

Forecasting of digitalization development in agriculture on the basis of the system analysis methods

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Abstract – This article considers the forecasting methodology of a complex system development – digitalization of agriculture on the basis of a wide use of the Internet of Things and Information Technologies in productive and economic processes and also of information and analytical systems that have been created on their basis. The major factors and conditions influencing development are defined. The concept of the basic of "a digital set" and efficiency of "a digital set" is given. The concept "efficiency" of a digital set" characterizes the providing system aspect, i.e. those opportunities according to the solution of tasks which the available "digital set" provides to the user. In other words, how providing part and a set of technical means satisfy inquiry of the user and define efficiency of use of a system by it in general. It is drafted the provision of an overall forecast. The conclusion is that the solution of the problem can be resolved by systematic consideration of the forecasting subject, assessment of its various features, findings of characteristic factors and accounting of their influence.

Keywords – digitalization in agriculture, information technologies, digital set.

I. INTRODUCTION

Agriculture plays a huge role in national economy. It not only provides the state and its population with food, but also forms agricultural raw materials for industries. Level of its development predetermines food security of the country [1]. A number of the directions of achievement of this purpose is connected with development and wide use in agriculture the Internet of Things (IoT) and Information Technologies (IT-technologies) and also created on their base the Information and Analytical Systems (IAS). Increase in labor productivity in agriculture due to improvement of its controllability, automation of agrotechnological processes, acceleration of introduction of achievements of scientific and technical progress, release of workers from performance of routine operations and a possibility of their use for the solution of socio-economic objectives — all this is provided with use of IoT and IT-technologies. It is possible to say that use of IoT and IT-technologies has accurate social character and their influence on society even now significantly, will increase in the future and will be one of the most significant factors defining development of society in general.

All this defines the public importance and need of careful forecasting of development of IoT and IT-technologies and

those social consequences which they render and will render in the future. At the same time it is necessary to consider dynamism of this industry of social production and that impact which IoT and IT-technologies have on development practically of all parties of purposeful public work [2]. Therefore, it is extremely important, especially in the conditions of the market competition, to consider development of IoT and IT-technologies in agriculture in terms of digitalization of economy in general, i.e. to use methodology of the system analysis when forecasting, to consider the social, economic, technical and organizational factors defining development of the industry in interrelation with development of the national economy.

II. RESEARCH METHODOLOGY

The current state of use of IoT and IT-technologies in agriculture is characterized by insufficient efficiency that is connected:

- with the discrepancy of scientific and technical knowledge of innovative agrotechnologies and the methodology which is expressed in creation of a set poorly connected among themselves and territorially dispersed individual control systems which are not providing accurate interaction of economic units in the course of production;
- with lack of the innovative developments stimulating adoption of the management decisions capable, eventually, to provide the population with qualitative and safe products;
- with discrepancy of the available IT-technologies to those tasks which are defining for agriculture, that is an insufficient variety of the available IoT, their weak specialization, lag in development of platforms of management that reduces efficiency of use of IT-technologies at the solution of many tasks;
- with insufficiency and high labor input of creation of the provision (mathematical, program, information) allowing to increase significantly efficiency of the solution of the tasks necessary for development of agriculture.

Therefore, development of IoT and IT-technologies has to be directed to eliminate the specified shortcomings, to increase an efficiency of digitalization of agriculture. In this case the directions of development will be:

- formation of the main set of technologies and methodology of digital agriculture for effective use of the available resources for implementation of economically reasonable optimum technologies increasing profitability of agricultural production, providing a possibility of production and processing of agricultural products in a uniform chain;
- starting of the administrative platform for producers promoting formation of modern schemes of the organization of production allowing efficient use of producer resources: energy opportunities, staff, financial resources, sales channels and marketing tools;
- implementation of platforms of objective monitoring and management of transport and logistic infrastructure in agricultural production;
- integration of information systems of supervisory authorities (Rosselkhoznadzor, Rospotrebnadzor) and veterinary services to the state-private digital platform for the purpose of direct interface of control systems and supervision to control systems of business of economic entities for identification and traceability of animals and inclusion in through digital chains of a full production cycle of products of livestock production [3];
- development of digital technologies of domestic selection and genetics (including on the basis of blockchain technology), the accelerated breeding and production of the new plant varieties and breeds of animals adapted to specific soil climatic conditions of regions with a high potential of productivity, additional weights and resistance to diseases and pest damage with creation in regions of the selection and seed-growing centers;
- creation various, on the target orientation and use, of IT-technologies and formation of the IoT parks which are most meeting the requirements of various levels of agriculture;
- training of the IT-specialists capable effectively work with innovative technologies and providing active participation of the nonprofessional user (i.e. the economic manager) in the solution of any tasks by means of IT-technologies.

