Artificial intelligence in agriculture of Kabardino-Balkaria: current state, problems and prospects

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Abstract. Kabardino-Balkaria, occupying a little more than 0.07 % of the total area of Russia, produces almost 1.0 % of agricultural products, including 0.85 % of grain (more than 1.1 million tons and more than 1300 kg per person, whereas in the country this figure is only 920 kg), for vegetables it is more than 3.6% (about half a million tons and more than 576 kg per person, whereas in general in Russia it is only about 93 kg), for fruit and berries it accounts more than 8% (producing more than 215 thousand tons and almost 250 kg per person, despite the fact that in the country it is just over 18 kg). All this is achieved not due to the size of the sown area, which accounts for 0.35% in the sown area of Russia, but due to the introduction of new technologies, among which artificial intelligence (AI) plays an important role, ensuring the growth of labour productivity, yield and food production. The industry is in the process of separating the sub-sectors (and segments) associated with the use of AI and the formation of a corresponding subsystem, which in the future may be separated into an independent industry. In this regard, a number of problems arise, first of all, overcoming the transfer of AI created in agriculture, secondly, the transition from the so-called point or localized use of AI to the system, through the expansion and deepening of the use of AI. Apparently, in both cases we are talking about the transition to a new, more perfect form of AI. The above-mentioned issues are described in the paper.

1. Introduction

According to leading scientists, at present the current civilization is moving to the sixth technological mode, one of the most important signs of which is the use of artificial intelligence [1]. The term "artificial intelligence" (AI) expresses the ability of intelligent systems to perform creative functions, traditionally considered the prerogative of people [2, 3].

After analysing the sources on the issue of interest [4, 5], several directions of AI can be distinguished. The first is the development of programs capable of solving creative tasks and performing creative operations. The second is the creation of technical means capable of carrying out creative tasks. The third includes programs and hardware, creating programs and hardware for solving creative problems, i.e. production of AI for the development of AI.

In this study, we consider AI from the point of view of an integrated system in which a program and a material carrier (hardware or a set of hardware) are capable of solving problems that require independent decision-making based on the analysis of the situation and the design of prospects with regard to obtaining a positive effect and without direct human involvement. Another feature of this study is the state and prospects for the development of national agriculture. It is known that in the new
decade, agriculture acted as a growth driver [6, 7], becoming an important currency supplier, increasing its share in GDP, employment, investment, etc. At the same time, it is noted that the main achievements in the field of national agriculture are mainly related to the expansion of agricultural land, an increase in the number of animals, favourable climatic and weather conditions, growth in employment, etc. Of course, factors such as increased yields and productivity are also involved in this process. But the latter are achieved, again, in the traditional way. Therefore, growth is observed in the production of grain and grain legumes, vegetables, fruit, poultry, pork, and other products located on this technological line. The reason for the latter, as well as poor results in other segments and sub-sectors, in the opinion of researchers, is the poor introduction of modern technologies related to the use of AI in the industry [7].

The experience of developed western countries (Germany, Great Britain, Denmark, Holland, etc.) [8-11] shows that the translation of national agriculture to the principles of a new technological mode, with active implementation of AI in the main agricultural processes, allows increasing the volume of agricultural production without increasing the traditional (land, labour) factors (resources) of production. This experience indicates that this trend is global. In international competition, those countries that are the first to introduce AI in national agriculture will win, making this introduction deeper and wider. The paper describes the experience of introducing the elements of AI in the practice of Kabardino-Balkarian Republic (KBR) agriculture.

