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ECONOMY. ECONOMIC SCIENCE. OTHER BRANCHES OF THE ECONOMY

POWER ENGINEERING, ELECTRICAL ENGINEERING, AUTOMATICS.

ENVIRONMENTAL PROTECTION. WATER MANAGEMENT, HYDROLOGY

AN INSTITUTIONAL AND ECONOMIC FRAMEWORK FOR THE DEVELOPMENT OF GLOBAL VALUE CHAINS IN FOOD AND AGRICULTURE

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Abstract

The article deals with the processes of exchange of agricultural products, which are carried out in several countries. Also, the types of formation of the value chain are considered: forward and backward participation in the trade of other countries, ways of delivering the added value created within the framework of the GVCs to the final demand, Due consideration was given to the role of services in agri-food production, as well as their share in value chains. Some factors that may influence the increase or decrease in the flows of international trade in agri-food products are analyzed.

Introduction. Since the 2000s, international trade in agricultural commodities and food has increased several times in real terms over the last period. Over time, economic entities increasingly resorted to the mechanisms of international trade to increase specialization and use their comparative advantages, dividing the production process into stages and choosing a place to organize each of them in such a way that production is the least expensive. As a result, production processes have become cross-border and global value chains (GVCs) have emerged, i.e., stages of the production process are located across different countries. In the food and agricultural sectors, there are also have GVCs.

Theoretical basis. The 2020 OECD report on the role of global value chains in the production of agricultural products and food reveals 2 stages of the development of fragmentation of production. So, for agri-food sectors, the initial unbundling was primarily characterized by commodity trading and supported by the development of standards and grades. These developments allowed the mixing of products from different origins in bulk shipments, facilitating their transport and use for final consumption or in other production activities. The second stage corresponded to a de-commodification process, with the increasing importance of information about the way food is produced and supported by a range of developments in contracting and marketing arrangements that helped build trust among value chain participants. This resulted in the integration of various agri-food chains with marketing channels and led to an increase in the importance of services both upstream and downstream in the chain. This second unbundling was further driven by innovations in the agri-food sector and improvements in trade logistics.

Revealing the content of the elements of individual links in value chains, the authors of the OECD report emphasize that the cost of an individual product consists of the sum of the costs of several resources, some of which are local (local raw materials, production equipment, labor, working capital, etc.), and some are imported (ingredients, imported equipment, and services, spare parts, etc.). consumables, consulting services, attracted international capital, etc.) Gross trade values are made up of the sum of the value of all those inputs. Understanding GVCs requires unpacking these various elements so that the amount of local transformation can be identified for any given product traded. This approach allows estimation of trade in value added terms.

There are two parts from any given country's perspective:

• a forward looking part that shows the extent to which a country's exports form part of a production process in another country, contributing to that other country's exports

• a backward looking part that shows the extent to which imports from other countries are used in the production of a country's exports.

Broadly, the backward participation index is measured as the shape of foreign value added that is included in the total export value of a country. The forward GVC participation index is measured as the share of a country's value added arising from its own exports included in exports of other countries.

The calculation of value added exported for a sector includes both that embodied in direct exports and that which is captured in the exports of other using domestic industries. For example, if the paddy rice industry exports directly into a production process in another country that exports to a third country, but also the processed rice industry exports rice that it sources domestically to that same foreign processing industry, the value added attributed to the domestically sourced paddy rice within processed rice exports are included in determining the forward participation of the paddy rice industry.

Results. The source of value added in final demand can be broken down into the different paths to final demand created by GVCs. These include:

• bilateral path – GVCs that cross two countries and link producers in one country to final consumers in the other;

• other country path – GVCs that cross three or more countries and link producers in one country to final demand in another country via processing that occurs in a third (or fourth or so on) country;

• import own domestic value added path – GVCs that link producers in a country to domestic final demand via a second (or third or so on) country.

According to the OECD report, the most common GVC path is the first – the bilateral path. This accounts for 96% of all domestic value added that ends in foreign final demand (in 2011), compared to 93% for non agri-food products. Imports of own value added, the third path, are relatively small across the world.

Agri-food GVCs are made up of more than just food and fiber –services also matter. Agri-food GVCs extend well beyond these sectors, with linkages to a wide variety of other sectors. For example, even at the farm level, many sectors contribute to production. The production makes use of fertilizers, machinery, and advice from farm consultants such as agronomists, along with applications of new farming methods derived from research and development sectors. Farmers also seek advice from accountants, market analysts, and climate specialists, and use information and data when

making decisions. Once a product leaves the farm, the transport sector is involved and feeds into a wider production system that, in the case of cattle, may extend from the abattoir for meat to the car industry, which uses hides for leather seats and steering wheels.

Unpacking these linkages provides a means to explore what goes into the products end consumers buy. Focusing just on the final consumption of food and fiber,4 the average share (globally) of $1 of agri-food products consumed shows that, while agriculture is important, it does not represent the largest value addition to the food we eat or the clothing we wear. In developed countries, the value contributed by the agriculture sector is on average 26% of the final value, with the contribution of food processing sectors at around 30% (Figure 1). In developing countries, agriculture represents a larger share of the value of the final product – most likely associated with the lower level of product transformation that occurs, rather than differing market structures with, for example, a much higher share of production going straight from producers to consumers through local markets.

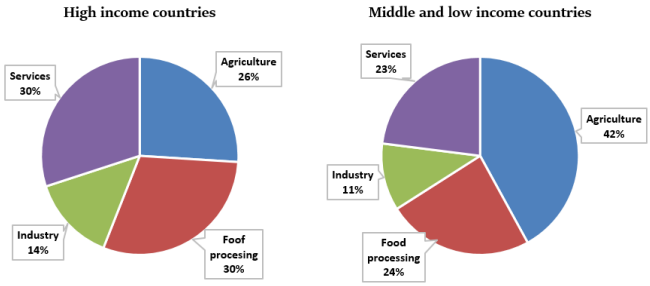

Figure 1. Distribution of returns from final demand along the value chain, 2014[3].

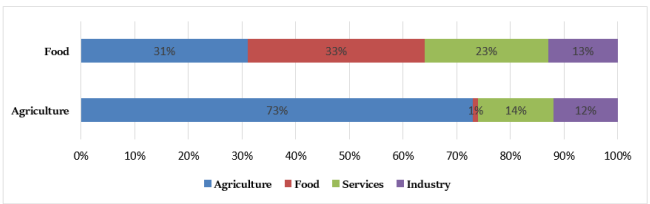

Figure 2. Distribution of average gross export value Share of USD of export value across broad sector groupings[2]

* OECD (2020-02-04), "Global value chains in agriculture and food: A synthesis of OECD analysis", OECD Food, Agriculture and Fisheries Papers, No. 139, OECD Publishing, Paris.

Globally, four major service sectors provide inputs into agricultural production and therefore exports. These include trade (all retail sales; wholesale trade and commission trade; hotels and restaurants; repairs of motor vehicles and personal and household goods; retail sale of automotive fuel), transport, financial, and business services (Figure 3). These four sectors accounted for over 86% of service provision to the world's agricultural exports in 2014 – a figure that has remained stable over time.

Most of these services are provided by the domestic market. In 2014, on average, 80% of the services provided to agriculture and 73% to food were sourced from the domestic market. This underscores the importance of the quality of the domestic services market for agri-food production, including for its international competitiveness.

* OECD (2020-02-04), "Global value chains in agriculture and food: A synthesis of OECD analysis", OECD Food, Agriculture and Fisheries Papers, No. 139, OECD Publishing, Paris.

Increasing service use along the value chain, as represented by an increase in the service share of exports, is beneficial for domestic value added growth. This highlights that the development of GVCs in the agriculture and food sectors is not just about mechanization and investments to promote efficiency. The "de-commodification" of output means that it is not only about what is produced, but how it is produced and how it gets delivered to export markets or final consumers wherever they may be. Agricultural production and trade have grown significantly over the past decade. According to the World Bank (2021), the value added by agriculture, forestry, and fishing increased from $1.13 trillion in 1990 to 1.14 trillion dollars in 2000 and to $3.7 trillion in 2020 (at current prices. Figure 4).

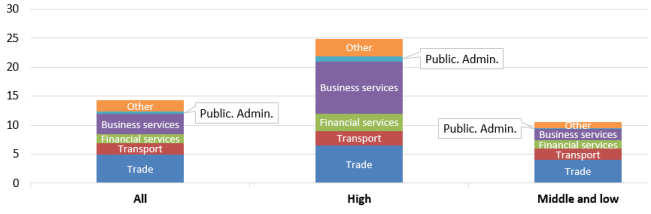

Figure 3. Major service inputs into agri-food exports by broad country groupings, 2014 Global weighted averages expressed as a share of total industry domestic value added[2]

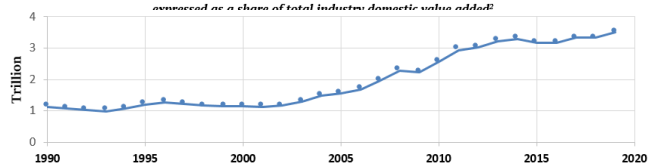

Figure 4. Agriculture, forestry, and fishing, value added World Bank national accounts data, and OECD National Accounts data files4.

*Agriculture, forestry, and fishing, value added (current US$), World Bank national accounts data, and OECD National Accounts data files.

The Food and Agriculture Organization of the United Nations (FAO, 2019) indicates that the value of global agricultural and food trade flows has increased fivefold over the past three decades. The report shows that food exports (excluding fishing) in 1997 amounted to $304 billion. This figure increased to $618 billion in 2007 and to $1.26 trillion in 2017.

Vincent H. Smith, Joseph W. Glauber (2020) cite data showing the importance of agricultural trade. In 2018, almost a quarter of global wheat consumption came from imports. As for rice, global import penetration (imports as a percentage of world consumption) more than doubled from 4% to 9% between 1995 and 2015, and soybean imports increased from 25% of world consumption in 1995 to 42% in 2018. The import penetration of vegetable oils has also increased significantly. Imports of meat, beef, and pork increased compared to world consumption, but the penetration of chicken imports remained relatively unchanged at 10%, even though world consumption of chicken doubled. In 2015, world food exports from developing countries were almost 40% (26% in 1995). Their share in world food imports also amounted to 40% in 2015 (31% in 1995). Trade between developing countries increased, accounting for more than 20% of total trade in 2015 (11% in 1995). Exports from developing countries account for more than 80% of world exports of rice, 70% of sugar, 50% of oilseeds, 46% of cotton, and 64% of tobacco exports. The authors conclude that the contribution of developing countries to world trade in agricultural products has made global supplies more diversified, which reduces the risks to food security.

The OECD asserts that the food and agricultural sector is increasingly organized within the framework of global value chains (GVCs), in which different stages of the process

of converting raw materials into final consumer products are located in different countries. The separation of production, transformation, and delivery was facilitated by the reduction of barriers to trade and investment, as well as the development of contract activities, marketing, and logistics.

The data show that about 20% of exports are re-exported by the first importing country. Services are becoming an increasingly important component of agri-food GVC. They account for about 25% of the total value added in agricultural exports and 35% in food exports. In addition, the services sector accounts for 30% of the final value of agri-food products in high-income countries and 23% in developing countries.

Discussion. Given the wide range of factors affecting agri-food GCDs and the fact that countries may suffer from barriers to other countries' exports, comprehensive and collective action is key to helping all countries benefit from agri-food GCDs.

1. Non-tariff measures (NTMs) are generally higher for agricultural and food products than for many other sectors and often exceed tariffs. They can support or hinder trade, depending on their design.

2. Safety and quality standards can increase consumer confidence, thereby increasing demand. However, unreasonably high compliance costs can lead to higher prices and limit firms' participation. The underlying principles of regulatory development can help to ensure that NTMs facilitate trade and participation in the GCDS without impeding a country's right to regulate. These principles include transparency and predictability, non-discrimination and proportionality (i.e. rules based on scientific evidence and consistent with agreed international standards).

3. Government support policies need to facilitate participation in GVCs and manage associated adjustments across the food and agriculture sector Domestic agricultural support policies need to be carefully designed. Distorting agricultural subsidies have a harmful effect on the growth of agricultural value added, and particularly on export returns from participation in GVCs that involve domestic processing sectors. This reduces sector competitiveness and harms downstream sectors over time. Subsidies linked to outputs and inputs create market distortions and have a negative impact on labor returns from GVC participation, and hence a longer run negative impact on the employment and wage growth opportunities from trade and GVC participation.

4. The enabling environment to support agricultural production is likely to be a key determinant of the economy wide gains from agricultural and food GVCs. Physical infrastructure, such as quality ports, roads, railways, and airports, plays a key role overall and particularly for economic actors in marginal areas – indeed quality physical infrastructure has been found to have a positive influence on domestic value added creation from GVC participation by agri-food sectors.

5. Telecommunications technology and Information technology (IT) infrastructure that enable consistent access to digital information also support the co-ordination of complex and dispersed production processes. Services, such as transport, telecommunications, finance, and insurance, are essential inputs for economic activities and knowledge-based services contribute to value addition by helping differentiate products for specific markets and consumers. Services represent around 25% of the total value-added in traded agricultural products and around 35% of food sector exports, with restrictions to services trade negatively influencing domestic value added creation in agri-food GVCs.

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ANALYSIS OF WORLD DEVELOPMENT OF THE BEEKEEPING INDUSTRY

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Abstract

To solve theoretical and practical issues of increasing the efficiency of regional beekeeping development, an analysis of the economic state of the beekeeping industry, as well as factors affecting the dynamics of its development in the five leading honey exporting countries. The paper shows some sectoral features of the functioning of beekeeping and the dynamics of the sale of its products, organizational and economic mechanisms for the interaction of agricultural producers and processing enterprises.

Keywords: *beekeeping development, beekeeping products.*

Introduction. The development of agriculture and the improvement of food supply to the population is one of the priority state tasks. Beekeeping has a high value due to the resulting marketable products and the creation of opportunities for natural pollination of crops in order to increase their productivity. Therefore, areas of intensive agriculture have great potential in the development of the industry. Honey bees pollinate 80% of entomophile's crops, thereby making an irreplaceable contribution to the production of berries, vegetables, fruits, plant seeds and forage crops, while not only increasing the yield of cross-pollinated crops by up to 50%, but also improving the quality of seeds and fruits. The cost of additional harvest from bee pollination exceeds the cost of direct beekeeping products by 10–12 times. Thanks to bees, a third of the food consumed by mankind is produced.

The relevance of the problem of the effectiveness of the development of regional beekeeping is determined by the increasing importance of its products for nutrition and treatment of the population, ensuring the country's food security, and improving the supply of raw materials to a significant number of industrial sectors. Under the conditions of Uzbekistan's wish entry into the World Trade Organization (WTO), the activation of the development of beekeeping is necessary for the formation of parity relations in the international beekeeping market, in which, despite economic difficulties, the country can occupy one of the leading places in the world. In addition, the implementation of the State Program for the Development of Agriculture and the Regulation of Agricultural Products, Raw Materials and Food Markets for 2020-2022 has not yet been provided with applied scientific tools for the development of the beekeeping industry.

Increasing the effective level of development of regional beekeeping does not require large budget expenditures and can produce a positive social and economic effect in the short term, including by increasing the level of employment in rural areas. Compared to other branches of agriculture, beekeeping is less laborious - it can be done by various categories of the population, including pensioners, teenagers, housewives, etc. Modern technologies for breeding and keeping bees do not require the use of hard physical labor.

Study area. The object of the study was the organization of the functioning of the beekeeping industry in the five leading honey exporting countries - China, New Zealand, Argentina, Germany, Spain. The study is based on the principles of dialectical logic, systemic and institutional approaches to the analysis of economic phenomena and processes; analysis and generalization of theoretical provisions and empirical experience in the development of the industry in countries with developed beekeeping. To achieve new scientific knowledge, scientific approaches were applied that are justified and widely used in modern scientific research: economic, statistical and analytical methods, selection, distribution, comparison, generalization, problem-hypothetical knowledge, forecasting, graphic description.

Results. The demand for bee products is formed by two categories of consumers: 1) those who consume honey as a food product; 2) purchasing bee products as raw materials for further processing in the food, cosmetic, pharmaceutical, paint and varnish and other industries. Recently, the need for the last category of consumers, concentrated in large settlements, has increased, which leads to the need to attract intermediaries and develop the beekeeping market infrastructure. One of the criteria for the competitiveness of an industry or agriculture is the export of its products. This also applies to beekeeping. The development of the beekeeping industry in a single country can be judged by the volume of honey supplies abroad. According to the consulting company WTEx (World`s Top Exports) (Table 1), in 2019 natural honey was produced in the world for 2.2 billion US dollars. Export of honey amounted to 825.3 million US dollars, or 36.8% of the value of honey produced in the world.

Table 1.

The share of top countries in the world honey exports, 2019

#	Countries	Honey export (million dollars)	Share in hole products, percentage
1	China	276,6	12,3
2	New Zealand	206,7	9,2
3	Argentina	168,9	7,5
4	Germany	144,9	6,5
5	Spain	109,0	4,9
6	Ukraine	108,2	4,8
7	Mexico	93,7	4,2
8	Brazil	92,0	4,1
9	Turkey	75,9	3,4
10	Russia	74,2	3,3

The share of the continents in the world export of honey in 2019 is: Europe - 36.8%; Asia - 23.5%; Latin America (without Mexico) and the Caribbean - 14.5%; Oceania (mainly New Zealand and Australia) - 10.6%; North America - 7.8%; Africa - 6.8%.

Beekeeping in China. China is the world leader in the production and export of honey. In 2019, the country produced about 450 thousand tons of honey, and exported honey to other countries in the amount of more than 276 million US

dollars. The country's share in world exports is 12.3%. The number of bee colonies in China reaches 9 million, most of which are accumulated by amateur beekeepers. The center of Chinese beekeeping is Zhejiang Province. Here there are 1 million bee families, 15 thousand beekeepers and up to 1/3 of the total volume of honey collected in the country is produced. About 2 thousand small and medium-sized companies, as well as 10 large companies with a product turnover of more than 15 million US dollars per year, are engaged in processing and marketing of bee products, for example, Dalian Sangdi Honey bee Co., Ltd. The number of beekeepers employed in the industry is about 300 thousand people.

The state does not provide direct financial assistance to beekeepers, but in turn finances veterinary services, the promotion of new scientific developments and the training of qualified specialists. Honey in China is not taxed, which favorably affects the development of the beekeeping industry in the country. Standards aimed at increasing the quality of products sold have been approved. These measures allowed Chinese beekeepers to enter the world market, which was a significant impetus to the development of the industry in the country. About 50% of Chinese honey is exported. The main importing countries of Chinese honey: Japan, Great Britain, Belgium, Spain, Thailand, Thailand, Germany, the Netherlands, Poland, Portugal.