Main objective of the forecast is the identification of conditions performing which the directions of development of digitalization are implemented, the defects of their use are eliminated. The indicators characterizing degree of satisfaction of need of agriculture for IoT and IT-technologies at restrictions for the volumes of investment will become criterion of satisfaction of conditions.

Basic data for the forecast are defined on a basis on:

- analysis of current state (structure of the IoT park and IT-technologies, solvable tasks, volumes of the processed information);

- existing and predicted needs of agriculture for IoT and IT-technologies;
- private forecasts of scientific and technical development of IoT and IT-technologies: private forecasts of the size of costs of development of the Information and Computer Technologies (ICT); investments on introduction of the main directions of digital transformation of agriculture and scientific and technological development in the field of "clever agriculture".
- The methodology of forecasting is based on a number of the provisions used both at private and at the general forecasts of development of IoT and IT-technologies. As such provisions are accepted:
- digital transformation of agriculture assumes the systemic and accelerated digitalization of agricultural production and integration with the directions of programs of digital economy;
- the purpose of digital transformation of agriculture – increase in labor productivity and efficiency of agrarian business;
- digital transformation of agriculture provides the most effective mechanisms of public administration regarding financial support, training of citizens, achievement of steady indicators of food security and also increase in the standard of living of rural people.

III. CONDITIONS AND MATERIALS OF THE RESEARCH

The technical prerequisite of creation of IAS became development of information technology and the computer equipment which caused a possibility of development of the built-in control facilities processing equipment and also development of robotics which allowed automation routine operations on loading and unloading of agricultural machinery and equipment.

At this stage of development of economy in the industry of informatization and communication in the Republic of Tatarstan it is steadily gained gross revenue [4]. Thus, in 2018 it is made 56.7 billion rubles and grew in comparison with 2017 by 1.8 billion rubles, i.e. 3.3%. The share of gross revenue of the industry in a gross regional product of the republic was 3.1%. In general, this indicator on the Republic for 2007-2018 tends the steady growth which is described by the following equation:

$$y = 19,6 + 3,4 \cdot t, R^2 = 0,941 \quad (1)$$

3.9 billion rubles are invested in development of fixed assets of the enterprises of the industry of informatization and communication of the Republic of Tatarstan in 2018 that is 25% more than in 2017. Since 2007, the volume of investment into capital investments of the industry of informatization and communications annually grows.

According to the Strategy of social and economic development of the republic till 2030 gross revenue of the industry will grow almost by 8 times to 389 billion rubles that will allow increase a share of the industry of informatization and communication in a gross regional product of the Republic of Tatarstan to 7%. At the same time the share of information technologies in gross revenue of the industry will grow to 75%, the volume of investment into the industry will be 68.6 billion rubles.

It is known that rates of innovative development of agriculture in the Republic of Tatarstan remain low. First of all, it is because of the low level of the technological equipment in many respects determined by technical and technological level of the industry and insufficient staff qualification [5]. While international and European experience of conducting agricultural works is already directly connected with information technologies, in Russia this direction develops since the beginning of the 2000th, and for many reasons rates of its development remain low.

At the present stage the prospect of information technology development in agriculture is extraordinary high. In some large integrated formations of the Republic of Tatarstan such as JSC "HC "Ak Bars", CJSC "Agrosila Group", LLC "MC KV Agro" already now new technologies of housekeeping are successfully used [6]. At the present moment it is, first of all, programs for calculation and optimization of diets of feeding and mixes of forages for various animals, software products for diagnosis of diseases of animals and crops, information systems of automation of operational accounting, the program for selection of animals, the geographic information systems, accounting information systems considering branch specifics, complex enterprise management systems [7].