The KBR agriculture is, first, one of the technologically and organizationally advanced in the North Caucasus and in Russia, and second, in such segments as vegetable growing, fruit growing, as well as individual segments in grain growing (hybrid varieties of corn) it is technologically the most advanced region in Russia. In 2016 in KBR, over 1,300 kg of grain per capita was produced. By grain yield (56.6 centners per hectare), the republic takes up 1-2 places (on par with Krasnodar Territory). In the gross harvest of vegetables, it had the 8th place, in fruit and berries - 4th place. At the same time, the share of sown areas is only about 0.4% of the total sown area of Russia. By cattle livestock it took the 22nd place, in sheep and goats – the 13th place, in milk production – the 25th place, etc. The main source of growth in agricultural production is provided by modern technologies used in the agriculture of the republic. An important segment in the technological structure is AI, which is used in a number of areas and sectors, and although the use of AI does not have a so-called frontal character (it is rather fragmentary and localized), but, first, there are certain achievements that can be expanded and deepened in real practice, second, the directions can be prolonged. In particular, we are talking about scientific experiments that can be implemented in practice and give the result which is not only purely scientific, but is also applied.

The theoretical and methodological basis of the study consists of the provisions formed by cognitive, computer sciences and sciences in the field of artificial intelligence.

2. Results and discussions
As it is shown in a number of works on the current state and prospects of the development of agriculture in the KBR [12, 13], the main engine of growth in the new decade was active modernization of such sectors as vegetable growing, fruit growing, grain growing, pig breeding, poultry farming, as well as individual segments of cattle breeding. Massive inflow of new technologies and investments in the KBR agriculture in the 2000-s created a new trend in the development of regional agriculture, ensuring higher yields, productivity and overall cumulative resource productivity. In the works of domestic researchers, the current model of regional agriculture is conventionally defined as a model of sectoral re-industrialization [14, 15], the main criterion of which is the fastest and greater return on investment. An important element with the re-industrialization of agriculture in the KBR is AI introduction. The transformations provided high places in agriculture of Russia (it steadily enters the pool of developed, advanced and progressive with a growing share of gross output. In terms of production per capita for vegetables and fruits of the KBR, it takes 1-2 places in the ranking of Russian territories) and the economy of the KBR.
In KBR agriculture, there are several main types and a wide variety of AI subtypes. The first type, which we conventionally call adaptable, is characterized by a limited number of factors and conditions that are taken into account by the programme and the linear algorithm of reaction to them. The AI acts as a programme that cannot regulate the parameters themselves, but functions only within the limits of the specified parameters and permissible deviations. This type of AI has found application in the Kabardino-Balkaria Selection and Breeding Centre (KB SBC) for artificial insemination and transplantation of cattle embryos [16, 17], as well as in the territorial fruit cluster. "Centre" has a special laboratory and barns. It functions on the basis of a program in which all information on embryos, donor cows and recipient cows is laid. The essence of SBC AI is, first, to monitor the storage of embryos, where temperature and other modes are monitored, second, to assess the uterine (maternal) population (according to the blood, the laboratory establishes the state of the maternal individual, its ability to carry high-grade offspring), third, the assessment of the likelihood of a positive result or possible nyayce, (as a rule, the accuracy of the result is 98%), fourth, the assessment of the future product. To maximize the coverage of the territory of the republic, and in the future, and the entire North Caucasus in the "Centre" is the creation of 20 mobile mini-laboratories with breeding functions. Veterinary clinics operating in the settlements are integrated into the “Centre,” which are supplied with mini-laboratories and specialists, which allows the population to carry out insemination and transplantation without leaving the settlement.

The same type of AI is used in the territorial cluster associated with the cultivation of apples by the so-called intensive technologies, which are represented by such large companies as “Intensive Kenzhe gardens”, “Fruit-Trade”, “Baksan Gardens”, “Elbrus Garden”, etc. Kabardino-Balkaria leads in laying gardens in Russia. “Intensive gardening in the KBR is more than 90% of all the gardens in the region and over 50% in the North Caucasus Federal District. In recent years, 5-6 thousand hectares of new gardens have been laid. According to the plan, by 2020, the garden will be laid to 10 thousand hectares [18]. In the AI of the fruit cluster, one direction is associated with growing apples and controlling the state of the soil and, in general, regulating nutrition. The other one monitoring the state of the atmosphere, is connected with the protection of the crop against hail and rain with the help of a grid, which is stretched over the apple plantation, as well as with the help of shooting off thunderclouds and transferring them in places safe for plantations.