Beekeeping in New Zealand. About 19.8 thousand tons of honey were produced in the country, and honey was exported in the amount of 206.7 million US dollars. According to this indicator, New Zealand ranked second after China and far ahead of Argentina, Germany and Spain. According to the Ministry of Basic Industries, the assets of the beekeeping industry for the period from 2010-2016. increased from 75 million to 1.2 billion New Zealand dollars (50 billion rubles). The country's share in world exports is 9.2%. The number of beekeepers and beekeeping farms employed in the industry is 8.5 thousand. Of this number, 29 farms are classified as large. They account for 34% of the bee colonies in the country. In the largest of these farms, there were 30 thousand bee families. The number of bee colonies in the country is about 820 thousand. According to the forecasts of the management of Beeline Supplies, by the end of 2018 the number of bee colonies in the country may grow to 1 million. Owners of 50 bee colonies become members of the association automatically. There are also 16 regional branches. The budget is formed from membership dues.

The second category of beekeeping enterprises includes specialized farms, pilot farms, bee nurseries, bee farms and bee complexes, apiaries at diversified agricultural enterprises (20%). A large number of farms are provided with modern means of production, staffed with qualified personnel, actively introduce innovations, achievements of science and best practices of domestic and foreign beekeeping. In the countries under study, the beekeeping industry does not stand still and is being reformed in accordance with the model of economic integration between countries: the number of amateur beekeepers is declining, and the number of professionals tends to grow, respectively, the size of apiaries and the number of bee colonies contained in them are increasing.

An increase in honey production and a decrease in its cost in the countries under study is carried out by creating a synchronized legal framework for beekeeping, liberalizing the honey trade, rationing beekeeping equipment and equipment, increasing the level of automation and mechanization of the industry, joining forces in the fight against bee diseases, training qualified personnel, etc. .

One of the main features of the effective development of the industry is that beekeepers unite into associations (societies) in various areas of activity: production, processing of products and raw materials; introduction of achievements of science and innovations; training and retraining of qualified personnel; environmental protection; control of diseases and pests of bees. The association of beekeepers in associations (societies) allows them to adapt to the conditions of the modern market. The technological chain of activities of such formations, as a rule, has a specific purpose and provides each of the participants with higher final results.

In countries with developed beekeeping, effective relations have been established between this industry and other sectors of the national economy, and its worthy place in the domestic and foreign markets has been secured. For a more rational placement of bee colonies in places with a rich honey base, permanent economic relations have been established with the branches of crop production regarding the pollination of entomophilous crops, with horticulture, grassland, forestry, park and reserve farming. It is practiced to pay beekeepers for pollination and rent of bee colonies for the period of flowering of melliferous vegetation.

Conclusion. The experience of beekeeping development in the five leading honey exporting countries - China, New Zealand and other countries - confirms that in order to further effectively improve the industry in the country, it is necessary to develop a typical economic model for the development of regional beekeeping.

In modern market conditions, the main directions for improving the efficiency of regional beekeeping are associated with increasing the competitiveness of the industry's products in the domestic and foreign markets. The main directions of development of beekeeping in the region include the intensification of production; deepening the specialization of agricultural enterprises and increasing the concentration of production; rational distribution of economic facilities throughout the region; improvement of the organization of work. The development of beekeeping in the region is associated with the observance of scientifically based standards, in accordance with which the industry is formed and functions. As basic rules, the norms are aimed at extended production. These include organizational, characterizing the conduct of beekeeping in general; organizational and technical, reflecting the internal content of the system of production and management of the industry; social, related to the responsibility of business entities, and others.

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FEATURES OF THE APPLICATION OF GAME THEORY IN THE PROBLEMS OF THE ORGANIZATIONAL AND ECONOMIC MECHANISM OF THE GREENHOUSE INDUSTRY IN THE REPUBLIC OF UZBEKISTAN

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Abstract

The article analyzes the current organizational and economic mechanism for the functioning of greenhouses in the Republic of Uzbekistan. With the help of game theory methods , the problem of optimal cultivation of vegetables and fruits in a greenhouse has been solved. The subject of the study is the organizational and economic mechanism for the functioning of greenhouses in the Republic of Uzbekistan. The purpose of the work is to identify the problems of development of the organizational and economic mechanism for the functioning of greenhouses in the Republic of Uzbekistan with the help of game theory. According to the decree of the President of Uzbekistan dated November 20, 2018 "On measures to create additional conditions for the development of greenhouse complexes", another 105 modern greenhouses worth $343.3 million will be created in the coming years. New complexes, according to the document, will occupy another 800 hectares of land. A significant part of them (47 per 405 hectares) with a total value of more than 230 million dollars will be created in the Tashkent and Samarkand regions. Methods: game theory methods, payoff matrices, analysis, comparison. Results (Findings) : with the help of game theory, the problem of optimal cultivation of fruits and vegetables in a greenhouse has been solved. Conclusions: The use of game theory can be of great help in building production and financial plans in the greenhouse industry.

Keywords: *greenhouse farming; agricultural commodity producers; game theory; organizational and economic mechanism; vegetables and fruits.*

Introduction. Due to the tense economic and international situation, food supplies today occupy a special place in the priorities of public policy. In solving the problem of increasing the self-sufficiency of the population with food, the main role belongs to areas in which the effective economic and economic activity of agricultural producers is of great importance for the economy. Today, business entities need to create conditions that ensure a consistent process of continuous reproduction of agricultural products. That is why it is necessary to have appropriate organizational and financial mechanisms for the sustainable development of the industry in the region (5, p. 1378).

The term "organizational and economic mechanism" of agricultural development should be understood as the interaction of problems of production relations based on economic and administrative-legal levers and effective forms of organization of social production processes that ensure the sustainable development of agricultural sectors (3, p. 45). The main functions of the organization and financial management are: creating favorable economic conditions, increasing the efficiency of production activities, ensuring the competitiveness of products, increasing the interest of employees and teams in the high economic performance of the enterprise, ensuring the high quality of the company's transformation, material and technical base.

In this paper, a study is made of the possibility of using game theory in the problems of the organizational and economic mechanism of the greenhouse industry.

Materials and methods

The following situation was chosen to solve the research problem. A transition to new agricultural machinery is envisaged. The experts found that if successful , there is a chance that (70%) will receive 1.5 of the profits that can be made with old equipment. Otherwise (30%), the company will lose 0.3% of profits if the equipment does not meet expectations (often failing, producing defective products). At the same time, you can use additional equipment maintenance services with a one-time profit of 0.5, the success rate in this case will be 90%. It is also possible to partially install new equipment. In this case, the probability of success will be 60%, the profit will be 1.1, and the loss will be 0.05. The cost of additional services in this case will be 0.3 of the standard profit, and the chances will remain the same. The best option needs to be determined .

Literary review

The agro-industrial complex is an integral part of the productive forces of the Republic of Uzbekistan, is subject to the general laws of the economic development of the region and is specific, with its own characteristics. Today, the economic situation of the greenhouse economy in the region is characterized by instability, economic growth problems continue to exist, and the organizational and economic mechanism should create conditions for an effective economic system in the industry. The level of profitability of agricultural organizations, including subsidies, in 2019 reached 5.9% of rural households (21.8%). Without state support, production efficiency was -32% in agricultural enterprises and -29.6% in agricultural holdings. This shows that the mechanism of financial management in the region does not fully meet the tasks assigned to it and is characterized by the destruction of agricultural potential, the problem of adapting agricultural products to market conditions, and inefficient fiscal and credit policies (17, p. 104).

In today's economic conditions, only those business entities that introduce innovations and major scientific and technological achievements based on the use of new generation technologies and efficient production methods that allow rational use of resources and reduce costs can meet the requirements of competition. Therefore, the modernization of the technological sphere of production, associated with the transfer of agricultural enterprises to new generations of equipment and technologies, plays an important role in the sustainable development of the greenhouse industry.

It is recommended to include the technical and

technological modernization of production, the development of information systems and marketing activities in the region's agriculture in the group of innovative industries to improve the organizational and financial mechanism. The development of agriculture largely depends on the state of the material and technical base of farms and, above all, on the safety and availability of a fleet of engines and tractors. In 2019, in agricultural organizations, compared to 2018, only 4 tractor fleets increased by 4 units, in agricultural (agricultural) enterprises - by 12 (10, p. 490). In such conditions, the formulation of problems with the help of game theory helps a lot.

Results and analysis

According to the task, calculations are carried out (from left to right, the standard profit is taken as 100):

1) 127.5-12-50=65.5
2) 120-16-50=54
3) 93.5-0.75-30=62.75
4) 66-2=64

According to the information provided, the best option for the company would be to switch to new equipment using additional services. However, the final prices for other options do not differ much from the optimal ones, so they can also be taken into account. You don't always have to rely on data from a single analysis. It would be advisable to conduct a comparative analysis of old and new equipment. Approximate indicators for comparing equipment can be (13, p.63):

1) the value received as a result of the operation of the equipment;
2) reliability
3) maintenance
4) the cost of consumables and replacement parts and their availability on the market;
5) ease of use
6) useful life of the equipment.

It is also worth considering the use of additional services that allow you to quickly resolve problems with equipment, orienting employees on the correct use and maintenance of equipment with the possibility of improving it. However, it is possible that the services will be provided not in accordance with the contract, but "through the sleeves", and it may be necessary to strengthen the quality control of work, which may increase the cost.

The choice of partially used equipment from a purely logical point of view will be the most correct, since before a complete transition to something new, it is necessary to test the equipment, determine the nuances of work, compare indicators based on the results of old and new equipment, prepare curators for equipment that will train staff on working with new equipment. If deficiencies are found, there is no need to completely recall or modify all equipment, which will cost the company high cost or downtime. Partial application is widely used when changing the management of a company and is very effective because it pushes the company to grow and improve, while guaranteeing stability in the company's work (4, p. 127).

There is also an option to reject the application. In this case, the company has nothing to lose, but never gains. This option is used in a conservative policy, it makes sense when the company receives a stable income and does not seek to increase profits. Deciding to be inactive about something can have a positive effect. For example, some companies look to other companies to innovate and track the success of their applications. Thus, such companies with a conservative strategy minimize the risk associated with innovations by applying them after their effectiveness has been proven, and have received several fixes to work consistently.

Summing up all the options, I can't recommend any particular one, since each case has its own specifics that should be taken into account. When making decisions, it is sometimes dangerous to approach all issues with a universal template solution based on analysis; it is worth considering all the nuances of the problem if it is directly related to production, that is, to the main activity of the company, as in this case.

Strengths: • a stable number of orders from regular customers • product simplicity, wide application • A small company allows you to manage it more efficiently	Weak sides: • narrowly focused production as a result of the inability to maneuver in case of low demand • limited number of suppliers and consumers • consumer addiction
Capabilities: • Expansion of production when new orders appear. • Expansion of the product range • new consumer contracts	Threats: • emergence of new competitors for vegetable growing • appearance of product substitutes • decrease in demand for vegetables • Delays in deliveries of raw materials from suppliers • invisible circumstances

Figure 1. Matrix "Business Screen"

The effectiveness of this method lies in finding the best option in the face of complete uncertainty. This method is used when there are many alternatives and several possible scenarios that, as a rule, cannot be influenced. The effectiveness of the method directly depends on the accuracy of predicting the alternative in a particular scenario. For example, with a specific demand, it will be possible to achieve a certain volume of production (18, p. 236).

The choice of the optimal strategy is adapted to many criteria, based on which you can determine the best option. You can also use weighted criteria scores if the topic prefers some criteria over others.

For greenhouses, the criteria for choosing the optimal strategy are applied in cases of product selection when the demand for them is unknown, when expanding production and expanding the range of products. An important factor in the effectiveness of this method is the accuracy of predicting the results of choosing an alternative under certain conditions. The statistics of recent years, observations and conclusions of expert groups contribute to the greatest accuracy. However, the expansion of trends may not always give accurate forecasts, especially in our time. Therefore, it is also worth considering current trends, experience in the development of the industry.

Discussion. The greenhouse sells its products through stores. Sales are subject to weather conditions. The cost of growing vegetables is $\alpha 0$, and fruit - $\beta 0$ rubles, the selling price corresponds to $\alpha 1$ rubles and $\beta 1$ rubles, respectively. Determine the best business strategy.

$a = 1000$, $b = 2300$, $c = 1400$, $e = 700$,

$\alpha 0 = 20$, $\beta 0 = 5$, $\alpha 1 = 40$, $\beta 1 = 12$.

We compose a mathematical model of the problem. With regard to possible demand conditions, the company has two strategies.

1. F1 = (1000, 2300) - produce 1000 vegetables and 2300 fruits,
2. F2 = (1400, 700) - produces 1400 vegetables and 700

fruits.

Nature (the market) also has two strategies:

1. D1 = hot weather,

2. D2 = cool weather.

If the company adopts the F1 strategy and the demand is indeed in the first state, i.e. the weather is hot (D1), then the products will be fully sold and the revenue will be w11 = 1000 · (40-20) + 2300 · (12-5) = 36100 .

If the company adopts the F1 strategy and demand is in state D2 (weather is cool), then the fruit will be sold only partially, and the income will be: w12 = 1000 · (40-20) + 700 · (12- 5) - (2300-700) . 5 = 16900.

Similarly, if the company chooses the F2 strategy and nature chooses the D1 strategy (the weather is hot), then the income will be (vegetables will be lower):

w21 = 1000 · (40-20) + 700 · (12-5) - (1400-1000) · 20 = 16900, and if nature chooses strategy D2, then

w22 = 1400 · (40-20) + 700. (12-5) = 32900.

Since the maximin strategy in the game is a = max (16900, 16900) = 16900, and the minimum strategy is b = min (36100, 3290) = 32900, then the value of the game is in the range

16900 den units <v <32900 den . units

We solve this game analytically. The average performance of the first player, if he uses the optimal mixed strategy x′ = (x1′, x2′) and the second player, the pure strategy corresponding to the first column of the paytable, is equal to the value of the game v:

36100 · x1′ + 16900 · x2′ = v.

The first player gets the same average odds if the second player uses the strategy corresponding to the second column of the payroll, i.e.

16900 x1 + 32900 x2 = v.

Thus, the company optimally grows 1218 kg of vegetables and 1427 kg of fruit.

Conclusion.

Summarizing the results of the study, we can formulate the following conclusions. The agricultural sector is the most promising in the economy of the Republic of Uzbekistan. Game theory is widely used in the innovation economy. In recent years, its importance has increased significantly in many areas of economics and social sciences. In the field of finance, this applies not only to solving general financial problems, but also to analyzing the strategic problems of companies, which contributes to the choice of the main production sector and the adoption of optimal management decisions. The application of game theory contributes to the successful development of the greenhouse industry.

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TRENDS IN THE DEVELOPMENT OF THE AGRICULTURAL SECTOR OF THE REPUBLIC OF UZBEKISTAN

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Abstract

At present, the priority for substantiating the prospects for the development of the agrarian sector, which occupies practically the main positions in the country's economy and has a multiplier effect for related industries, is a strategic approach that allows the most real way to respond to the challenges of a dynamically changing external and internal operating environment. The article is devoted to the development trends of the agricultural sector of Uzbekistan and the disclosure of priority areas established in the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030, the tasks and organizational and economic mechanisms for their implementation. The results of the study are formed in the conclusions and recommendations for further ensuring the development of the agricultural sector in Uzbekistan.

Keywords: *agriculture, agrarian sector, agro-industrial complex, development strategy, dekhkan (personal subsidiary) farms, farms, crop production, animal husbandry, state support.*

Introduction. The role of the agricultural sector of the economy, both before and in modern conditions, can hardly be overestimated. The agricultural sector as a whole occupies a strategic position in the economy of any state, since agriculture acts as the main production system and performs the main task - ensuring food independence, and this is the key to the national security of the country. These goals can only be achieved through the formation of a stable and efficient agricultural production.

The level of well-being and quality of life of the country's population depends on the level of development of the agricultural sector. In addition, the development of the republic's industry as a whole depends on the development of agriculture, where a large part of the population is engaged in the processing of cotton, meat, milk, wool, astrakhan fur, mulberry cocoons, raw hides, etc. Therefore, as world experience shows, agricultural growth can have a large multiplier effect in stimulating industrial growth.

Another factor that characterizes the relevance of agricultural development is the surplus of labor in rural areas. The population of rural areas of the republic is young, more than 55% of them are under 30 years old. The country also has a high birth rate (23.3 per thousand), respectively, there is a significant number of the younger generation. Therefore, saturation of the domestic market with food, achieving self-sufficiency in the field of their production and ensuring food security are priority areas in the development of agriculture. The effective implementation of these areas will make it possible to fully resolve acute social issues, including the employment of the population, improving its well-being, and the improvement of cities and villages. In this regard, the analysis of trends and prospects for the further development of agriculture is a priority for the economic development of Uzbekistan, which determined the relevance of the material in this article.

In Uzbekistan, a significant breakthrough in the economy and its sectors, including agriculture, is due to radical structural shifts in their development as part of the implementation of national strategic priorities. The tasks for the modernization and intensive development of agriculture for the period from 2017 - 2021 are identified as a priority for the development and liberalization of the economy, established in the Action Strategy for the further development of the Republic of Uzbekistan [1]. Measures for and their solution are reflected in a significant number of legal documents adopted over the past four years in the country. They concerned the reform, modernization and intensive development of all areas of agriculture and were aimed at improving the system of public administration, the widespread introduction of market relations, strengthening the legal framework for relationships along the chain, producing, processing and selling agricultural products, attracting investments into the industry, introducing resource-saving technologies, providing producers of agricultural products with modern equipment, etc.

Literature review. Agricultural production is the initial branch and determines the beginning of all social production. Nobel Laureate in Economics Gunnar Myrdel argues that "The outcome of the struggle for sustainable long-term development will be decided in the agricultural sector" [2]. Before revealing the dynamics of the development of the branches of the agricultural sector of Uzbekistan, a few more quotes from famous people on this topic should be given. So Jean-Jacques Rousseau noted that: "The only way to keep the state independent of anyone is agriculture. If you have at least all the riches of the world, if you have nothing to eat, you are dependent on others. Trade creates wealth, but agriculture provides freedom." According to F. Blanchard, "The main burden of development and provision will fall on the shoulders of that part of the economy where agricultural activity dominates, i.e. to the agricultural sector.

World and national practices show that the long-term strategic development of agriculture is the tool, the use of which will make it possible to rationally use land and water resources, attract investments to the industry and increase the competitiveness of products.

Materials and methods. The theoretical and methodological basis of the article was the works of domestic and foreign scientists - economists on the problems of agricultural development, legislative acts, the Strategy for the Development of Agriculture, program documents, resolutions and decrees of the President on the formation of a management system for the agricultural sector.

The study is based on a general scientific methodology, which provides for the application of a systematic approach to solving problems. The basis of this work is the analysis of official statistics.

Analysis and results. The level of well-being and quality of life of the country's population depends on the level of development of the agricultural sector. On the agrarian and food map of the world, the republic occupies a certain niche.

The following points can be highlighted. The agriculture of the republic is developing more slowly than the agriculture of the world. The growth of the latter was stimulated by an increase in the population of the planet and an increase in per capita income in developing countries. However, at the same time, the population of Uzbekistan is also increasing from year to year (from 24487.7 thousand people in 2000 to 345558.9 thousand people in 2020, i.e. in 20 years by 1.4 times), and at the current pace of economic development, thanks to the implementation of measures to further increase production volumes and expand the range of food crops grown in the republic, there is a provision for the most complete satisfaction of the population's needs for food products.

The right approach to the production of fruits and vegetables has become an important part of the entire life support system for the population, creating conditions for employment and one of the main vectors of the economic and social policy of our state. Uzbekistan is a densely populated territory, where 49.4% of the population of the republic (17,071.4 thousand people, as of 01/01/2021) lives in rural areas, and 28% are employed in agriculture.