At the same time the convenient environment for storage and information processing is the "cloud" computing technologies uniting in themselves license software, hardware, communication channels and also technical support of users [8]. All this provides to specialists of agricultural enterprises a possibility of connection to a system from any workplace in real time, excludes costs of transfer and data unzip, updating of a databank. In LLC "MC KV Agro" in livestock production a common information space on IAS "Seleks" is realized. It allows to exchange data through workplaces of various services (veterinarians, livestock specialists, appraisers and others) and also to unload via web applications regional reports, breeding document flow, exhibitions, realization of the cattle on Племторг.рф, etc.

In the same place the modern software product "Fodder Diets" is developed. It allows making the best decisions in feeding of cattle for increase in profitability of herd. Within this product it is realized: maintaining database of diets and premixes; creation of the database on nutritional value of forages; assessment of the actual diets; calculation of need for sterns; use at the choice of standards of need of animals for nutrients; the analysis and assessment of the received diets.

In CJSC "Agrosila Group" IAS "Veterinary science" is realized. It allows to store and use information on all levels of the organization of work of specialists of veterinary service: from a way of introduction of medicine to a consumption of medicines in the enterprise; from diagnosis of one animal to an overall picture of incidence in herd; from planning of preventive treatment to preparation of the annual reporting; from survey of a newborn calf to the analysis of the reasons for disposal of animal; from detection of a disease to treatment cost. Use of IAS "Veterinary science" allows increase efficiency of management decisions in the organization of work of veterinary service and all livestock complex of the agricultural enterprise.

Use of information technologies increases productivity and efficiency of administrative work, allowing solve many problems in a new way [9]. One of the relevant directions of use of information technologies in agriculture is becoming "precise agriculture" which main objectives are optimization of production for the purpose of receiving the maximum profit and rational use of resources, including natural and also environment protection. "Precise agriculture" is considered as an integral part of resource-saving and environmentally friendly agriculture. It allows provide control of performance of agrotechnological operations. In recent years, among technologies which became irreplaceable elements on fields it is possible to distinguish the systems of automatic control of agricultural machinery, the systems of automatic control of application of fertilizers and quality control of field works, mapping of productivity and some other. Today the technics equipped with the systems of automatic control carries out operations with high precision, sowing complexes are capable to turn off automatically crops of seeds on overlappings.

Use of modern digital technologies allows obtain quickly reliable data about the executed amounts of works, about the reaped crop, the spent materials, about a condition of crops of various cultures, location of a large number of various equipment. Thus on this basis it is possible to make the justified management decisions which directly affect the end result of work of the agricultural enterprise.

For conducting "precise agriculture" CJSC "Agrosila Group" uses special devices and technologies on the basis of artificial intelligence. For example, for environmentally friendly weed control this company uses robot "ecorobotix" which has computer sight for identification of plants and manipulators for weeding. Another device is a swarm of robots "prospero" which consists of small cheap robots. These robots carry out the same task at the same time, communicate among themselves and easily replace one another. To hold agrochemical actions the system of uniform introduction "Leopard-5" is used. This device is intended for automatic adjustment of liquid consumption (fertilizers, means of protection of plants and other). This system is successfully combined with the system of parallel driving "the Atlas 730" which keeps data of 9 fields, 12 various dosages, etc.

IV. ANALYSIS AND DISCUSSION OF RESULTS

Now a lot of forecasts of development of digitalization are published [10, 11, 12]. Let's consider only interrelation of results of private forecasts of development of IT-technologies with the offered methodology of an overall outlook.

Private forecasts of development of digitalization usually are based on the analysis of current state, known now results of basic and applied scientific research and define possible quantitative and qualitative characteristics of IoT and IT-technologies and time of their realization. At the same time various methods of the forecast (the Delfi method, extrapolation of trends, etc.) are used [13]. In the considered methodology results of private forecasts are used as basic data in determining future opportunities of IoT and IT-technologies in performance of agrotechnological operations. As the main criteria are offered:

- productivity of agriculture and return from unit of area due to digital agriculture;

- availability to farmers, experts and consultants of mobile and online applications;
- expansion of capacity of traditional domestic markets of sales of products and creation of niches in the international markets;
- possibility of automatic exchange of information between participants of a supply chain and the minimum use of warehouse and logistic infrastructure of intermediaries of a wholesale link.