The second type is additive, characterized by the ability of the AI to assess the state of the main parameters, their interrelation, selects the optimal architecture of the parameters and make changes to individual parameters. The basic characteristics of this type of AI: the ability to (1) assess the state of parameters, their compliance with the standard, evaluate the deviation from the norm, determine the degree and level of deviation, (2) choose the optimal response to deviations, (3) affect individual parameters, (4 a) carry out the calibration, culling of factors and create a rational combination to obtain the result. By the described type AI includes segments in the poultry and crop production. As for the poultry industry, the two companies are most significant: Veles-Agro and Baksan Broiler. In these poultry complexes, the AI does not only monitor the feeding of chickens, but also the process of creating a diet for each category of birds, as well as the process of raising young animals and selling finished products. We are talking about such AI processes as: 1) the formation of food supply and nutrition in accordance with the diet of each individual, depending on its age and condition, 2) breeding and growing eggs and birds, 3) selling grown products (eggs, finished chicks and meat). The basic parameters for regulation are: the state of bird physiology, temperature, humidity, light, etc. These are the so-called external factors for which the program is configured. The program ensures that in the rooms where there are eggs, poultry, feed, there are temperature, humidity, light and other parameters that correspond to the standards. The program works in the mode: "answers - calls". It simultaneously monitors more than a dozen parameters, forming the optimal complex from them. Therefore, if a failure occurs in any parameter, the system signals the appearance of deviations from the norm and the appearance of a critical situation. In this case, the AI of the complex has the ability to carry out the correction of external conditions. By reducing, for example, the humidity of the air in the room, a valve is activated, which lets in additional moisture vapour. When there is an excess, another
valve is activated, which lets in dry air. The same procedure is connected with temperature, lighting and so on. Thus, AI makes regulation of external parameters of the environment.

Along with the poultry industry, this type of AI has been implemented in the livestock complex near Köndelen PF "Zhappueva ZH.H.". It is associated with the robotization of the entire production cycle of milk and raising calves [19]. The AI of the complex is enclosed in robots that work according to a program in which certain parameters of the animal’s condition as well as the condition of the milk are included. When observing deviations both in the state of the animal and in the milk, the robot signals. The duty operator makes a decision. The other side of the complex is in the feed base. The entire food supply operates in a closed cycle, i.e. the program assesses the quality of raw materials, rates of additives, the nature of feed, etc. then gives permission to issue feed.

The third type is self-regulating, self-replicating, characterized by the fact that within certain parameters AI can make independent decisions on (1) combination of parameters, (2) response to changes in parameters, (3) it can combine factor-parameters, create an optimal combination of them for result, (4) form the result of the factors and with the help of the factor, combine the factors. The described type of AI is used in KBR vegetable and fruit complexes, which is represented by Agro-Com [20], etc. The greenhouse complex Agro-Com operates on the principle of a closed cycle. Inside the complex. All operations are automated and connected to a computer. First of all, the program itself regulates temperature and humidity conditions, pressure, lighting and other atmospheric parameters. Second, it regulates the fodder supply of vegetables, monitors the state of the necessary substances in the diet. Third, it evaluates product quality and makes adjustments to other production processes [21]. Its operation is carried out on the principles of norm-deviation. The program contains certain (permissible) deviations from the standards that do not lead to negative consequences for the products. In addition, there are directions in the program, by setting which you can change the size, colour, shape, taste, aging time, and other parameters. The intelligence of this complex, which represents a computer and its programmes, consists, first, of a positive reaction to changes in the atmospheric environment, second, of response to changes in the food base, third, in response to the appearance of plant pests, i.e. the basic principle of the AI is “answers - calls”. It is important to indicate the presence of a wide range of responses. The computer not only signals the appearance of certain calls, but also finds the answers to them and adjusts the state of the system. Of course his work - the answers - is in a certain range. For example, it cannot repair itself, and if a program crashes or in some of the segments, it can only signal the onset of the so-called critical/crisis state in the system, but cannot debug the failure. Then participation of the person - the programmer or the system administrator is necessary.