The results of the socio-economic development of the republic in 2020 and six months of 2021 showed that agriculture is one of the few sectors of the economy that shows steady growth even in the face of the negative impact of the coronavirus pandemic. If we consider the ten-year period 2010-2020. In general, production indices of agricultural products did not have negative values (Fig. 1), i.e. there was a slight increase. While the indices of crop production for 2017 and 2018 had a decline compared to previous years. If you look at the whole over the past 5 years (2016-2020), the share of gross value added of agriculture in GDP has changed in leaps and bounds, and was characterized by an increase in the indicator, then by its decrease. Starting from 2017 to 2020, there has been a decrease in the indicator by 4.2 p.p. Despite this trend, the gross value added of the agricultural sector over the analyzed five-year period increased by more than 2 times and amounted to 151250.9 billion sums. Source: compiled by the author according to the State Statistics Committee of the Republic of Uzbekistan.

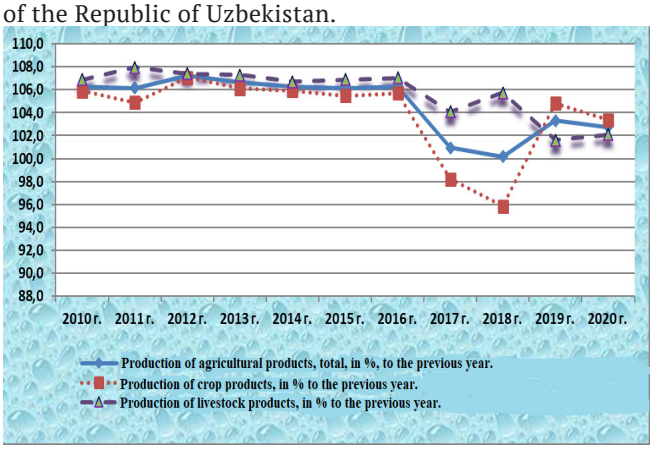

Figure 1. Indices of agricultural production in Uzbekistan for 2010-2020.

Sustainable growth in agricultural production is ensured mainly through the intensification of agricultural production, improved breeding and the introduction of new crop varieties, and the development of modern agricultural technologies. According to the main target parameters established in the Strategy for the Development of Agriculture for 2021-2030, after its implementation, the goals were set to achieve an annual increase in value added in agriculture of the republic in 2021 of 3%, and 5% each in 2025 and 2030 [3].

The volume of production (services) of agriculture, together with forestry and fisheries, increased 2.2 times over the analyzed five-year period, from 119.7 trillion. sum (2016) to 260.3 trillion. sum (2020). As the table data show, this indicator in 2020 increased by 1.2 times compared to 2019. According to the growth of agricultural production volumes, the volume of these products per one inhabitant of the republic also increased. So, over the past five years, the volume increased 2 times and amounted to 7227.0 thousand soums.

Table 1.

Indicators of the development of the agricultural sector in Uzbekistan

In actual prices; billion soums

Indicator	2016	2017	2018	2019	2020
Gross value added (GVA) of the industry	74779,0	90983,9	113660,7	130306,9	151250,9
Agricultural production	115599,2	148199,3	187425,6	215672,6	249754,5
including:					
Crop production	61755,1	83303,4	98414,5	108240,1	123556,0
Animal husbandry	53844,1	64895,9	89019,2	107432,5	126198,5
Agricultural production per capita, thousand soums	3629,7	4575,7	5687,5	6328,5	7227,0
The volume of production (services) of agriculture, forestry and fisheries	119726,7	154369,4	195095,6	224288,8	260306,8
The number of people employed in the industry, thousand people	3646,7	3671,3	3537,2	3544,6	3560,0
Number of registered enterprises and organizations, units	19596	22062	25438	31731	44657
Number of operating enterprises and organizations, units	17962	20530	23975	29379	41321
Area of agricultural crops, thousand hectares	3706,7	3474,5	3396,0	3309,4	3373,1

Source: compiled according to the State Statistics Committee of the Republic of Uzbekistan.

The table data on the number of registered enterprises and organizations in agriculture show that out of their total number (44.7 thousand units), 92.5% or 41.3 thousand units (excluding farms and dekhkan farms) carried out their activities, which amounted to 10% of the total republican number of enterprises and organizations. In the agricultural sector, there are 92.6 thousand farms, 27.6 thousand organizations engaged in agricultural activities, as well as 5 million dekhkan (personal subsidiary) farms. Dekhkan farm, in accordance with Article 3 of the Law of the Republic of Uzbekistan "On Dekhkan farm" [4] is "a farm engaged in the cultivation and sale of agricultural products based on the personal labor of members of the dekhkan farm on a land plot provided to the head of the dekhkan farm on the right of lifetime inheritable possession or lease (sublease). Such a dekhkan farm independently: 1) determines its specialization, including the types and volumes of agricultural crops, methods of their cultivation and carrying out agrotechnical measures; 2) sets prices for agricultural products produced, based on the ratio of supply and demand in the market; 3) has the right to freely transport and sell its agricultural products on the territory of the republic, in the field, at dekhkan markets and in shopping centers, as well as by organizing outbound trade in settlements without additional permits (licenses).

Another category that is statistically taken into account in conjunction with dekhkan farms is the personal

subsidiary farms of the republic. Their labor activity is connected with the cultivation (processing) of agricultural products, both for free trade and for the needs of the family on personal household land plots (Article 3 of the Law of the Republic of Uzbekistan "On subsidiary plots") [5]. A personal household plot of land is a land plot provided for running a subsidiary plot for the purpose of growing agricultural products or individual housing construction and home improvement.

The annual increase in crop and livestock production shows that the domestic market of the country is saturated with certain types of products of these agricultural sectors. Thus, the production of crop products by all categories of farms increased from 61.8 trillion. sum (2016) to 123.6 trillion. sum (2020) or 2 times, and livestock products for the period from 2016-2020 2.3 times and amounted to 126.2 trn. amounts (2020) (Table 2).

In 2020, in crop production, the largest share of production (50.9%) falls on farms, and in livestock - on dehkan (personal subsidiary) farms - 91.4% (Fig. 2). The share of organizations engaged in agricultural activities in 2020 is insignificant and amounts to 5% in crop production (compared to 2016 +3.4), and in livestock 3.5% (+0.3).

All categories of farms produced 7.6 million tons of grain, 82.0% of their total production falls on farms. In addition, all categories of farms produced 10.5 million tons of vegetables, 2.9 million tons of fruits and berries.

However, an interesting situation is emerging with changes in the indicators of crop and livestock production in the total volume of agricultural production. If, earlier, from 2016 to 2019, the largest share of this indicator fell on the volume of crop production, and the smaller one - on livestock products, then starting from last year (2020) the situation has changed radically, outweighing in the opposite direction. Thus, in 2020, the smallest share of agricultural production was obtained in crop production (49.5%), and the largest (50.5%) - in livestock products, the share of which increased over the period from 2016 to 2020 by +3.9.

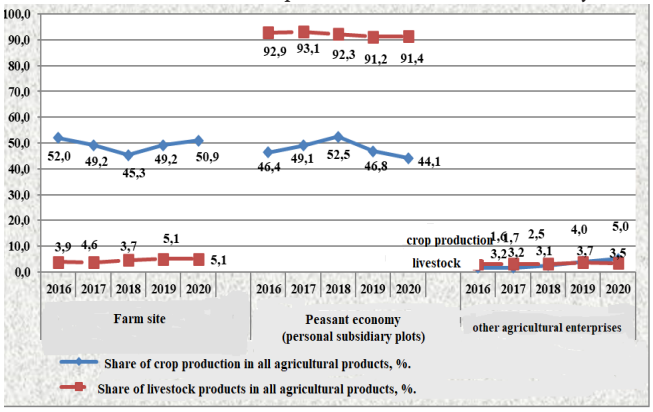

Figure 2. Structure of crop and livestock production by farm categories, %. *(Source: compiled according to the State Statistics Committee of the Republic of Uzbekistan.)*

Changes that led to an increase in the share of livestock production were obtained from an increase in the number of livestock, which also affected the saturation of the domestic consumer market of the republic with livestock products (meat of cattle, goats, sheep, horses, poultry and fish).

In 2020, all categories of farms produced 2526.2 thousand tons of meat in live weight (2.1 times more than in 2019), 11009.9 thousand tons of milk (by 2.8%), 7825 million pieces eggs (by 0.7%), 35.7 thousand tons of wool (by 1.5%), 144,085 tons of fish were caught (by 18.4%). At the same time, there are still problems in animal husbandry related to feed stocks, breeding and productivity.

If we compare the indicators of production in 2020 with 2016, then 20 percent more meat (in live form) and 2.2 times more fish were produced. This was facilitated by the previously implemented measures to further increase the potential of the livestock industry, as well as the systemic state support provided. According to the Ministry of Economic Development and Poverty Reduction of the Republic of Uzbekistan, last year 70,000 citizens of the republic received subsidies totaling 173.2 billion soums. Of these, for the development of private subsidiary plots of 35.5 thousand people - 109.5 billion soums; within the framework of cooperatives in agriculture, 23 thousand people receive subsidies in the amount of 50.7 billion soums.

Today, Uzbekistan is on its way to becoming a leader in global markets for a number of its agricultural products. By increasing the supply of vegetables and fruits abroad, the country has good prospects for promoting deep-processed products with high added value. This is due to the fact that in recent years a course has been taken for the active improvement of the public administration system, the widespread introduction of market relations, the attraction of investments into the industry, the introduction of resource-saving technologies, etc.

It should be noted that the measures taken to support agricultural producers make it possible to ensure the use of land for double sowing and harvesting fruits and vegetables. Since 2017, for the first time in his practice, he has introduced year-round sowing of various crops. This is due, first of all, to the plans of the republic to increase the volume of exports of fruits and vegetables, as well as to increase the supply of fruits and vegetables to the domestic market. For example, in 2020, in areas freed from early crops and grain crops, it is planned to re-plant crops on 858.5 thousand hectares of land. Due to the timely implementation of agrotechnical measures in these areas, about 2254.9 thousand tons of vegetables, 665.2 thousand tons of melons, 851.5 thousand tons of potatoes and other agricultural products will be grown [6].

Thus, in order to further increase, or at least maintain the current trend in some indicators of the growth rate of the industry, it is important to expand the demand for products and increase the scale of exports of agricultural products. For this, at present there are favorable conditions in the republic that contribute to the development of agriculture, namely: sown areas without toxic substances, which today is 3373.1 thousand hectares; regions free from genetically modified organisms (GMOs); opportunities to increase the income of the population, including through the export of grown products in household plots and increase employment through the development of agrocluster systems, logistics and cooperation, etc. At the same time, to strengthen the position in international markets of agricultural products grown in the republic, including organic, it is necessary to adhere to the international requirements of Organic and Global G.A.P. for the quality and safety of products on the world market.

In all years, regulatory documents, presidential decrees and decrees were adopted in the republic, which established measures to support the agricultural sector, including livestock [7, 8, 9, 10]. In 2020-2022, the state allocates subsidies in the amount of 1 million soums to farms producing livestock products for each unit of breeding

stock purchased from breeding farms operating in the territory of the republic. Also, subsidies in the amount of 2 million soums are provided for each unit of breeding stock, in the amount of 400 thousand soums for each breeding sheep and goat imported from foreign countries.

Farms that grow fish using the intensive method receive subsidies in the amount of 1 million soums per ton of intensively grown fish products. In addition, subsidies in the amount of 50 percent of expenses up to 3.5 million soums for 1 breeding stock of fish imported into the country. Poultry farms are provided with subsidies to compensate for 9,000 soums of expenses associated with the import of each one-day-old thoroughbred chicken.

There are still unresolved problems in agriculture. Here are some of them: the limited fodder base for livestock and poultry, which is primarily due to the insufficient provision of the industry with land resources for growing high-yielding fodder crops; low profitability of used land areas; poor development of the regulatory and legal framework in terms of ensuring the independence of agricultural producers in the production and sale of products with high added value (the need to improve it); procedures for leasing agricultural land are not transparent; insufficient development of mechanisms for protecting tenants' land tenure rights, their confidence in the lease agreement; not fully formed cadastral inventory and assessment of the value of agricultural land, the weakness of land sublease mechanisms; imperfection of the water distribution system for agricultural needs, low level of use of modern water-saving technologies, high level of irrigation water consumption in agricultural production.

All this required an early solution to ensure the development of agriculture in the republic and ensure food security.

The Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030 [3] is, in fact, the main policy document for the implementation of the tasks previously identified by the President of the Republic of Uzbekistan for the development of the industry. Its main goal is to radically improve the state policy and deepen the ongoing reforms aimed at increasing the competitiveness of the agri-food sector. The strategy is based on an integrated approach to the transformation of agriculture and is aimed at implementing such strategic priorities as: ensuring food security of the population; creation of a favorable agribusiness climate and value chains; reducing the role of the state in managing the sphere and increasing investment attractiveness; ensuring the rational use of natural resources and environmental protection; development of modern public administration systems; phased diversification of public spending in support of the sector; development of science, education, systems of information and consulting services in agriculture; rural development; development of a transparent system of sectoral statistics.

To implement these areas, government documents are adopted, which indicate specific measures and the range of ministries and departments responsible for their implementation [8,10]. For example, in the direction of developing and implementing state policy in the field of food security, a system of intervention purchases is being gradually introduced. The implementation of this will allow uninterrupted provision of the population of the republic with grain products and the prevention of sharp fluctuations in prices. Starting from the 2021 harvest, a phased reduction in the volume of state orders for cereals is envisaged, including the introduction of market mechanisms that ensure free competition in the purchase and sale of cereals. In addition, a mechanism has been developed for the transition from the state order system to the use of the state reserve to ensure food security.

In order to create a favorable agribusiness climate and value chains, starting from the 2021 harvest, there will be a transition to market principles for pricing, purchasing and selling raw cotton by setting minimum prices when determining the terms of contracts for its supply, produced by farms for cotton textile clusters. All this will be carried out on the basis of an analysis of market conditions and a predictive calculation of the costs of carrying out agrotechnical measures.

In addition, in terms of the implementation of the direction "reducing the role of the state, increasing the investment attractiveness of the industry" in areas not involved in the production of raw cotton and cereals, a system of phased specialization of districts is being introduced based on their soil and climatic conditions and market conditions.

We should also dwell on the implementation of such a strategic priority, designated by the President of the country in the Strategy for the Development of Agriculture for 2020-2030, as the development of science, education, systems of information and consulting services in agriculture. The transition of agriculture of the republic to a new qualitative state predetermines the importance of intensifying innovative activity. This, in turn, requires fundamental changes in the structure of production, education and the composition of the labor force. It is also necessary to change the vector of development based on the use of predominantly natural resources to development based on knowledge and information.

Certain steps have already been taken towards the implementation of this priority, outlined by the President. In particular, the Concept for the Priority Development of the Knowledge and Innovation System in Agriculture in 2021-2025 was adopted [11]. Its main goals are to further deepen the integration of education, science, innovation and production. Its implementation will allow for the formation and application of new knowledge, the introduction of resource-saving innovative technologies, advanced achievements of foreign and domestic science. Here, the training of specialists with modern knowledge and qualifications, as well as the development of a system for the provision of agricultural services, is also important. Positions for further reform and development will be, firstly, the system of agricultural education, which will be aimed at developing human capital in accordance with changes in the labor market; secondly, scientific and innovative activities of scientific institutions of the agro-industrial complex; networks for the provision of agricultural services for entities engaged in the production, storage and processing of agricultural products, operating on the basis of an information and consulting system.

Conclusions and recommendations. The analysis of trends in the development of the agricultural sector allowed us to draw the following conclusions and recommendations:

1. One of the most complex, but at the same time an important part of the economy is agriculture. Immediately after gaining independence, Uzbekistan was not immediately able to achieve significant success in this sector of the economy. The reason for this was the legacy of the planned economy. Today, the current state of affairs

in the republic's agriculture has not had the problems that it had in the early 1990s for a long time. However, they were replaced by new problems and challenges.

2. Agricultural production increased in 2020 compared to 2016 by 2.2 times. The increase in the share of animal husbandry in 2020 compared to 2019 is fully due to the intensification of state consideration of issues in this area, expressed primarily in the use of the instrument of state support and subsidies. In general, in agriculture in 2020, there was an increase in crop production compared to 2016 by 200%, livestock - by 236%.

3. A strategy is a kind of declaration of intent, a basic guideline for the implementation of practical steps to improve a particular area of socio-economic life, an important signal for business and external partners. Such a document for the implementation of the tasks outlined by the President of the Republic is the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030. Targets adopted by the state become elements of the strategy if: there is a clear ranking in terms of implementation, as well as priorities for achieving the set result; the optimal correspondence between "expenses" and "result" has been established, that is, the chosen goal must be achievable, and the budgetary burden must be clearly predicted; the territorial localization of the selected set of measures, as well as the effect of their implementation, was taken into account. The main goal of the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030 is the fundamental improvement of state policy and the deepening of ongoing reforms aimed at increasing the competitiveness of the agri-food sector.

4. One of the main directions is to maintain positive growth dynamics in the agricultural sector and reform agriculture. Due to the restoration of the cultivation of productive and useful products on low-yielding lands, as well as the resumption of the use of 41.5 thousand hectares of fallow lands, it is possible to increase the growth rate in this industry by another 0.2% starting from 2021. The stability of prices in the food market and the strengthening of food security must be ensured. In addition, the introduction of water-saving technologies in 2021-2022. should improve the efficiency of water use.

5. It is necessary to further stimulate the development of all forms of cooperation, marketing, consumer, supply, and production. This is especially true for the layer of farmers and dehkans operating in the agrarian sector of the economy of the republic in such areas as processing and selling agricultural products, repairing and maintaining equipment, carrying out soil and environmental protection measures, and developing the social infrastructure of the village.

6. For the further development of agriculture in the republic and ensuring food security, it is necessary to continue to carry out the processes of shifting the role of the state from the system of state orders, placement of crops and control over the production of agricultural products to the provision of public services necessary to increase labor productivity in farms and dekhkan farms, food safety and quality improvement, environmental protection and other goals not provided by the private sector. The use of the mechanism of public-private partnership will enhance cooperation with the private sector in the provision of public services.

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FEATURES OF DEVELOPMENT OF LIVESTOCK INDUSTRY IN THE FIELD OF FOOD SECURITY

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Abstract

Today in Uzbekistan it is necessary to bring pedigree animals not only for the purposes of commercial production, but also for use in the field of selection of science. At the same time, the study of the level of import of breeding materials from different regions of the world and their adaptation to the regions of the republic will create great opportunities for the development of the cattle industry in the future. Especially in rural areas, the demand for machinery and equipment for processing dairy and meat products, components and spare parts and mini-shops requires the promotion of imports at the state level. Livestock sector plays an important role in generating income for the rural population of the country, so the problems and prospects of its development are a priority of Uzbekistan's agrarian policy. Currently, more than 90 percent of livestock production is grown on small dekhkan farms. The main problem of the industry is the imbalance between the number of livestock and the amount of resources available to feed them.