Unfortunately, in the majority of the known forecasts there are no estimates on volumes of the resources necessary for realization of one or another indicator. It is obvious that the economic indicators characterizing the required volumes of resources and their distribution are necessary for carrying out an overall outlook and, in particular, in determining options of development. It is supposed that elaborating private forecasts of development of IoT and IT-technologies necessary resources will be identified. Thus, performing an overall outlook of development of IoT and IT-technologies and control systems it will be used the technical indicators characterizing change of opportunities of IT-technologies of processing of information, and the resource estimates showing what volumes of resources are necessary for achievement of the predicted technical indicators.

The forecast of development of production of IoT and IT-technologies is the most difficult part of an overall outlook. It is explained by the closest coherence of development of this branch of production of goods with other branches of economy. In this regard the forecast can be carried out only as the approximate based on the general trends of development of national economy and the analysis of the existing capacities of production [14]. It is obvious that the main increase in production of IoT and IT-technologies will be defined by the planned increase in productivity of work that is provided with increase in level of automation of production. The indicators characterizing the forecast of production are: production of IoT and IT-technologies for branches of economy and types of devices; the planned increase in productivity of work; general production capacities.

The following provisions are taken for a basis of an overall outlook of development of IoT and IT-technologies which is carried out on the basis of private forecasts:

- each level of a control system of agriculture is characterized by the information features;
- to information features of level it corresponds quite certain set of IoT technical means and IT-technologies and also the corresponding configuration of a control system which set can be called "a digital set" of level;
- number of types of "digital sets" is limited;
- productivity of "a digital set" is determined by calculated efficiency;
- efficiency defines degree of satisfaction of need of the user with this IoT set and IT-technologies and the available provisions (program, mathematical, information);

- for each level of a control system the number of types of "a digital set" is limited and does not exceed three.

The offered methodology is based on two basic concepts: "digital set" and "efficiency "of a digital set". It is possible to consider that the concept "digital set" more characterizes technical aspect of the system using in the basis IoT and IT-technologies, i.e. structure, a configuration and organizational form of interaction of various technical means in the course of the solution of tasks. The concept "efficiency "of a digital set" characterizes the providing aspect of a system, i.e. those opportunities according to the solution of tasks which the available "digital set" provides to the user. In other words, how providing part and a set of technical means satisfy inquiry of the user and define efficiency of use of a system by it in general.

Application of IoT and IT-technologies in control systems of any type (organizational, technological, technical, information, etc.) demands performance of a number of the conditions defining efficiency of their use. These conditions include:

- an opportunity of formalized (verbal, graphic or mathematical) descriptions of the procedures performed by a system in management process;
- existence of such completeness of IoT and IT-technologies which provides performance of all agrotechnological operations in agricultural production;
- existence of the software allowing to decide (to perform) by means of IT-technologies all procedures of management at all stages of agrotechnological process;

existence of means of communication with the user who does not have special training, and providing the maximum convenience to the last in task solution. The user hereinafter is understood as a certain individual (manager, expert, worker, etc.), and as any technical or other organized system aimed at achievement of the goal interacting with IT technologies in the course of the tasks solution.

It is possible to consider that conditions of completeness of IT-technologies and existence of means of communication correspond to technical aspect of efficiency and are corresponded to the concept "digital set". At the same time conditions about formalization of the description, existence of the software and means of communication define the providing aspect of efficiency and correspond to a concept "efficiency "of a digital set".

V. CONCLUSION

Thus, the offered methodology of forecasting of development of digitalization in agriculture considers set of IoT, IT-technologies and IAS of management on their base as the complex developing system having the complex versatile purposes. Therefore, the main objective of forecasting of such system is identification of such options of development which in the best way provide a compromise between opportunities of satisfaction of the noncoincident, versatile purposes of a system in the conditions of limited resources. Respectively, the solution of an objective can be received for the account of system consideration of a subject to forecasting, assessment of its various features, findings of characteristic factors and accounting of their influence.

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