The fourth type is an independent full-cycle production process independent of human presence. It has two subtypes: one is realized in the production of the so-called “smart grain”, the other in retail and logistics, where the AI evaluates the state of the situation, searches for customers, forms contracts, changes conditions, etc. As for logistics and retail, starting from the livestock complex to vegetable and fruit, there is its own local logistics everywhere. The main task of AI is related to customer service, optimization of supply, inventory of inventory, cost reduction. In some cases, it is also about demand forecasting and advertising. AI began (for example, in “Baksan Broiler”, “Fru-Trade”, Baksan Gardens”, “Agro-Com ”) to master Internet technologies, build a customer base through online stores, prepare product recommendations both in the context of customers and and on the geography of the markets, which are sent to the registered user by e-mail.

3. Conclusions
The first and main conclusion - practice shows that the future development of national agriculture is associated with the development of AI systems. Even today, sectors, sub-sectors and segments in which AI is used demonstrate higher development parameters, growth rates of production, labor productivity, income, profits, lower cost, etc. And in the future, taking into account the reduction in the number of workers, the reduction of acreage, environmental degradation and so on, the value of AI in agriculture will increase. But practice has already shown that there are major flaws in the existing AI system. The first is the fragmentation of using AI. Separate elements and nodes of AI are used, and
There is no holistic one. This means that it is necessary to switch to a new concept of AI in agriculture, in which integrity must be accepted as a basic feature. Currently, there are fragments of AI, which are trying to link into some integral system. But the result is eclectic structures or, at best, conglomerative, but not systemic. As a result, the functioning of the AI as a whole decreases due to the appearance of inconsistencies and the principle of the smallest (A. Bogdanov), when the weak link is decisive in the operation of the system. Thus, a new agriculture AI architecture is needed, which, although formed on the basis of the block principle, would assemble these blocks on a holistic basis. Second, there is no so-called obsession of various sectors and segments into a single chain and a single AI of agriculture. Apparently, the main reason is not in agriculture, but in AI types, in specific AI blocks (for example, vegetables, fruits, grains, etc.). The third is the use of foreign AI and the absence of its original AI systems.

The overwhelming majority, if not all segments, sectors and sub-sectors of agriculture, in which AI is used, function on the basis of foreign programs and their computer systems, i.e. and software, and "iron" foreign. The reason is not that our people do not know how to make programs, but because foreign partners offer products in a certain package, in which the presence of their programs and computers is considered a prerequisite. Thus, they not only sell the product, but also a complete ideology. They form the architecture of AI in our agriculture. This is the principle of competition and we should recognize it as such and try to go out or get around it.

There are two ways to solve this problem. One is to enter foreign companies that implement AI as a shareholder and partner who not only purchases their products, but also offers their own. And in this regard, it is necessary to put a condition: we buy your product, provided that our program is in it. Another is to create parallel structures in China’s experience [22]. We need what is called “across the road” to create similar objects, but with our AI. We need to study at their facilities and hone our experience, etc.

Finally, the fourth, - today the introduction of individual elements and structures of AI in agriculture is confronted with certain technological, organizational, economic, and also ethical ones, including psychological problems that will obviously increase as AI penetrates into the system of traditional agriculture. And in this regard, it is required to provide for these challenges and responses.

Apparently, there are two basic directions in the development of AI in agriculture. One is connected with the so-called decentralization of AI, i.e. each object has its own AI and functions on its own AI. Thus, a situation is created which can be defined as “multiple intelligence”. Objects (enterprises, complexes, etc.) compete not only (and now not so much) with their products, technologies, but with also its AI. The one who has more competitive AI wins. Another direction - the opposite of the previous one, is to create a centralized AI. All existing AI, which operate in the system of agriculture (in its various objects: enterprises, concerns, etc.) are integrated into a single AI. As a result, a “single mind” is created, which observes, coordinates, controls, etc., in a word, manages private AIs located in separate objects (enterprises, concerns and complexes) of agriculture. Which of the directions will be decisive today is obviously premature to say. One thing is true, both directions will evolve. But which of them will be more effective, the time will tell.

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