Keywords: *livestock, Uzbekistan, agriculture, food, food security, concept, economic methods, administrative methods, prospects.*

Introduction. One of the most important agricultural sectors in the country, livestock is also an essential ingredient for ensuring the food security of the population. In the agricultural sector, reforms are aimed at improving food security by expanding the area under other types of crops while reducing the area under cotton by optimizing the composition of agricultural crops through private ownership. As a relatively small agricultural enterprise needs to produce livestock products such as meat, milk, eggs, and wool, along with increasing efficiency of the sector, this issue should be addressed according to market requirements. Livestock accounts for 31% of Uzbekistan's gross agricultural output. This sector plays an important role in generating income for the rural population of the country, so the problems and prospects of its development are a priority of Uzbekistan's agrarian policy.

In Uzbekistan, market relations are being gradually established in the livestock sector under the leadership of the state. The livestock sector, which was originally public and state property, has started to be privatized. At the same time, loans were issued in case of lack of funds from buyers. As a result, owners began to form in this area. However, this event of great political significance did not yield the expected results. Because the owners of livestock could not provide them with fodder, they began to sell pedigree, productive animals. This is due to the fact that in the process of privatization of livestock, the amount of arable land that provides fodder for livestock is not leased for a long time.

Materials. The issue of livestock development and increasing economic efficiency has been studied by researchers and practitioners as a key issue in ensuring food security. However, most of these studies were conducted in conditions where the legal and economic independence of economic entities was not ensured, and there were insufficient conditions for the materialization of scientific and practical proposals in this area to the real economic conditions. Now it is necessary to put forward new research, views and opinions that can be realized in a market economy, based on the study of various views and theories in the existing scientific literature.

Currently, more than 90 percent of livestock production is grown on small dekhkan farms. The main problem of the industry is the imbalance between the number of livestock and the amount of resources available to feed them. Between 1992 and 2021, the number of cattle in Uzbekistan increased 2.3 times, meat production 2.9 times and milk production 2.7 times. At the same time, the area under fodder crops decreased by 73 percent. The area of pastures owned by agricultural producers has sharply decreased. Farmers and ranchers are feeling the lack of nutrients for proper nutrition and dairy farming. One of the factors hindering the development of dairy farming is the very small size of the majority of producers in this sector. Basically, milk is produced on farms and used for personal consumption. Small producers do not have the opportunity to introduce advanced zootechnical standards, sell their products efficiently, as well as buy good fodder crops.

In the case of livestock, state support mainly consists of soft loans for livestock producers and tax incentives for processing enterprises. Veterinary stations throughout the country vaccinate, treat, and artificially inseminate farm animals. These procedures, however, are often accompanied by the need to cover additional expenses. Small dekhkan farms sometimes use artificial insemination.

A number of factors led to the lack of a material and technical base for the livestock industry in recent years, as well as the material interest expressed by commodity producers and the need to improve measures to support the industry in relation to market needs and the insufficient incentives for the use of new technologies in the production of livestock products, as well as the imperfect economic relationships between producers and processors as well as those involved in its trade.

A market economy promotes economic freedom among its participants, which is a key characteristic of a market economy. As a result of the gradual reform of agriculture, the previous order for cultivating agricultural products has been abolished. Livestock farms primarily supplies meat, milk, cattle, calves, and wool to independent partners via free economic contracts on farms that produce livestock products. Due to the availability of a sufficient supply of fodder, arable land, pedigree cows, veterinary services, etc., it will be necessary to rationally organize production in a free market environment.

One of the most pressing issues today is the development of scientifically based and practical feedback, suggestions and recommendations to address the above problems.

Farms are the main producers of agricultural products in the world. In this case, the farm can be established as a private farm and operate as a land lease or as a private property. Taking into account the world experience, the establishment of farms instead of state farms has been widely introduced in Uzbekistan, and this policy has been decided as a method of production that is irreversible today and will be further developed in the future.

Farmers demonstrate their long-term experience as agricultural enterprises in developed countries, such as their efficiency, competitiveness, and ability to quickly adapt to market conditions. Due to this reason, farms are also a promising alternative in rural areas in Uzbekistan.

In Uzbekistan, as in other countries, private farms are rightly becoming the leading producer of agricultural products in the countryside.

In recent years, the imbalance between the prices of agricultural products and the prices of industrial products produced and used in agriculture has led to the need to further improve measures to support the industry in line with market requirements. In addition, insufficient incentives for the use of new technologies in the production of the industry, imperfect economic relations between producers and processors and those engaged in its sale, and other similar issues lead to higher than the cost of agricultural products and reduced economic efficiency.

Today, as the country's population grows year by year, the country's leadership is creating additional opportunities for entrepreneurs to address the issue of providing the population with relatively low-cost dairy and meat products that are sufficiently quantitative and qualitatively meet sanitary standards.

From March 1, 2021, businesses that use the compensation and guarantee of the State Fund for Entrepreneurship Support will be able to repay their loans on time in the field of livestock, poultry, fisheries and rabbits. Until the debt is fully repaid, the guarantee of the Fund on new loans will be allowed to be used again;

Privileges granted in accordance with the Resolution of the President of the Republic of Uzbekistan dated March 18, 2019 №PR-4243 "On measures for further development and support of the livestock sector" also applies to livestock entities and enterprises producing compound feeds;

From January 1, 2021 to January 1, 2024 for breeding entities on their main type of activity income tax (excluding interest on funds placed in commercial banks), property tax, land tax and the tax rate for the use of water resources is 50 per cent.

Earlier, the President of Uzbekistan signed a decree on further deepening economic reforms in agriculture, introducing intensive, cost-effective technologies in agricultural production, ensuring financial stability and economic efficiency of farms, expanding the export potential of agriculture.

This resolution sets the forecast parameters for the number of livestock and poultry in the country in 2016-2020, the growth of livestock production, the establishment of breeding farms.

The Ministry of Agriculture, the Ministry of Economy, the Farmers' Council of Uzbekistan, "Nasl-Xizmat" Association, the Council of Ministers of the Republic of Karakalpakstan and regional administrations ensured the implementation of the forecast parameters of livestock development in 2016-2020. It is clearly stated that they should take the necessary measures to improve. At the same time, a number of important benefits are provided for livestock services and livestock farms.

According to the Ministry of Agriculture and Water Resources, in accordance with the Decrees of the President of the Republic of Uzbekistan №PD-842 of April 21, 2008 and №14 of January 27, 2015, 86 types of goods are imported into the country using import preferences.

The current benefits for livestock entities are valid until January 1, 2023. Based on this decision, in 2014-2015, benefits were provided in the amount of more than 255 billion soums for breeding chickens, 25.5 million hatching eggs, 250,000 doses of breeding bull semen and many others feed additives, various components, tools and equipment.

If we focus on the tasks set for the development of the livestock industry and the content of the work carried out as part of their implementation, resolution PR-2460 will improve animal husbandry, provide breeding animals with nutritious and high-quality feed, imported breeding animals and breeding material, technological equipment is aimed at ensuring financial sustainability and economic efficiency of production in the livestock service sector, as well as in livestock farms by providing customs benefits for the import of components for the preparation of feed. This will ensure sufficient supply in the domestic livestock market.

Because today in our country it is necessary to bring pedigree animals not only for the purposes of commercial production, but also for use in the field of selection of science. At the same time, the study of the level of import of breeding materials from different regions of the world and their adaptation to the regions of the republic will create great opportunities for the development of the cattle industry in the future. Especially in rural areas, the demand for machinery and equipment for processing dairy and meat products, components and spare parts and mini-shops requires the promotion of imports at the state level.

Small dekhkan farms raise livestock mainly for their own needs, not for the market, and produce livestock products for their own needs. Fifty-two percent of farms sell cattle, including 20 percent bulls. On specialized farms, the figure is 78 percent and 54 percent, respectively. This indicates that small dekhkan farms are less involved in market relations.

Discussion. Most of the livestock products are sold in the regional markets and wholesale outlets of farmers and dehkan farms. Only a few enter the regional market. Farmers refer to wholesalers as milk pickers who often come to the villages and collect the produce for resale. This villager can also be such a collector.

One of the main problems in the development of dairy farming in the country is the provision of cows with nutritious and fortified feed in accordance with scientific standards. In particular, the issues of production and quality improvement of compound feeds and their supply to livestock farms (through various private businesses) remain relevant.

In Uzbekistan, the domestic demand for mineral supplements and components for the preparation of complete rations of strong feed for cattle is mainly covered by imports. It is precisely this area that needs to be addressed - the development of industrial enterprises producing feed additives and mineral components for livestock. Because the territory of the republic is rich in all minerals found in nature, it is possible to prepare mineral supplements at the expense of local raw materials. It is also desirable to address the issue of import of laboratory equipment, feed components and technical equipment for this industry.

If we look at the activities of existing veterinary stations, most of them are not as effective as expected. At the same time, first of all, the material and technical base of the outlets does not meet modern requirements, and

the quality of services provided is declining due to the low level of supply of qualified specialists. This, in turn, leads to poor implementation of the terms of contracts with farms and dehkan farms specializing in animal husbandry.

In contrast, when service outlets lose trust in farms, the resulting reduced demand worsens the financial situation of those farms. This situation will persist in a circle, which will complicate the process of strengthening the material and technical base of service entities and attracting qualified specialists. The organization and financial support of the state are vital in this situation.

Conclusion and suggestions. In general, the experience we have gained for the development of the dairy industry requires the solution of issues related to the financial stability of not only producers, but also service providers, increasing the economic efficiency of their activities. If we take a broader approach to the essence of the tasks before us, we will be able to develop through the growing shortage of important natural resources in the world, the sharpening of food security, the gradual implementation of evolutionary changes in the real economy within the country, individual groups, national traditions, customs requires moving forward.

The growth of the productivity of the dairy cattle will be facilitated by:

1) Optimization of the process of growing, collecting, storing and rational use of feed.

2) Improving the technology of growing fodder crops, increasing their yield and quality, using, where possible, scientifically based crop rotations. This will improve the quality of feed.

3) Revision of the diet of animals. The diet should be balanced coarse, juicy and concentrated feed. Often the right diet is enough to increase productivity.

4) Compliance with the technology of dairy farming. Veterinarians said that they had to observe cows at 430 and even at 470 days of lactation. On the other hand, the dry period is sometimes prolonged. This reduces the productivity of cows. The cycle “Free period - pregnancy - birth of a calf – lactation” should be strictly observed, to meet the deadlines. Then productivity will be higher.

5) Increasing awareness of products, services and professionals in the industry can also improve productivity. Effective feed additives, veterinary preparations, services of a qualified veterinarian are able to increase the productivity of dairy livestock.

6) Microclimate. It is important to avoid exposure of animals to extremely high temperatures, significant temperature fluctuations, dampness and other factors that can inhibit body functions and harm the health of cows.

7) Prevention of parasitic and infectious diseases. Healthy, untreated animals are always more productive.

8) Artificial insemination, reproduction and rearing of young animals. Breed improvement, proper rearing of young cows is one of the ways to increase productivity.

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DEVELOPMENT OF FISH FARMING BASED ON INTENSIVE TECHNOLOGIES: INFLUENCING FACTORS AND ECONOMIC INDICATORS

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Abstract

In this article, the main prospects and directions of strategic development of fish-farming in the conditions of economic issues are considered. It is shown that the main ways to improve economic efficiency should be conservation and protection of water resources, improvement of organizational and economic mechanisms of fish-farming development; government support to fisheries as a whole. An important aspect that must be considered when determining the level of factors affecting the efficiency of fishing industry is the correct choice of factors. If we analyze this by region or organization, the same factor may have different effects on the socio-economic efficiency of the industry. Therefore, this article is devoted to determine the influence level and relationships between factors affecting the efficiency of fish-farming.

Key words: *factors, factor analysis, intensive fish-farming, fish production, fisheries, economic efficiency of fish-farming, state support.*

Introduction. All reasonable human activity is somehow connected with the problem of efficiency. This concept is based on limited resources, the desire to save time, to get as much products as possible from available resources. The problem of efficiency - how to allocate and how much resources to use for current and future consumption. The level of efficiency affects the solution of a number of social and economic problems, such as rapid economic growth, raising the standard of living of the population, reducing inflation, and improving the working and rest conditions.

In the economic literature there are deep theoretical studies reflecting some of the problems of the economic efficiency of fish production. The works of many scientists present not only the complex problems of the theory of economic analysis of fisheries efficiency, but also reflect specific issues related to the formulation of methodological aspects on the formation of indicators of economic efficiency of fish production. Consequently, the original model of quantitative performance evaluation is the ratio between economic results and costs, resources. Maximizing outcomes per unit of costs and resources, or minimizing costs and resources per unit of outcome, is the primary goal of society, the workforce, and the individual (employee). This goal, the method of its achievement, the ways and reserves of increasing economic efficiency (their classification and quantitative assessment) are the content of economic science and economic disciplines (industry and functional). The basic principles for measuring production efficiency for all social formations are similar.

Factor analysis is a multidimensional method used to study the relationships between the values of variables. The dependence of known variables on some variables and random errors indicates the relevance of the factor.

In General, factor analysis has the following main objectives:

- determine the relationships between variables ("classifications of variables"), i.e. whether they are related to variables in the relationship, directly or indirectly, these relations are characterized directly or indirectly;
- the degree and scope of the relationship between variables;
- reduce the number of variables needed to describe the data.

Factor analysis allows the researcher to solve two main problems:

- first, in a complex and at the same time compactly detect the object of measurement;
- secondly, factor analysis defines hidden variables responsible for the existence of linear, statistical and correlation relations between the observed variables.

To study relationships between variables, it is proposed to use methods of economic-mathematical modeling and multidimensional statistical analysis – one of the main tools for progressing the economic mechanism, structural transformation of the regional market and forecasting the dynamics of production and sales of products. A variety of economic and mathematical models is the optimization model. Its use allows you to analyze the dynamics of the development of organizations in the region and take advantage of large amounts of real information [23].

Materials and Methods. The effectiveness of fish-farming is characterized by its performance, which is reflected on the catch of fish and the profit from the sale of fish products by fishing organizations and enterprises. Consequently, the efficiency of fish production can be defined as the optimal use of resources in comparison with public needs.

The increase of efficiency of fish production is not an accidental, but a natural, stable, repetitive and causal process that acts objectively. It should be noted that the more civilized the society, the more important is the increase of production efficiency, as the need and awareness of the need to save public costs increase; the purpose of fish production is to meet the needs of society, and at the same time priority is given not to the material, but to the social result. All this suggests that increasing the efficiency of fish production acquires the features of economic law, which can be formulated as a law of increasing production efficiency. The law of increasing production efficiency is a law trend, since opposing factors often impede the growth of efficiency of aggregate social labor.

In conditions of transition to a market economy, the interpretation and hierarchy of efficiency criteria, their content and characteristics obviously change. Since the basis of a market economy is efficiency, income, the primary criterion of economic efficiency is the maximization of profit per unit of costs and resources with high quality products, works and services, ensuring their competitiveness. The national criterion of efficiency is also preserved under the new conditions: maximization of national income, gross national product per unit of costs and resources with an increasing level of well-being of the

people's life.

Evaluation of economic efficiency is always correlated with the goals of production in the future, but it describes the performance of the past, and its value is manifested in the present period. Consequently, the totality of the results of production activities for separately taken period of time is the efficiency of fish production.

All factors of the economic efficiency of the fish production can be classified: according to the resources and costs of production, according to the main directions of formation of the economic efficiency of production on the implementation of directions at various levels of management. Classification of resources and costs allows you to identify the sources of increasing the efficiency of production and its components. It answers the question of what resources or costs can be achieved saving labor, increasing the efficiency of fish production.

The main directions of formation of economic efficiency, i.e. with the help of which the growth of production efficiency is achieved. They are also very diverse, the most important of them are technology, specialization and size of production, labor organization, scientific and technical progress and the best practices. Improving the quality of work tools is to increase the productivity and profitability of production fixed assets. But no matter how the production resources themselves are committed, the economic efficiency of fish production can be relatively high, provided that these resources are used quite fully and intensively. At the same time, the realization of factors of efficiency in the use of production, resources, production as a whole, from the point of view of material-material elements, is possible only if there are appropriate production relations (Figure 1).

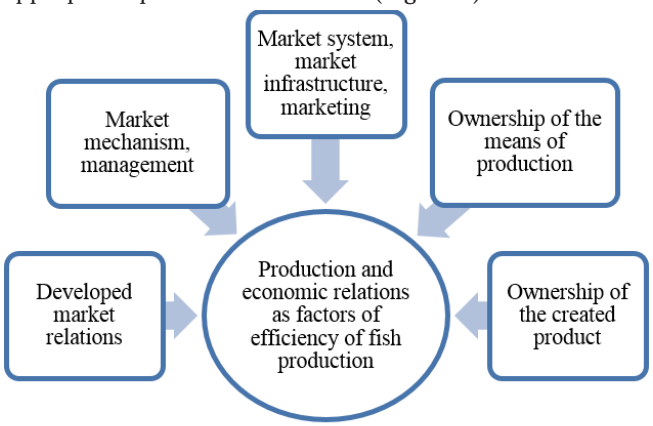

Figure 1. Production and economic relations as factors of fish production efficiency [23].

The decisive factors of efficiency from the point of view of production relations are the incentive motives of commodity producers to work and developed market relations. The realization of relations on the created product, income and on the means of production can be carried out with the greatest efficiency in the system of developed market relations.

The implementation of factor analysis begins with checking its state. The existence of such conditions will allow us to conclude that the process or phenomenon of the event, its current or future status and the influence of certain factors will allow us to evaluate and predict the course of action or changes in the process. Failure to comply with this requirement may lead to a completely unexpected conclusion and suggestions about what was said.

Mandatory requirements for factor analysis are as follows [12]:

- all marks must be quantitative;
- the number of observations should be at least twice as large as the variables;
- samples must be identical;
- the initial variables should be symmetrically distributed;
- factor analysis should be associated with variables.

From the earliest times of independence, the country's economic and social, organizational and regulatory conditions for economic management and production organization have changed dramatically due to the implementation of economic and social reforms aimed at the formation and development of elements of a market economy in the fisheries. A new system based on market relations was created. As a result of the reform, the fisheries sector led to the work with fish farms of various formations.

During the study, we analyzed the factors affecting the efficiency of the fish production on the following four groups:

- Organizational and legal factors;
- Economic factors;
- Natural and geographical factors;
- Socio-demographic factors.

Organizational and legal factors include regulatory documents, foreign and domestic policies, state support for industry, the level of resource provision. Decrees and resolutions of President of the Republic of Uzbekistan, decrees and resolutions of the Cabinet Ministers of the Republic, as well as decisions and regulations adopted by the interested ministries, departments and organizations (Ministry of Agriculture, Ministry of Water Resources, "Uzbekfishindustry" Association), are directly used for the development of fisheries.

It should be noted that over the past two years, conceptual changes have been made on the ground as part of the reorganization of the "Uzbekbaliksanoat" Association and within its objectives and capabilities. In addition, due to organizational and economic changes in the system of ensuring the feed base of the fish sector, especially, in providing material and technical resources, as well as new rules and regulations, the economic activity of fisheries has changed in a positive way.

Natural and geographical factors - the geographical location and relief, air temperature, rainfall and season; the number, composition and status of water; the state, number and structure of the animal and plant world are natural - geographic factors.

