of the research results showed that Canada is focused on the approach to information systems management in Agritech to ensure food security, which is supported by all interested parties. Government, business, technological sector, R&D sector, educational sector, and human resources make their contributions to the innovative growth of the agrarian sphere. Even though certain farms do not implement complex approaches to precise farming given the latest ICT, each of them demonstrates the use of certain agrarian

technologies that contribute to the growth of competitiveness of products in the domestic and external markets. An important role in the promotion of Agritech in Canada belongs to the government, which creates a favourable climate for the functioning of farms. In this case, this includes financing and support in attraction of investors, to raise technological support for agricultural productions that are aimed at sustainable development.

The rates of implementation of agrarian technologies in information systems management in Vietnam are rather slow. However, Vietnam has various programmes to support of farmers in mastering ICT to raise productivity and achieve ecologization. The approach used by Vietnam could be called stabilising. Since the country's economy is moving towards the sphere of production and services, the agrarian sector demonstrates lower digitalization and productiveness. To ensure a high level of food security, motivational programmes for the use of agricultural technologies are applied. There are trends for sustainable agriculture. One can expect refusal from the production of crops that require large labour and resource expenditures. Undoubtedly, this will influence the structure of food support. The more comprehensive and quick transition to sustainable agricultural production, based on innovative agrarian technologies, including intellectual information systems, will require systemic reconsideration of the country's policy in this sphere. Special attention is paid to the interaction between the government, business, and society for the establishment of the advantages of this transition (Popkova et al., 2024).

5. CONCLUSION

In the course of this research, we were able to establish two approaches to information systems management in Agritech for food security, which are used in Canada and Vietnam. Despite substantial differences in the adoption of the necessity for the implementation of agricultural technologies among all interested parties in the two countries, there are certain similarities. In traditional agricultural productions of Canada and Vietnam, we can observe certain opposition from farmers to the use of new models of process management. This is caused by traditions, a focus on a cheaper workforce, and an insufficient level of understanding of the advantages of digitalization in this sphere. Accordingly, to raise the level of information systems management in processes related to innovative agrarian technologies, it is necessary to involve propaganda on the relevance of technological improvements in the agrarian sector.

An increase in the productivity and sustainability of Vietnam’s agrarian sector may need reconsideration of the national policy in education management and professional training of personnel for agriculture. This is true for farm managers and ordinary employees. The creation of a quality educational system of training and the implementation of standards of wages for farms will motivate the population for training and constant improvement. This might also lead to farmers' striving towards the improvement of the productivity and efficiency of their activities.

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