Economic factors – factors such as tax, credit, insurance, inflation, customs fees, purchasing power, pricing policy, payment system, monetary policy by central bank, foreign currency liberalization, including, financial independence.

Socio-demographic factors - such as population, composition and location, National mentality, traditions, Fish culture, interests and Infrastructure condition, location.

In many spheres the problem is that, according to the results of observations, it is necessary to determine the relationship between the associated parameters.

The relationship and influence between factors have been studied widely in foreign literatures, use of these factors in the development of region and fishery

sector allows them to substantiate not only economic, but also ecological sustainability [13, 14, 15].

In addition to the factors mentioned above, we should pay attention to the economic indicators of fish farming through a closed water circulation system in the Fergana region, then the total income of 0.75 hectares in a closed water circulation system in 2018 amounted to 607.2 million soums, in 2019 – the income accounted for 709.6 million soums (Table 1).

The costs of the farm in 2018 amounted to 367 million soums, in 2019 - 424 million soums, while the level of profitability was 65% and 67.2%, respectively.

The farm has taken advantage of tax incentives for setting up a fish farm using intensive technologies. The closed circulation system used 16,000 cubic meters of water. It is important to note that the water can be re-discharged into the water source by purifying it in a closed system. In this case, the water consumption is 3%.

According to the Resolution of the President of the Republic of Uzbekistan dated April 6, 2018 № PR-3657 "On additional measures for the accelerated development of the fishing industry", the widespread introduction of innovative and modern intensive technologies, including cage, closed water circulation systems is very important. Particular attention was paid to increasing the volume of catches due to fish farming and increasing the productivity of artificial reservoirs, improving the work on the cultivation and breeding of valuable species of fish and fry within the framework of public-private partnerships [1].

Table 1.

Economic indicators of fish farming through closed water circulation systems in Fergana region [22]

Indicators	Unit of measurement	2018	2019
General indicators			
Total land area	ha	0,75	0,75
Grown fish	kg	50590	53214
Water consumption	thousand cubic meters	18	15
The number of workers	person	5	6
Costs			
Salaries and deductions	thousand soums	120000	144000
Feed costs	thousand soums	186500	214000
Electricity costs	thousand soums	34000	35000
Water costs	thousand soums	3780	4000
Cost of fry	thousand soums	9500	10000
Biostimulants	thousand soums	6000	5000
Depreciation expense	thousand soums	4562	7845
Other expenses	thousand soums	3645	4567
Economic indicators			
Total income	thousand soums	607185	709616
Total costs	thousand soums	367987	424412
Total profit	thousand soums	239198	240763
Profitability	percent, %	65	67,2

The issue of using intensive technologies in fish farming has risen to the level of public policy. In particular, as noted in the government videoconference on November 14, 2019: "There are many problems in the development of highly productive areas of animal husbandry in the short term, in particular, poultry farming, fish farming, rabbit farming". In particular, today only 460 hectares (1%) out of 38,000 hectares of artificial reservoirs create an intensive form of fish farming. The main reason for this is that the cost of intensively farmed fish is 2 times more expensive than traditional farmed fish. Therefore, entrepreneurs are comfortable with the simple method. However, if fish farming in this way does not exceed 2-3 tons per hectare, you can get up to 100 tons of fish in intensive fish farming [21].

Another effective method of intensive fish farming is the cage method, which is also very promising in our country.

Intensive fish farming in cages has advantages over traditional fish farming in ponds. One of them should be placed directly in water bodies and occupy only a part of them.

This allows the use of water resources not only for fish farming, but also for other industries. Another advantage is that, as in water bodies, the use of significant land areas in agricultural use is not required.

Unlike traditional fish farming, cage culture does not require forced water exchange or energy consumption to pump water. Cages are always passive, that is, they do not require special labor from a person. The exchange of water inside the cage is created by the movement of the fish and occurs due to the movement of waves. Therefore, the cages have a constant renewal of water and its quality complies with the standards of fish farming. The same physicochemical regime is created in reservoirs with good water permeability of cages. This allows an increase in the number of fish species compared to water bodies. More carp and African catfish can be grown this way.

The cages installed in lakes and reservoirs make it possible to use the natural forage resources of lakes and reservoirs. That is, an increased concentration of zooplankton, phytoplankton, benthos, and wild fish is observed around the cages, which can enter the cages using a jet of water with mixed feed and fecal residues washed through nylon holes.

One of the social benefits of cages is the ability to place them in and around settlements.

This will open access to the farm, labor resources, the use of ready-made communications (power lines, water supply, gas pipelines, transport, food, etc.).

The cages use plastic nets with cells from 8x8 cm to 20x20 cm, each side of which is 5 meters. The depth of the mesh is 8 meters. As the fish grows, they are transferred from one mesh to another.

Marketable fish in cages is raised for 5-7 months. During this period, the fish grows from 250 g to 1.5 kg. The water temperature should not exceed 20 degrees, and the oxygen content in the water should not be less than 7 mg / l. It is advisable to discard 100-250 eggs per m3. On average, 10-15 kg of commercial fish are caught from 1 m3 of the basin. The average profit of 1 kg fish is 10 thousand soums [22].

Discussion and suggestions.

The main expected economic results of intensive fish culture in cages are:

• does not require placement on large areas of water

bodies or lakes;

• As in traditional fishing, it is not necessary to equip large reservoirs, occupy agricultural land;

• The physical and chemical regimes in the cage are the same as in water bodies, which allows reproduction of valuable fish species, including salmon and sturgeon, in comparison with water bodies.

• It is possible to place the cage near to ready-made communication stations, which reduces the cost of production (power lines, water supply, gas pipelines, transport, etc.).

Expected ecological results of intensive fish culture in cages:

• cage fish farming is aimed at preserving the environment;

• does not harm the water body or natural landscape;

• a zone with a high concentration of zooplankton, phytoplankton, benthos, wild fish has been created around the cage.

Expected technical results of intensive fish farming in cages:

• there is no need to consume the water pump and the electricity to provide forced water exchange.

Expected social results of intensive fish culture in cages:

• additional jobs will be created for the local population;

• provide the population with local valuable fish species.

It is advisable to develop an organizational and economic basis for the development of intensive fish farming in the future and implement the following ways to improve it. Including:

Economic support methods:

1. One of the important factors in ensuring the efficiency of the intensive fish farming sector is the cleanliness of the water in the fish ponds. The analysis shows that after the introduction of innovative and resource-saving fish farming technologies in the most intensive fish farms, due to the lack of working capital from 2-3 years of operation, repair and replace equipment and structures that purify unusable water and transfer it to new ones. Due to the lack of working capital, they are unable to ensure the quality of water at the standard level. This leads to an insufficient weight of fish during the technological period, incomplete absorption of nutrients and a decrease in quality, which ultimately leads to a decrease in the productivity of the basin.

Therefore, we consider it expedient to introduce a system of state subsidies for 50% of the costs of water treatment in fisheries for 5 years and 30% for the next 3 years. Targeting saved water treatment costs towards farm modernization and mechanization of cooling and work processes, as well as building the farm infrastructure will serve as a criterion for this subsidy system to ensure the complete establishment and development of farm infrastructure in 3-5 years.

We consider it expedient to determine the rating of fish farming and introduce such a system of benefits and support based on the rating of fish farming, so that this system and the mechanism of economic support from the state are not periodic, but targeted and permanent, and the conditions for subsidies are transparent. We consider it expedient to use the basis of such a rating as a system of indicators reflecting the production and socio-economic and environmental efficiency of economic activity. Giving farms priority in the ranking of such economic support systems will increase the interest of these farms in the modernization of production and the formation of economic infrastructure, as well as encourage other farms to work more efficiently and actively.

Recommendations. One of the most pressing problems of the development of fish-farming in modern conditions is to increase the efficiency of the industry. Economic efficiency is a complex economic category in which the action of economic laws is reflected and the most important aspect of an enterprise's activity is shown - its effectiveness.

On the basis of theoretical assumptions, it can be concluded that the criterion of the economic efficiency of fish production is the quantity and quality of incubated caviar at minimal cost, fishing, and making a profit from the sale of fish products by fishing organizations and enterprises.

Consequently, the efficiency of fish production can be defined as the optimal use of resources in comparison with the social needs of caviar and juveniles released into reservoirs.

The significant importance of fisheries takes priority over the accelerated development of aquaculture in the country. But the lack of investment resources and working capital, high credit and tax rates, legal restrictions and bureaucratic obstacles complicate the development of this sphere. Therefore, the main task at the present stage is the search for an economic mechanism that stimulates the recreation and development of aquaculture. Currently, the most important process in aquaculture is to develop the market economy methods by fish enterprises.

The new conditions of their economic activity predetermine the need to develop new approaches to the problems of economic development, to improve management and production efficiency including, improving competitiveness of fishery products.

We believe that in order to implement, effectively manage and engage the interests of different levels of government, it is necessary to consider the size of efficiency. And in this regard, we propose a methodology for managing fish farms taking into account the effect of specific factors and processes of fish production on efficiency.

In order to better understand the specifics and essence of the efficiency of fish production as a component of fisheries, which will manifest itself in the current state of the economy and be taken into account, we have systematized a number of concepts and indicators in the future; characterizing only fish production and not using in other sectors of the economy, the relative indicators for evaluating the effectiveness of the main links of the technological cycle of fish production.

Conclusions. We propose a procedure for the formation of the management strategy of the fish-breeding enterprise, allowing to ensure the development of fish-farming.

When considering the characteristics and specifics of fish production, the main factors that have a significant impact on the development of fish-farming are formulated:

- natural factors in modern conditions are still not controlled;

- socio-economic favorable labor regime, optimal infrastructure, the general economic situation of the country, raising the living standards of the fish industry workers. These elements create favorable conditions for the efficient management of fisheries and fish production in particular, sustainable production, the implementation

of expanded reproduction;

- biological factors allow to increase the stability and efficiency of production;

- organizational - effective government support, rational use of production potential, organization of scientific activity. All this is intended to ensure the rational use of labor, material and natural resources, to promote the sustainability of development and the efficiency of fish production.

Thus, the rational and skillful use of the above factors and management strategy will ensure further sustainable development and the efficiency of fish-farming.

The study revealed that there is a link between fish farming and the feeding system in private farms.

In general, defining and analyzing the factors, affecting the development and efficiency of the fish-farming might be give a big opportunity to prepare favourable conclusions, to identify factors and eliminate problems relative to the sector, and in the end this can be give great results. In addition, intensive fish farming is a new direction in the country, and by improving it, it will be possible to satisfy the population's demand for fish farming products, increase their processing and the possibility of creating added value in the industry. Short-term experience in the field of fish farming shows that the development of closed fish farming, increasing its productivity and resource efficiency remain among the urgent tasks, and the solution to this problem is the organizational and economic support by the state.

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ORGANIZATIONAL AND LEGAL FRAMEWORK FOR THE DEVELOPMENT OF PASTURE ANIMAL HUSBANDRY

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Abstract

This article shows that the institutional and legal framework for cattle breeding in our country is focused on the current state support for cattle breeding, as well as the development of pasture infrastructure and the creation of a mobile service center.

Key words: *pastures, livestock, land areas, infrastructure entities, digital technologies, market conditions, climate change, diseases and more.*

Introduction. It is known that when growing agricultural products on pastures, in particular in the production of livestock products, farms turn to the market for a number of goods and services. However, the breadth of pastures and their remoteness from infrastructure create inconveniences for pastoralists in accessing services. These factors, in turn, affect the quality, volume and duration of service.

Referring to the scientific literature, experts in the field have studied the services used by livestock farms, dividing them into groups such as infrastructures that are inextricably linked to network activities, and infrastructures that are not regularly mentioned in network activities. . Based on this, we can group the services and infrastructure used in grazing as follows.

Market infrastructure entities providing services to pasture livestock include banks, leasing, insurance companies, tax authorities, retail outlets, stock exchanges, as well as production infrastructure entities, in particular, transport, veterinary, feed and livestock services.

At the same time, roads, electricity supply and drinking water supply can be included in the social infrastructure facilities serving pasture farms.

As noted above, the dispersed geographic location of livestock farms on pastures and the year-round keeping of livestock away from infrastructure has led to a breakdown in permanent links between service users and service providers.

In the modern world, where economic sectors are developing, as well as forms of management are being improved, we can see that the requirements for the following services are formed due to the specifics of cattle breeding. Especially:

- services to promote the introduction of digital forms of management as a result of the development of digital technologies;
- formation of demand for entities providing them with consulting services in the conditions of organization and sustainable development of clusters;
- the emergence of new requirements for zootechnical and veterinary services in the face of a sharp increase in livestock imports from foreign countries;
- The emergence of new requirements for sanitary and epidemiological control of livestock products as a result of the destabilization of the epidemiological situation in the global economy;
- Increasing demand for resources, in particular, the use of groundwater resources, drilling wells, the system of their maintenance, as a result of improving the mechanisms for economic incentives for pastures, increasing their area and number;
- the need for transport services related to the movement of livestock from one region to another, the movement of breeding animals in the context of global climate change;
- Degradation of pastures, disruption of the forage supply system as a result of the loss of biodiversity, which requires the organization, development and organization of the seed market for desert-pasture plants;
- Increased demand for agro services, such as real-time information on pastures, market conditions, environmental impacts, medium and long-term forecasts and strategic development directions, etc.

Materials and analysis. This has led to an increase in demand for agricultural services in grazing, but in practice, as a result of an imbalance in supply and demand, livestock service providers do not provide services in desert areas or the cost of services is several times higher. above.

Based on the foregoing, based on the geographical location of pastures in the country, the type of pastures and livestock breeds and the state of pastures, it is advisable to create a Center for the Development of Pasture Infrastructure and Mobile Services (Figure 1).

The purpose of this center is to provide modern and sustainable pastoral services, develop pasture infrastructure, and ensure that quality services such as livestock and veterinary medicine reach the most remote areas.

In the course of its activities, the Center is responsible for increasing the productivity of pastures, water supply, repair of water facilities, provision of zootechnical and veterinary services, regular provision of market conditions, climate change, diseases, marketing and other information, digitalization. This type of service is provided to livestock and dekhkan farms, karakul farms, LLC and breeding experimental farms operating on Structure of the Center for Development of Pasture Infrastructure and Mobile Services.

The center is managed by a director in accordance with its organizational structure and may consist of 3 departments and 7 departments. The Innovation and Information Department includes the department of information support for livestock farms (weather, market, demand) on pastures, the department for strengthening the forage base and the department for introducing and digitalizing new technologies.

The mobile service department includes the pasture livestock veterinary service department and the water construction department, transport services department, logistics department, logistics department and accounting department.

Funding for this center can be coordinated not only with the state budget, but also with projects and research involving revenues from services and various institutions.

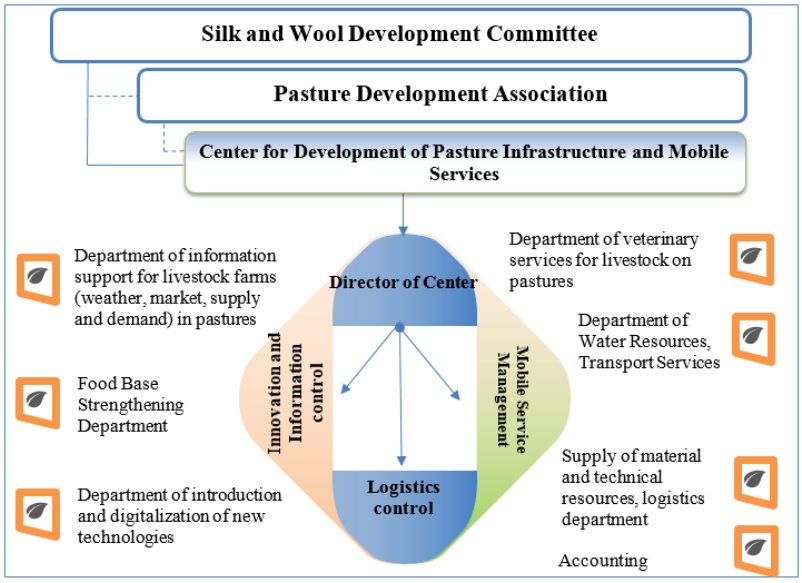

Figure 1. Center for the Development of Pasture Infrastructure and Mobile Services

Discussion. In particular, in accordance with the Decree of the President of the Republic of Uzbekistan dated March 14, 2018 No. PP-3603 "On measures for the accelerated development of the Astrakhan industry" Funds for the development of the Karakul industry created in accordance with the Decree No. PP-4420 can be directed to finance the center " On measures for the comprehensive development of the karakul industry.

At the same time, it is proposed to send 50% of the free part of the funds of the Doodle Development Funds in the republic and regions to the center from short-term cooperative deposits. According to studies, these funds generate about 20-30 billion soums per year in the form of free funds and give an average of 6-8 months to finance livestock development projects. During this period, it is advisable to invest these funds in cooperative deposits in commercial banks on demand (20% per annum).

At the same time, in accordance with paragraph 6 of the Decree of the President of the Republic of Uzbekistan dated August 16, 2019 No. PP-4420 to the Karakul Development Fund for 7 years with interest-free repayment, which will be returned to the state budget in 2026.

Article 14 of the law establishes the right to graze livestock and harvest hay in accordance with measures for the use and protection of pastures. As mentioned above, pastures are used not only in animal husbandry, but also in the cultivation of other types of agricultural products. In turn, under the conditions of increasing degradation, measures should also be established by law for the cultivation of desert-pasture plants and the collection of their seeds.

Pastures leased by the Committee for the Development of the Silk and Wool Industry to Karakul clusters are leased by clusters to livestock farms, as well as to other economic entities. In practice, sublease agreements are concluded for different years. In particular, in the Bukhara region, it is formed for a year, in other regions - for more than a year.

The sublease procedure is regulated by Article 242 of the Land Code of the Republic of Uzbekistan. According to him, a land plot for agriculture can be rented for up to one year.

Conclusion. However, the use of grazing land, especially the secondary lease of pastures for livestock care, has distinctive features compared to other categories of agricultural land, which is a short period of one year for cattle breeding. A short-term secondary lease does not contribute to the efficient use of pastures, and relentless and indiscriminate use can lead to degradation that is difficult to restore. In addition, digging wells for watering livestock and building cowsheds may be limited due to short-term leases. Therefore, Article 242 should provide for the automatic extension of the secondary lease agreement in case of compliance with the procedure for preserving biodiversity in pastures, increasing productivity, building and sharing water bodies.

In addition, Article 242 of the Land Code provides that the agreement on the secondary lease of agricultural land is subject to state registration in accordance with the law. Article 244 of the Land Code proposes the registration of agreements on the secondary lease of pastures by a specially authorized state body. bodies in the field of use and protection of pastures and responsible for their placement in the electronic information system of the State Cadastral Chamber of the Cadastre Agency under the State Tax Committee.

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DEMAND FOR HIGH-QUALITY AGRO-INSURANCE SERVICES IN AGRICULTURE AND THE MAIN INDICATORS OF ITS DETERMINATION

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Abstract

In modern society, insurance covers almost all areas of life and business - from life and health insurance, to the use of material, financial, vehicles, structures that carry out many types of business activities, including the agricultural sector. It is no exaggeration to say that the development of insurance institutions reflects the level of economic culture of society. Because this allows to create a complete system of protection against risks that inevitably arise as a result of the influence of natural and technical factors. Therefore, determining and analyzing the demand for insurance provides the provision of alternative insurance services, creates the conditions for the protection of many socio-economic subsystems of society from various risks, and provides sustainable development.

It should be noted that modern international insurance marketing already has a sufficiently developed set of tools that allow establishing effective and long-term relationships between consumers and service providers. However, these tools are aimed at ensuring the sale of various insurance products, and their attractiveness mainly depends on the profitability of the price offer, and are not aimed at developing an insurance culture, implying that certain types of activities are too risky without insurance. These types of activities include local agriculture, which is carried out in extremely unfavorable natural and climatic conditions. These measures do not always achieve their goal due to the fact that consumers misperceive the importance of this type of expenditure. Therefore, through marketing, it is necessary not only to encourage the purchase of insurance services, but also to form the idea that it is a correct rule of economic behavior, a mandatory institution for the implementation of agribusiness.

Introduction. Like many economic relations, the development of insurance should be carried out in two directions: on the one hand, the demand for insurance products should be formed in proportion to the supply. Insurers - producers of agricultural products must have insured interests. On the other hand, it is a supply, meaning that insurance companies have to offer different options for insurance programs and services. However, in modern economic conditions, the development of insurance in this field of agricultural production is mainly quantitative, due to the expansion of the list of insurance zones and insurance objects, changes in budget funds for subsidizing insurance.

Materials and Methods. A detailed analysis of the demand for products or services is necessary in the study and analysis of economic sectors. Demand for agricultural insurance also depends on a number of reasons. The main ones are:

1. Reasons related to risk protection and social functions of insurance companies;

2. Reasons related to the influence of demand on the market structure and behavior of insurance companies.

As for the growth of insurance activities in agriculture, it depends on the economic development of the country, the well-being of the population, the demand of the society to increase social security, the connection with insurance services, etc . First of all, it is necessary to determine what the demand for insurance services means. Demand for insurance service is the amount of money that potential insurers are willing to spend to legally protect a person, property, and liability in order to satisfy their needs. The proposal is determined by insurers - legal entities, who have received the right to carry out insurance activities in the manner prescribed by law. The size and composition of the offer is largely influenced by the factors of competition between insurers, the level of costs for the implementation of insurance activities and other factors that describe the situation in the insurance market.

Result and Discussion. In order to objectively evaluate the state and prospects of the insurance market, it is necessary to analyze the potential policy holders and insurance objects formed in the insurance market, considered as a need for insurance among the population, characterized by their number, as a demand.

It is appropriate to include an indicator that reflects the need for insurance and can be expressed through the demand coefficient of certain insurance services in the methodology of assessing the insurance market of the regions. This ratio is widely used in various sectors of the economy.

The use of this coefficient in the assessment of the regional insurance market allows to take into account not only the willingness of the respondents to purchase insurance services, but also the share of those who are consumers.

In order to achieve sustainable growth of the regional market, it is necessary to take the following measures for the formation of demand for insurance services: popularization of population insurance, development of insurance culture; improving the well-being of all layers of the population, supporting the further development of small and medium-sized businesses; providing legal assistance to citizens on insurance issues; to create an institution for pre-trial settlement of disputes between insurance companies and their clients.

In order to direct the disposable income of the population to insurance, several conditions are necessary, the most important of which, along with the ability to pay, is the awareness of the client about insurance, the level of economic thinking and the culture of insurance. The conditions of stable demand for insurance are the existence of relations with private property, as well as the accuracy and transparency of insurance activities.

The demand for insurance services is the amount of premiums that can be received by insurance companies in a certain geographical area and at a certain time. Here the question arises: "What form will the demand take?" General demand is divided into real and conditional. Real demand is the demand satisfied by the offer of insurance companies and recorded in official statistics, conditional demand is divided into potential and activated. Potential demand is understood as such a part of consumers that it is necessary to change the product to attract them. In turn, activated demand is not satisfied by the existing offer, it is

related to the way the product is presented.

In the process of studying the market of insurance companies, in particular, how to attract customers, the main focus should be on matching the analysis methodology with the goal. The real demand for total agricultural insurance services can be determined based on the following indicators:

- market scale;
- market saturation level;
- the level of penetration of the product into the market;
- cost component.

The main factor in assessing the size of the agricultural insurance market is the volume of insurance premiums, as well as the rate of growth of this indicator.

Demand is considered as the solvency need for insurance among the population and is characterized by the number of potential policyholders and insurance objects. The provision of insurance services is determined by insurers - legal entities, who have received the right to carry out insurance activities in accordance with the procedure established by law. The size and composition of the offer is largely influenced by the factors of competition between insurers, the level of costs for the implementation of insurance activities and other factors that describe the situation in the insurance market.

Table 1.

Dynamics of the main indicators of demand and supply of the market of insurance services of the Republic of Uzbekistan[2]

Indicator	2016	2017	2018	2019	2020
Demand indicators					
Insurance premiums	692,6	927,5	1 635,2	1 727,55	1 879,35 (billion)
Share of insurance premiums in GDP, %	0,27	0,29	0,38	0,32	0,31
Share of insurance premiums per capita	21,75	28,64	49,62	51,45	54,9 (thousand)
Supply indicators					
Number of insurance companies	26	27	30	28	30
Share of total insurance premiums attributable to 1 insurance company	26.64	34.35	54.51	61.7	62.65

The demand for insurance services is characterized by the following indicators:

1) Insurance premiums. In 2020, the amount of insurance premiums collected by insurers in Uzbekistan amounted to 1 879,35 billion soums, which is increased by 2.7 times compared to 2016 (692.6 billion soums).

2) Share of insurance premiums in GDP. During the years 2016-2020, the ratio of insurance premium and GDP in Uzbekistan has continuously increased. The indicator reached its maximum level in 2020 and was 0.31%.

3) Amount of insurance premium per capita. For 2016-2020, the indicator increased from 21,750 to 54,900 soums, the growth of this indicator was influenced by the development of the insurance market in Uzbekistan.

Despite the fact that the market of insurance services of Uzbekistan has already been formed, it is characterized by a number of problems, the most important of which is the imbalance between the demand and supply of insurance services.

This situation is caused by:

- decrease in the income of the main part of the population;
- low level of insurance culture in the society, lack of confidence in the activities of insurance companies;
- lack of basic research (insurance market situation);
- poorly developed infrastructure of the insurance market.

The activity of the joint-stock company "Uzagrosugurta", which operates in the field of agricultural insurance in our country, is of particular importance. One of the important tasks is to continue agricultural activities even in the conditions of the pandemic, to ensure food safety based on timely supply of agricultural products to the population, and to provide this process with insurance protection.

Today, 14 branches of "Uzagrosugurta" JSC, about 200 branches and 521 insurance offices in densely populated areas are operating in the Republic of Uzbekistan. "Uzagrosugurta" JSC directly conducts insurance activities in 17 categories.

The main clients of "Uzagrosugurta" are agricultural enterprises, farmers and peasant farms, small businesses and private entrepreneurs, as well as rural residents.

"Uzagrosugurta" joint-stock company is carrying out certain activities to insure consumers against accidents caused by various natural disasters and accidents. One of the important factors is the financial support of agricultural enterprises producing agricultural products by JSC "Uzagrosugurta" (Figure 1).

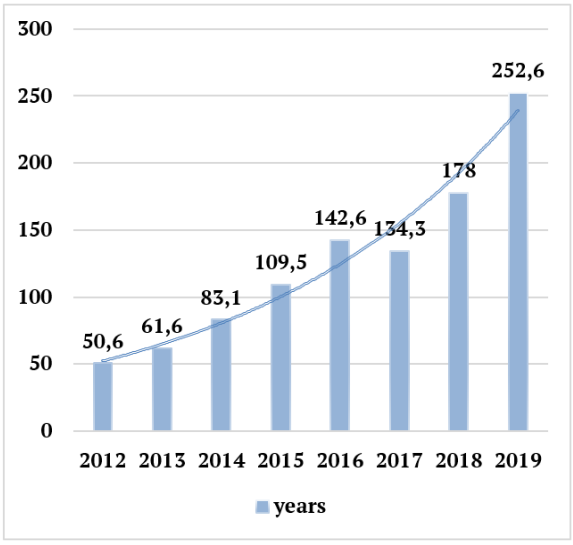

Figure 1. Analysis of the dynamics of insurance premium income of "Uzagrosugurta" JSC in 2012-2019[3] (billion soums).

"Uzagrosugurta" joint-stock company collected 50.6 billion soums of insurance premiums as a result of agricultural insurance in 2012, and in 2019 it reached 252.6 billion soums, which is 5 times more than in 2012.

In 2012, 7.5 billion sums of insurance coverage were paid to cover damages caused by natural disasters. By the end of 2019, 97.6 billion sums were paid by the company and its regional branches for compensation of insured persons' losses (Figure 2).

Providing the population and the country with a wide variety of agricultural products requires further

development of insurance protection to prevent food insecurity. The development of the agricultural insurance system supports agriculture as a financial mechanism for mitigating and stimulating the economic crisis.

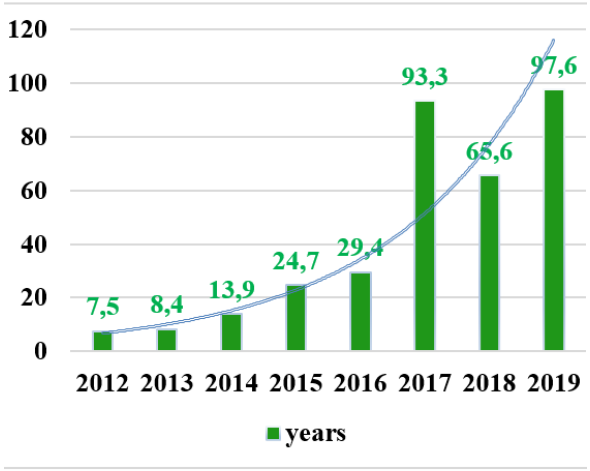

Figure 2. Analysis of dynamics of insurance coverage of "Uzagrosugurta" JSC in 2012-2019[4] (billion soums).

In order to alleviate the crisis in the conditions of the pandemic, the joint-stock company "Uzagrosugurta" paid 15 billion soums of insurance coverage to legal entities and individuals who had insurance contracts during the quarantine period. As a result of the insurance event, operational calculations and payment of insurance premiums were taken under control in order to compensate for the losses incurred in agriculture and other sectors of the economy. At the moment, the society has organized work to justify their trust and provide quality services based on remote communication with the insured.

Conclusions. Analyzing the problem of real demand for insurance services, it is important to note the factors affecting insurance and related to insurance premiums and types. For example, regulatory legal documents can help the development of insurance activity, and can also have a slowing effect on it.

When analyzing the demand for certain types of insurance, it is necessary to take into account the relationship between the volume of insurance premiums and other economic indicators.

The growth of insurance premiums in insurance types other than life insurance depends on the following: the ratio of the growth of gross domestic product income to insurance events.

If viewed from the point of view of demand, then the indicators should be compared with the value of the insured property and the attitude of the consumer to the quality of services. If viewed from a supply point of view, it is important to consider the company's performance and financial condition.

In the conditions of developed market relations, the offer of agro insurance services has a dual subjective-objective nature and, accordingly, has an economic and marketing nature.

On the one hand, agro insurance services are a set of services and goods intended for agriculture, which include material and non-material basic needs. This form of support for agricultural production describes its economic nature.

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SIMULATION OF DYNAMIC PROCESSES IN NONLINEAR DISCRETE SYSTEMS WITH DELAY ON THE BASIS OF GRAPHS

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Abstract

In connection with the problems of development and implementation of perfect automatic and automated control systems for complex technological processes based on modern information technology tools, the development of research methods for multidimensional nonlinear discrete control systems is of particular relevance. The variety of these systems is due to the types of modulation, non-linearities, modes of operation of impulse elements, characteristics of continuous parts. The article deals with the problems of modeling and research of one-dimensional and multidimensional pulse-frequency systems with delay based on the use of dynamic graphs. One of the key points in solving the problem is an approach based on the maximum consideration of the physical features of these systems. Given the structural complexity of systems, it is necessary first of all to establish the possibility of decomposing the system into simpler subsystems. Then the study of the system can be reduced to the study of individual subsystems and the nature of their interaction, that is, to the determination of the properties of the system as a whole by the properties of its elements. Systems with frequency-pulse modulation are essentially non-linear systems. The topological method based on dynamic graph models allows solving the fundamental difficulties of studying nonlinear discrete systems with delay, allows clearly and strictly formalizing their description, and makes it possible to obtain effective algorithms for analyzing one-dimensional and multidimensional systems of this class. The article presents an example of using the obtained algorithm.

Keywords: *nonlinear discrete system, frequency pulse modulator, frequency-pulse system with delay, dynamic processes, graph model*

Introduction. Currently, an exceptionally digital technique is used to manage automatic systems of various nature and various purposes. Measurements and control are carried out in discrete times, therefore discrete mathematical models of dynamic systems are relevant. Initially, systems with pulse-frequency modulation were widely used in radio engineering and telemetry [1]. At present, pulse-frequency systems are widely used in information and measurement technology [2,3,4], in automatic control systems [5,6,7], in modulating installations [8] and in the study of nervous activity [9,10]. Pulse-frequency systems belong to the class of essentially nonlinear systems, since there is a nonlinear element in their structure. To date, several methods of analyzing pulse-frequency systems have been developed. The first one is based on precise calculation methods and includes questions of obtaining and analyzing difference equations describing the dynamics of these systems. The second direction is based on approximate methods related to the linearization of a nonlinear element. Frequency methods based on the direct method of A. M. Lyapunov and the frequency access of V. M. Popov have found wide use in the study of the dynamics of pulse-frequency systems. A detailed review of the work and analysis of methods for studying pulse-frequency systems is given in [11- 15].

Materials and methods. Fig. 1 shows a non-linear discrete system with a constant control delay τ. Nonlinearity is created by a pulse-frequency modulator (PFM); the object is represented by a dynamic link of the l-th order (Figure1).

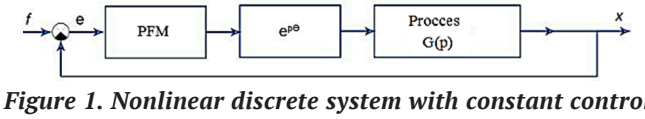

Figure 1. Nonlinear discrete system with constant control delay

The modulator generates a clock sequence of pulses according to the modulation characteristic.

$$T_j = t_{j+1} - t_j = \phi[e(t_j)], \qquad (1)$$

where is the error signal in the j-th interrupt period, t_j - is the moment of appearance of the j-th pulse at the output of the pulse-frequency modulator, T_j -is the variable interrupt period of the pulse-frequency modulator.

The output signal of the pulse-frequency modulator changes according to the formula:

$$e_j^*(t) = \begin{Bmatrix} signe(t_j), & t_j < t \le t_j + \tau_u \\ 0, & t_j + \tau_u < t \le t_{j+1} \end{Bmatrix}, \qquad (2)$$

On figure 2 proposes an equivalent circuit diagram of the system. The zero-order extrapolator in the frequency-pulse system keeps the signal $e^*(t_j)$ for a time equal to the duration of the frequency-modulated pulses τ_u.

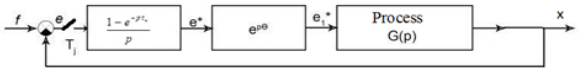

Figure 2. Equivalent circuit of a pulse-frequency system with a delay of the control signal

At the output of the frequency-pulse modulator, a sequence of pulses of the same width, but with a variable frequency, is formed [16–17]. The delay link delays this sequence by time θ (Figure 3).

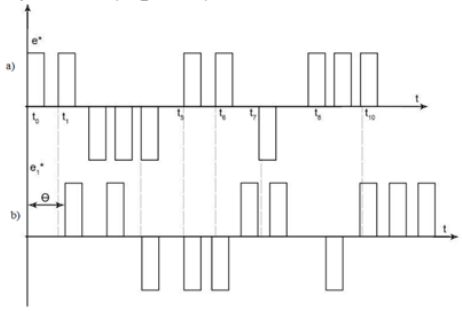

Figure 3. Pulse sequence at the output of the pulse - frequency modulator (a); pulse sequence at the output of the delay link (b).

Delayed control signals do not affect the linear part of the system under the condition - t ⩽ θ. For t ⩽ θ, the structural states of the system replace each other from cycle

to cycle. In each of these states, the system is linear and open-loop. From the output of the pulse-frequency modulator, the control signals arrive at the linear part of the system, provided that t > θ.

At t> θ, there is a non-programmed change in the structure of the system. The structural states of the system change in an arbitrary sequence (Figure 4). But in each of them, the system is also a linear open system [18-19]. Let us proceed to the construction of macromodels of the dynamics of the functioning of a pulse-frequency system with a constant delay.

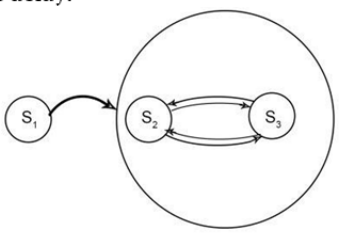

Figure 4. Changing the structure of a nonlinear discrete system with delay

Suppose that in the time interval [0, θ] the number of closures of the pulse-frequency modulator is equal to (k+1).

The sequence of pulses issued by the modulator at moments t0, t1,t2,..., tk is not skipped by the delay link.

Under the condition t > θ, some moment of closing the impulse element tq can be in different intervals. It depends on the value of the delay θ and the value of the variable interruption period of the pulse-frequency modulator (Figure 5).

a) within the range of the j-th pulse of the delayed pulse sequence, i.e.

$$t_j + \theta < t_q \le t_j + \theta + \tau_u$$

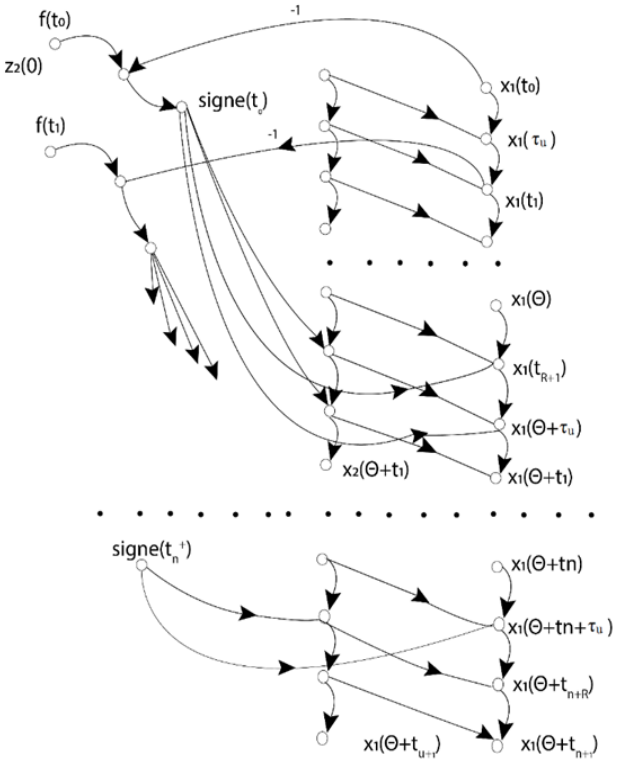

Figure 5. Dynamic graph model of the pulse - frequency system.

As can be seen from this condition, the state variables of the system are determined first for the moment of time tj+θ, then for the moment of time tj+θ+τu ;

b) outside the zone of action of the j-th pulse of the delayed sequence, i.e. within the interval covering the pause between the j-th and (j + 1)-th pulses.

When this condition is met, the state variables of the system are determined first for the moment tj+θ, then for the moment tq, and so on.

$$t_j + \tau_u + \theta < t_q \le t_j + \theta.$$

In this case, the processes are defined first for the moment tj+θ+τu , then for the moment tq, and so on.

The dynamic graph model of a system with a pulse-frequency modulator is shown in Fig. 5. We write down the recurrent relations obtained from the analysis of graph models.

t ⩽ θ

j = 0, 1, ... , k-1,

$$e(t_j^+) = f(t_j) - x_1(t_j), \quad (1)$$

$$e^*(t_j^+) = signe(t_j^+), \quad (2)$$

$$Tj = tj+1 - tj = \psi\,[e(tj)], \quad (3)$$

$$X(tj+\tau u) = A(\tau u)\,X(tj) \quad (4)$$

$$X(tj+1) = A(Tj)\,X(tj) \quad (5)$$

$$X(\theta) = A(\theta - tk)\,X(tk) \quad (6)$$

t > θ

j = k, k+1, ..., n.,

$$e(t_j^+) = f(t_j) - x_1(t_j),$$

$$e^*(t_j^+) = signe(t_j^+),$$

$$Tj = \psi\,[e(tj)],$$

If $tj-k+\theta < tj+1 \le tj-k+\theta+\tau u$, then:

$$X(tj+1)=A(tj+1-\alpha)X(\alpha)+B(tj+1-\alpha)\text{sign } e(t+j-k), \quad (7)$$

$$X(\alpha+\tau u)=A(\tau u)\,X(\alpha)+B(\tau u)\text{ sign } e(t+j-k), \quad (8)$$

$$X(tj-k+1+\theta) =A(Tj-k)X(\alpha)+B(Tj-k)\text{signe}(t+j-k+1), \quad (9)$$

where $\alpha = \theta + tj-k$

If $tj-k+\theta+\tau u < tj+1 < tj-k+1+\theta$, then

$$X(\alpha+\tau u) = A(\tau u)\,X(\alpha) + B(\tau u)\text{ sign } e(t+j-k), \quad (10)$$

$$X(tj+1) = A(tj+1-\alpha-\tau u)\,X(\alpha+\tau u), \quad (11)$$

$$X(tj-k+1+\theta) = A(Tj-k)\,X(\alpha) + B(Tj-k)\text{ sign } e(t+j-k+1). \quad (12)$$

Definition of system state variables with pulse-frequency modulator and control signal delay

1. A dynamic graph model of the system is built - the subgraph of the delayed signal and the subgraph of the continuous part of the system are combined.

2. For all steps starting from the first one (i = 0, 1,..., k), we define

$$e(t_j^+) = f(t_j) - x_1(t_j),$$

$$Tj = tj+1 - tj = \psi\,[e(tj)],\ ti+1 = Ti + ti$$

3. Calculate the state variables by the relations (4)-(6).

4. At the same time, we calculate the number of closures l=k+1 of the pulse element that occurred in the interval (0,

θ], checking the condition ti ⩽ θ

5. Starting from the (k+1) th step (t >θ, j = k+1, k+2,..., N), we define

$$e(t_j^+) = f(t_j) - x_1(t_j),$$

Tj = tj+1 – tj = ψ [e(tj)], Tj+1 = Tj + tj

6. If the conditions tj-k + θ < tj+1 ⩽ tj-k + θ + τu,, are satisfied, then the state variables are calculated by the relations (7) – (9).

7. If the conditions tj-k + θ + τu < tj+1 ≤ tj-k+1 + θ, are satisfied, then the state variables are calculated by the relations (10) – (12).

Within the framework of the obtained results, multidimensional pulse-frequency systems with a delay can also be studied. Figure 6 shows a block diagram of an N-dimensional pulse-frequency system with delays in the controls.

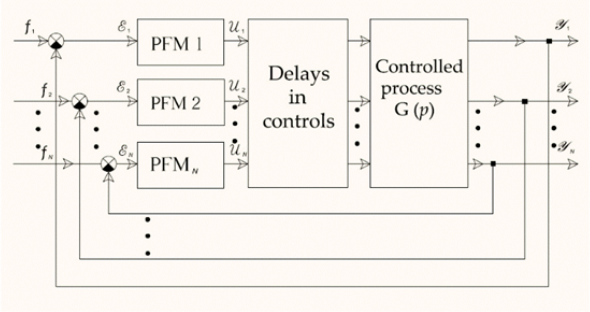

Figure 6. Multidimensional pulse-frequency system with control delays.

Autonomous pulse-frequency modulators implement the law of frequency modulation

Tjr = ψ r[erj(tjr)],

where tjr - the moment when the j-th pulse appears at the output of the r-th pulse-frequency modulator,

erj(tjr)- r - th channel error signal (r = 1, 2, ..., N).

Unsynchronized operation of autonomous modulators(in general), various delays in control actions cause significant difficulties in the study of the class of systems under consideration. Here, at first glance, there is an even more chaotic change of structural states than in a multidimensional pulse-width system with a delay. Nevertheless, by ordering the time sequences with which we are dealing in this case, it is possible to carry out a clear formalization of the description of the dynamics of the functioning of a multidimensional nonlinear discrete system with a constant delay.

Let the closing moments of the impulse elements tjr (r = 1, 2, ..., N) be determined at some j - th step. We obtain an unordered finite set of points:

T1 = (tj1, tj2, ..., tjN)

The set of time points that are delayed by the values θ rr, θ rk with respect to tjr, we denote:

$$T_2 = t_j^1 + \theta^{11}, t_j^1 + \theta^{21}, ..., t_j^1 + \theta^{N1}, t_j^2 + \theta^{12}, t_j^2 + \theta^{22},$$

$$t_j^2 + \theta^{N2}, ..., t_j^N + \theta^{1N}, t_j^N + \theta^{2N}, ..., t_j^N + \theta^{NN})$$

We will set the set of control pulse termination moments at the outputs of the corresponding delay links:

$$T_3 = t_j^1 + \theta^{11} + \tau^1, t_j^1 + \theta^{21} + \tau^1, ..., t_j^1 + \theta^{N1} + \tau^1, t_j^2 +$$

$$+\theta^{12} + \tau^2,$$

$$t_j^2 + \theta^{22} + \tau^2, ..., t_j^2 + \theta^{N2} + \tau^2, ...,$$

$$t_j^N + \theta^{1N} + \tau^N, t_j^N + \theta^{2N} + \tau^N, ..., t_j^N + \theta^{NN} + \tau^N),$$

where θrr (r = 1, 2, ..., N) – delay in the r-th cross channel,

θrk (r = 1, 2, ..., N, k = 1, 2, ..., N, r≠k)) – the delay in the (rk) - th cross channel, τr - the duration of the frequency-modulated pulses urk.

Let's define the union of finite sets T1, T2, T3

$$T = T_1 \cup T_2 \cup T_3$$

Let's order all points of the set T using the numbering sequence 1,2, ..., n. On the time axis we get a finite set:

T*= (t1, t2 ,..., tn).

We will introduce the time interval into consideration t1 < t ⩽ tn.

We will introduce the time interval into consideration t1 < t ⩽ tn. Divide it into (n -1) intervals:

(t1, t2], (t2, t3], ..., (tn-1, tn].

Within each time interval (ti, ti+1], i= 1, 2, ..., n, a multidimensional pulse - frequency system with a delay is in the same structural state. Using a topological model, it is not difficult to determine the behavior of the system at all specified intervals, including moments: (t1, t2, ..., tn].

Performing the described procedure sequentially for each step of the calculations, (j = 0, 1, 2, ...,), it is possible to fully define the processes in a multidimensional pulse-frequency system with delays in the controls.

The dynamic graph model of a multidimensional multidimensional pulse-frequency system with delays in controls is constructed similarly to the graph model of a multidimensional pulse-width system with delays and is a combination of graph models of system elements:

$$G_t^a = G_t^f \cup G_t^{\varphi 3} \cup G_t^z \cup G_t^{oy}.$$

Naturally, the calculation of such a structurally complex system as a multidimensional pulse-frequency system with a delay can only be performed on a computer.

The algorithm for calculating processes in such a system is proposed below.

Determination of state variables of a multidimensional system with pulse frequency modulation and control signal delay

of the system is constructed on the basis of combining graph models of its elements:

$$G_t^a = G_t^f \cup G_t^{\varphi 3} \cup G_t^z \cup G_t^{oy}.$$

At each step of the calculations, j = 0, 1,..., m, in accordance with the modulation characteristics, we determine the closing moments of the pulse elements:

*tj*1,*tj*2,...,*tjr*,

We determine the moments of occurrence of control pulses at the outputs of the corresponding delay links:

$$t_j^1 + \theta^{11}, t_j^1 + \theta^{21}, ..., t_j^1 + \theta^{N1},$$

$$t_j^2 + \theta^{12}, t_j^2 + \theta^{22}, ..., t_j^2 + \theta^{N2},$$

$$... \quad ... \quad ... \quad ... \quad ... \quad ... \quad ... \quad ... \quad ... \quad ...$$

$$t_j^N + \theta^{1N}, t_j^N + \theta^{2N}, ..., t_j^N + \theta^{NN},$$

We determine the moments of the end of the delayed pulses

$$t_j^1 + \theta^{11} + \tau^1, t_j^1 + \theta^{21} + \tau^1 \ , ..., t_j^1 + \theta^{N1} + \tau^1,$$

$$t_j^2 + \theta^{12} + \tau^2, t_j^2 + \theta^{22} + \tau^2, ..., t_j^2 + \theta^{N2} + \tau^2,$$

$$t_j^N + \theta^{1N} + \tau^N, t_j^N + \theta^{2N} + \tau^N, \ldots, t_j^N + \theta^{NN} + \tau^N),$$

We arrange the obtained points on a single time scale and mark the interval δj on which they are located.

Using the graph, we determine the state variables, the output coordinates of the system for all time points marked on the interval δj.

7. Return to step 2.l of the algorithm.

Consider an example.

Let us calculate the transient process in a frequency-pulse system with an ideal frequency-pulse modulator (PFM) and with a control delay (Figure 7).

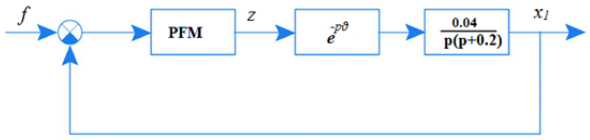

Figure 7. Structural diagram of a frequency-pulse system with an ideal frequency-pulse modulator (PFM) and with a control delay.

Initial data and system characteristics:

$$G(p) = \frac{0.04}{p(p+2)};\ T_n = \frac{2.5}{0.1+|e_n|};\ z_n = sign(e_n).$$

$$T_n = t_{n-1} - t_n;\quad \theta = 1 \text{ sek}$$

Solution:

$$e(t_0^+) = u(t_0) - x_1(t_0) = 1; z(t_0^+) = sign(e(t_0^+)) = 1;$$

$$T_0 = \frac{2.5}{0.1+|e(t_0^+)|} = 2.272;$$

$$t_1 = t_0 + T_0 = 2.272.$$

We build a graph of transition states of the system (Figure 8).

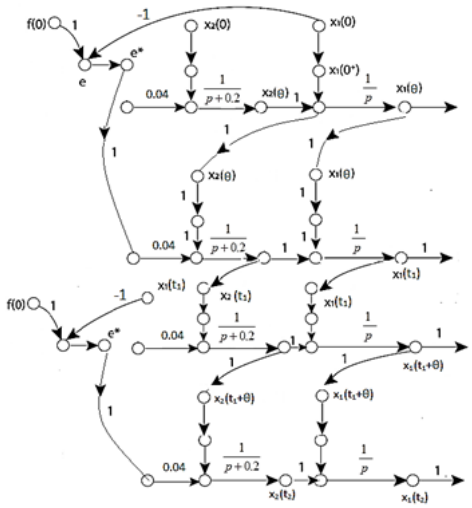

Figure 8. Dynamic graph model of one-dimensional nonlinear system.

with a pulse-frequency delay modulator.

Based on the graph model for the state variables of the system at the time $t = t_0 + \theta$, we write the following expressions:

$$x_2(\theta) = L^{-1}\left\{\frac{1}{p+0.2}\right\}x_2(t_0) = e^{-0.2\theta}x_2(t_0) = 0;$$

$$x_1(\theta) = x_1(t_0) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\}x_2(t_0) =$$

$$= x_1(t_0) + 5(1 - e^{-0.2\theta})x_2(t_0) = 0$$

$$x_2(t_1) = L^{-1}\left\{\frac{1}{p+0.2}\right\}[x_2(\theta) + 0.04z(t_0^+)] =$$

$$= e^{-0.2(t_1-\theta)}[x_2(\theta) + 0.04z(t_0^+)] = 0.031011;$$

$$x_1(t_1) = x_1(\theta) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\}\left[x_2(\theta) + 0.04z(t_0^+)\right] =$$

$$= x_1(\theta) + 5(1 - e^{-0.2(t_1-\theta)})\left[x_2(\theta) + 0.04z(t_0^+)\right] = 0.044946$$

For system state variables at time $t = t_1 + \theta$ we write the following expressions:

$$x_2(t_1 + \theta) = L^{-1}\left\{\frac{1}{p+0.2}\right\}[x_2(t_1) =$$

$$= e^{-0.2\theta}x_2(t_1) = 0.025389$$

$$x_1(t_1 + \theta) = x_1(t_1) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\}x_2(t_1) =$$

$$= x_1(t_1) + 5(1 - e^{-0.2\theta})x_2(t_1) = 0.073053$$

For system state variables at time $t = t_2$= 4,707 we write the following expressions:

$$x_2(t_2) = L^{-1}\left\{\frac{1}{p+0.2}\right\}[x_2(t_1 + \theta) + 0.04z(t_1^+)] =$$

$$= e^{-0.2(t_2-t_1-\theta)}[x_2(t_1 + \theta) + 0.04z(t_1^+)] = 0.049722$$

$$x_1(t_2) = x_1(t_1 + \theta) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\} \times$$

$$\times\left[x_2(t_1 + \theta) + 0.04z(t_1^+)\right] =$$

$$= x_1(t_1 + \theta) + 5(1 - e^{-0.2(t_2-t_1-\theta)}) \times$$

$$\times\left[x_2(t_1 + \theta) + 0.04z(t_1^+)\right] = 0.151389$$

For system state variables at time $t = t_2 + \theta$ we write the following expressions:

$$x_2(t_2 + \theta) = L^{-1}\left\{\frac{1}{p+0.2}\right\}[x_2(t_2) = e^{-0.2\theta}x_2(t_2) = 0.040709$$

$$x_1(t_2 + \theta) = x_1(t_2) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\}x_2(t_2) =$$

$$= x_1(t_1) + 5(1 - e^{-0.2\theta})x_2(t_1) = 0.196455$$

In general, for time points $t_i + \theta, i = 0,1, \ldots, n$ expressions for system state variables will look like:

$$x_2(t_{i+1}) = L^{-1}\left\{\frac{1}{p+0.2}\right\}[x_2(t_i + \theta) + 0.04z(t_i^+)] =$$

$$= e^{-0.2(t_{i+1}-t_i-\theta)}[x_2(t_i + \theta) + 0.04z(t_i)];$$

$$x_1(t_{i+1}) = x_1(t_i + \theta) + L^{-1}\left\{\frac{1}{p(p+0.2)}\right\} \times$$

$$\times\left[x_2(t_i + \theta) + 0.04z(t_i^+)\right] =$$

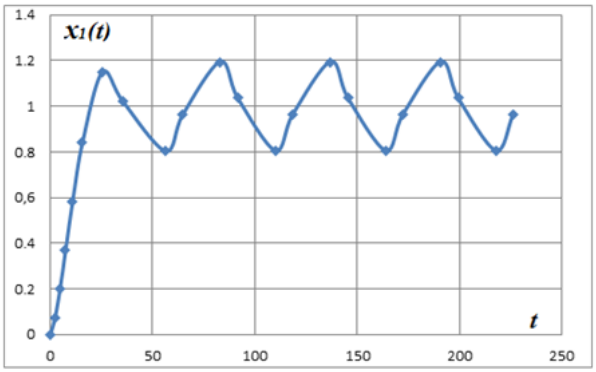

Figure 9. Graph of the transient process in the frequency-pulse system

system on the time interval t ∈ [0, 150] , obtained on the basis of the graph model.

Thus, we find successively the values of the system state variables x1(t), x2(t) at time t3, the error signal at the moment of the subsequent closing of the pulse element e(t3+), the output signal of the pulse-frequency modulator z(t3+), etc.

The calculation of the transient process in this system with PFM based on its graph model was performed in Microsoft Excel. Based on the results of the calculation, a graph of the output coordinate of the system was obtained - x1(t). On fig. 9 shows a graph of the transient process in the system on the time interval t ∈ [0, 150]

Conclusions. Dynamic graph models allow us to obtain recurrent relations for calculating processes in pulse-frequency systems with a delay. Based on the results obtained, algorithms for calculating processes in a one - dimensional and multidimensional pulse-frequency system with a control delay are obtained [20-22]. The use of transition state graphs makes it possible to perform a clear formalization and automation of computational procedures for calculating systems with non-program changes in the structure. The ordering of the time sequences that take place in this case allows us to perform a clear formalization of the dynamics of the structures of one-dimensional and multidimensional nonlinear systems with a delay.

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MODELING, FORECASTING OF SYSTEMS IN THE PROCESS OF BIOGAS PRODUCTION

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Abstract

The article deals with the problems of forecasting related to the insufficient quality and quantity of initial data, changes in the environment in which the process takes place, the impact of subjective factors. The process of formation of a mathematical model is analyzed, and the prediction of obtaining biogas in the fermentation process for a part of the bioreactor, which will facilitate the study of various processes occurring in this installation. A daptive neuro-fuzzy system of conclusions is discussed, which implements a fuzzy output system in the form of a five-layer neural network of direct signal propagation, as well as mathematical modeling of thermal processes in a biogas plant.

Key words: *forecasting, mathematical model, neuro-fuzzy system, neural network, modeling of the thermal process.*

Introduction. Mathematical modeling is an important stage of scientific research, because it allows you to imagine the physics of the process occurring in a particular object. The most accurate and complete model helps to simplify the process of analyzing the dynamic characteristics of a physical phenomenon or process occurring in the object of study, subject to verification for adequacy to the real process [1]. The expediency of mathematical modeling is due to the high cost of conducting experiments on a real biogas production unit (bioreactor). , subject to the need for its design and manufacture, and significant time costs, due to the high inertia of a number of processes, on the example of obtaining biogas from various agricultural wastes by anaerobic fermentation in the bioreactor, due to the large overall dimensions of the installation.

Material and methods. Consider the process of forming a mathematical model, and predicting the production of biogas during fermentation for a part of the bioreactor, which will facilitate the study of various processes occurring in this installation.

Forecasting is one of the most popular, but at the same time one of the most difficult tasks of data mining. Forecasting problems are associated with insufficient quality and quantity of initial data, changes in the environment in which the process takes place, the impact of subjective factors. The forecast is always made with some error, which depends on the forecast model used and the completeness of the initial data [2].

As the information resources used in the model increase, the accuracy of the forecast increases, and the losses associated with uncertainty in decision-making decrease.

Various forecasting methods are known and widely used: algorithms for extrapolating experimental data in simple engineering calculations and software products, as well as more cumbersome statistical methods using parametric models.

Four methods of identifying the nonlinear dependence of output are considered - using a linear regression model, a quadratic regression model, a fuzzy knowledge base and a neural-paring model. To solve this problem, consider a class of adaptive networks functionally equivalent to fuzzy reasoning systems. An important task is to determine the network inputs.

The adaptive neuro-fuzzy inference system is one of the first variants of hybrid neuro-fuzzy networks - a neural network of direct signal propagation of a special type. The architecture of a neuro-fuzzy network is isomorphic to a fuzzy knowledge base. Neuro-fuzzy networks use differentiated implementations of triangular norms (multiplication and probabilistic OR), as well as smooth membership functions. This makes it possible to use fast neural network training algorithms based on the method of backpropagation of errors to configure neuro-fuzzy networks [3, 4]. The adaptive neuro-fuzzy system of conclusions implements a fuzzy output system in the form of a five-layer neural network of direct signal propagation. The purpose of layers is as follows:

the first layer - the terms of the input variables;

the second layer - antecedents (parcels) of fuzzy rules;

the third layer is the normalization of the degrees of implementation of the rules;

the fourth layer is the conclusion of the rules;

the fifth layer is the aggregation of the result obtained according to various rules.

For a fuzzy system having two inputs x and one output y, fuzzy reasoning is shown in fig. 1, a, and the corresponding equivalent adaptive neuro-fuzzy network - in fig. 1, b.

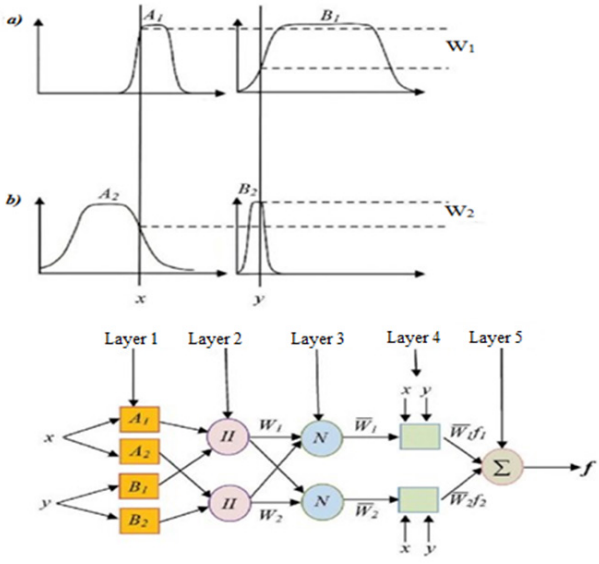

Figure 1. Fuzzy reasoning (a) and equivalent adaptive neuro-fuzzy network (b).

The knowledge base of such a system contains two fuzzy rules if

Rule 1: If $x = A_1$ и $y = B_1$ то $f_1 = p_1x + q_1y + r_1$,

Rule 2: If $x = A_2$ и $y = B_2$ то $f_2 = p_2x + q_2y + r_2$.

Layer 1: Each node in this layer is an adaptive node with the following node function:

$$O_i^1 = \mu_{A_i}(x),$$

where x is the input signal of node i, A_i is a linguistic

variable associated with a given node function. In other words, is the membership function of the variable $O_i^1 A_i$, which determines the degree to which a given x satisfies A_i. Normally, a bell-shaped function is chosen as: $\mu_{A_i}(x)$

$$\mu_{A_i}(x) = 1 \Big/ \left(1 + \left[\left(\frac{x - c_i}{a_i}\right)^2\right]^{b_i}\right),$$

where $\{a_i, b_i, c_i\}$ is the set of parameters of this layer. The parameters of this layer refer to the so-called *prerequisite parameters*.

Layer 2: Each node in a given layer is a fixed node that multiplies the input signals, the output value of the node being the weight of some rule:

$$\omega_i = \mu_{A_i}(x) * \mu_{B_i}(x), i = 1,2. \quad (3)$$

Layer 3: Each i-th node of a given layer determines the ratio of the weight of the i-th rule to the sum of the weights of all the rules:

$$\overline{\omega_i} = \frac{\omega_i}{\omega_1 + \omega_2} \quad (4)$$

The output signals of the 3rd layer is *called normalized weights*.

Layer 4: The nodes of this layer are defined by linear (for a Model of the Sugeno type) functions of the output variable membership:

$$O_i^4 = \overline{\omega_i} f_i = \overline{\omega_i}(p_i x + q_i y + r_i), \quad (5)$$

Where is the output signal of the 3rd layer and is the set of parameters of this layer (the so-called $\overline{\omega_i}(p_i x + q_i y + r_i)$*output parameters*).

Layer 5: The only node in this layer is a fixed node in which the total output value of the adaptive network is calculated as the sum of all input signals:

$$O_1^5 = \sum_i \overline{\omega_i} f_i = \frac{\sum_i \omega_i f_i}{\sum_i \omega_i} \quad (6)$$

Obviously, for the given values of the prerequisite parameters, the total output value (Fig. 2) is a linear combination of the output parameters:

$$f = \frac{\omega_1}{\omega_1 + \omega_2} f_1 + \frac{\omega_2}{\omega_1 + \omega_2} f_1 = \overline{\omega_1} f_1 + \overline{\omega_2} f_2 =$$
$$= (\overline{\omega_1} x) p_1 + (\overline{\omega_1} y) q_1 + (\overline{\omega_1}) r_1 + (\overline{\omega_2} x) p_2 + (\overline{\omega_2} y) q_2 + (\overline{\omega_1}) r_2 \quad (7)$$

where $p_1, q_1, r_1, p_2, q_2, r_2$ are the output parameters.

Typical training procedures for neural networks can be used to configure an adaptive neuro-fuzzy network since it uses only differentiated functions. Usually, a combination of gradient descent is used in the form of an error backpropagation algorithm and the method of least squares. The backpropagation algorithm configures the parameters of the antecedents of the rules, i.e. the membership functions. Each iteration of the configuration procedure is performed in two steps. At the first stage, a training sample is fed to the inputs, and the optimal parameters of the nodes of the fourth layer are found by an iterative method by the interaction between the desired and actual behavior of the network. At the second stage, the residual residual residual is transmitted from the network output to the inputs, and the parameters of the nodes of the first layer are modified by the method of backpropagation of the error. At the same time, the coefficients of the conclusions of the rules found at the first stage do not change. The iterative configuration procedure continues until the residualness exceeds the preset value.

Consider a typical prediction algorithm carried out using neural networks.

Selection of significant factors. At the first stage, the maximum number of significant factors affecting the forecast is allocated. Such additional factors affecting the behavior of the predicted value are called exogenous (external) or artifacts. Here, the observation interval (sliding window) is selected, that is, it is found out by how many previous values of the time series the forecast is made.

Data preprocessing. At the second stage, insignificant, according to the expert, and not affecting the forecast, data are eliminated. If necessary, the missed information is also restored. Skillfully carried out data preprocessing can significantly improve the quality of the forecast.

Build the model. At the next stage, the most suitable paradigm and structure of the neural network, as well as the algorithm and parameters of its training, are selected for this analyzed process.

Actual *forecasting (obtaining the result).* Experiments are carried out according to a scheme similar to the one in which the training was carried out.

Results

Consider theathematic modeling on the example of thermal processes in a biogas plant. According to Newton's law, the force of internal friction opposing motion between water particles moving at different speeds is determined by the formula:

$$s = \mu \frac{dw}{dn}. \quad (8)$$

Consequently, the heat transfer process is represented in this way.

Each particle moves at a different speed: the particle velocity decreases towards the wall of the bioreactor of the biogas plant, and the velocity of the particles adhered to the wall of the bioreactor is zero. Considering the law of thermal conductivity, this makes it possible to determine the heat flow through the layer of water near the wall.

$$q = -\lambda_b \left(\frac{dT}{dy}\right)_{y=o}. \quad (9)$$

Where: λ_b is the coefficient of thermal conductivity of water; T is the current temperature.

Differential equation for a moving particle of liquid has the form:

$$\frac{dT}{d\tau} + \omega_x \frac{dT}{dx} + \omega_y \frac{dT}{dy} + \omega_z \frac{dT}{dz} = \alpha \left(\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} + \frac{d^2T}{dz^2}\right) + \frac{W}{c\rho}. \quad (10)$$

Where: τ – time, from; $\omega_x, \omega_y, \omega_z$ - components of water velocity; m/s; W is the amount of heat absorbed by a unit volume per unit time, J/s; $c\rho$ - specific volumetric heat capacity,
J/ ($m^3 \cdot K$); x, y, z - current coordinates.

The heat transfer law can be used to determine the heat capacity,
J/ ($m^3 \cdot K$); x, y, z - current coordinates.

The heat transfer law can be used to determine the heat transfer process. However, it is necessary to know the kind of temperature field function in a liquid, which is described by the differential equation (10).

This equation contains the components of the velocity that can be determined from the system of equations: $\omega_x, \omega_y, \omega_z$

$$\frac{d\omega_x}{d\tau} + \omega_x \frac{d\omega_x}{dx} + \omega_y \frac{d\omega_x}{dy} + \omega_z \frac{d\omega_x}{dz} = v\left(\frac{d^2\omega_x}{dx^2} + \frac{d^2\omega_x}{dy^2} + \frac{d^2\omega_x}{dz^2}\right) + \left(g_x - \frac{1}{\rho}\frac{dP}{dx}\right), \quad (11)$$

$$\frac{d\omega_y}{d\tau} + \omega_x \frac{d\omega_y}{dx} + \omega_y \frac{d\omega_y}{dy} + \omega_z \frac{d\omega_y}{dz} = v\left(\frac{d^2\omega_y}{dx^2} + \frac{d^2\omega_y}{dy^2} + \frac{d^2\omega_y}{dz^2}\right) + \left(g_y - \frac{1}{\rho}\frac{dP}{dy}\right) \quad (12)$$

$$\frac{d\omega_z}{d\tau} + \omega_x \frac{d\omega_z}{dx} + \omega_y \frac{d\omega_z}{dy} + \omega_z \frac{d\omega_z}{dz} = v\left(\frac{d^2\omega_z}{dx^2} + \frac{d^2\omega_z}{dy^2} + \frac{d^2\omega_z}{dz^2}\right) + \left(g_z - \frac{1}{\rho}\frac{dP}{dy}\right) \quad (13)$$

After solving equations (11–13), we get:

$$\frac{d\rho}{d\tau} + \frac{d(\rho\omega_x)}{dx} + \frac{d(\rho\omega_y)}{dy} + \frac{d(\rho\omega_z)}{dz} = 0. \quad (14)$$

Discussion

Equation (14) is called the flow continuity condition. Equations (11-13) and (14) outline the relationship between physical parameters. To fully describe thermal processes, the system of equations in question must contain additional equations. These equations must contain physical, geometric, time and boundary conditions. Thus, solving the considered system of equations is a difficult task. Therefore, only experimental studies will help to obtain numerical values of the desired variables, after which equations are drawn up that describe the results of the experiments [5]. In this regard, it will be necessary to make a computational experiment.

Conclusion

As a result of the study, a method for forecasting output is proposed, based on the construction of approximate models in the form of adaptive neuro-fuzzy networks trained on samples of real data for past periods. Based on the proposed method, an approximating model of the forecast was created.

The considered features of the use of fuzzy sets and neural networks, which show their *advantages* in comparison with other existing methods when choosing a forecast model.

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WHY HYDROLOGICAL MODELLING: SWOT ANALYSIS

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Abstract

Due to exponential changes in climate and land use, spatial and temporal variability in the global water cycle are being reported by many studies. Human activities are affected by rapid social and economic developments, consequently, water has turned into the most demanded resource which leading to severe water shortage around the world. In this research, systematic review method was used to analyze the recent climate and hydrology studies, and besides, SWOT analysis was performed to see Strength, Weakness, Opportunity and Threat of modelling studies, hydrological modelling in particular. The results showed that the studies were carried out in the various river basins, lakes and watersheds, where mostly impact of climate change on water resources was investigated using hydrological models. It was reported that limitation of the modelling were issues with data sufficiency, software skill requirement and misinterpretation of model results by the end users. Moreover, modelling holds some threats that when there is uncertainty in input data that leads overestimated values in model simulation.

Keywords: *hydrological modelling, hydrological cycle, SWOT analysis, climate change, river, reservoirs*

Introduction. Water is considered as a finite resource, which make important role in life of all living organism, and for maintaining and supporting sustainable socio-economic development. However, due to exponential changes in climate and land use, spatial and temporal variability in the global water cycle are being reported by many studies [1]. Besides, human activities are affected by rapid social and economic developments, consequently, water has turned into the most demanded resource which leading to severe water shortage around the world [1, 2]. Clearly, greenhouse gas emission can be one of human activities, which hold great effect on water cycle. According to IPCC (2014), climate change can be characterized by temperature rise, and more frequent extreme events, including heavy rains, floods, sudden droughts, and heatwaves.

The most parts of Central Asian region are located in arid zone, which depends on surface water resources coming from Tien Shan, Pamir and Altai mountains [3]. Low precipitation leads to low water availability in the region, and the region has already been experiencing water shortage, which is key limiting factor for socio-economic development [4]. The most of water resource in the region is used for agriculture production. For instance, in Uzbekistan, around 90-92% of the country`s total water is consumed by agriculture sector, which is quite high than neighbor countries, Kazakhstan and Tajikistan [5]. Obviously, majority of water are taken from transboundary rivers, Amu Darua and Syr Darya, accounted for 80%. Therefore, it makes the country vulnerable to changes in climate and hydrological cycle, which might negatively affect sectors such agriculture, forestry and fishery.

Changes in climate and its influence on water resources, plant growth, sedimentation process in open channels, rivers and reservoirs, crop yield are very complex and heterogeneous [6]. Clearly, it is important to take into account many factors influencing the process when it is intended to investigate impact of climate change or change in water availability in both temporal and spatial scales. It might be a bit challenging for researchers to study all factors at once for long term at different locations[7]. Therefore, modelling tools have been created and proposed, which are being used for many years, to simplify the process and to better understand any event before it happens [8]. However, sometimes, there is mistrust towards modelling studies, which might be due to knowledge gap on how model works [9]. Aligning this, this research intends to review and analyze some of recent model studies and main parameters used in hydrological modelling towards filling existing lack of knowledge about modelling and its importance in scientific research works.

Materials and methods. In this research, systematic review method was used to analyze the recent climate and hydrology studies conducted in China, Germany, Uzbekistan, Kyrgyzstan, Kazakhstan, Tajikistan. In this method, each research paper was analyzed based on followings such as type of hydrological models, study area, main factors, main equations, model inputs, and methods of model correction [10].

Besides, SWOT analysis was performed to see Strength, Weakness, Opportunity and Threat of modelling studies, hydrological modelling in particular. SWOT analysis is considered as framework, which can be used to evaluate internal and external factors, and current and future potential that have positive or negative influence on business, regulation, human life and outputs of scientific activities [11]. In this research, SWOT analysis was performed to see strength, weakness, opportunity and threat of modelling studies in hydrology field. In this case, more than 20 articles were reviewed and analyzed towards identifying positive and negative sides of hydrological modelling. The analysis of the articles was given in the table 1, where study site, climate models, hydrological models, simulation and optimization approaches, periods and results were taken as the main indicators.

Results and Discussions. In the most hydrological cycle and water resources researches, quantitative analysis was performed towards investigating human impact on hydrological cycle and researching changes in hydrological process in land surface under climate change effect. In the recent hydrological studies, quantitative analysis was done using different hydrological models, in which better understandings of anthropogenic impact on water availability, climate change and sedimentation process in the reservoirs can be obtained [1]. However, sometimes, modelling of hydrological events can be difficult due to model type, required data (availability and access), study areas, and calibration, validation process. Clearly, hydrological models can be distinguished as following: predictive models can answer to specific problems, and investigative models towards better understand of hydrological process and its interaction with climate, soil, biodiversity and crop yield [12]. It is stated that investigative models require data, which are simple in structure and esitmates.

Data requirement is diverse in different hydrological

models. If mode is intended to simulate impact of climate change on water resources in certain location, long term historical climate data can be required towards observing frequency, duration and intensity of hydrometeorological events [13]. It is reported that hydrological parameters, water depth, groundwater, suspended sediment, precipitation, surface temperature and evapotranspiration, have pivotal role in the accuracy and reliability of hydrological simulations [14]. With this, forthcoming issues in extreme water management, policy-making, water allocation and sustainable water resource management are identified and solved. Furthermore, the scenario modelling was also considered as one technique of hydrological simulation, where changes in water discharge is assessed under climate change. In the most hydrological studies, potential evapotranspiration was calculated from daily temperature, relative humidity, wind speed and solar radiation using the Penman-Manteith equation [15].

Table 1. Hydrological studies conducted using models in different locations around the world (Compiled by the authors)

Table 1.

Hydrological studies conducted using models

Authors	Study site	Climate models	Hydrological models	Periods	Main results
Usmanov et al., 2016	Chirchik River Basin, Uzbekistan	Observed climate data (UzHydromet)	MIKE SHE	2009-2013	Evapotranspiration was found to be the main water loss factor among water balance components, with an average of 821 mm/year (77% of the total water budget). Estimated groundwater recharge varied between 180 - 221 mm/year, making up 17% - 20% of the total water budget.
Uzbekov U et al., 2021	Ugam River Basin, Uzbekistan	CMIP5	SWAT	2019-2048	The stream discharge is expected to decrease by approximately 42% within thirty years, with a 1.4 °C increase in temperature and 286 mm decrease in precipitation. The peak point for the future period is 40.32 m^3/s in 2037 whereas the lowest discharge, predicted for 2048, accounts for 22.54 m^3/s.
Gulakhmadov et al., 2020	Vakhsh River Basin, Tajikistan	CMIP5	SWAT	2022-2060 2061-2099	An increasing tendency of average annual streamflow, from 17.5% to 52.3% under both RCPs 4.5 and 8.5, by the end of 2099. A shift in the peak flow month was also found, i.e., from July to June, under both RCPs.
Ongdas et al., 2020	Yesil River Basin, Kazakhstan		HEC-RAS	2017	Comparison of different mesh sizes (25, 50 and 75 m) for the simulation of the event from 2017 demonstrated no significant difference in terms of model performance between different model versions.
Wortmann et al., 2022	Tarim River, China/Kyrgyzstan	WATCH, AHPRODITE	SWIM-G WASA	2011-2040 2041-2070 2071-2100	Depending on the low, medium or high emission scenarios, temperatures are projected to rise by about 1.9 °C, 3.2 °C or 5.3 °C in the ensemble mean by the end of this century (2071–2100) compared to the 1971–2000 reference period, while precipitation may intensify by about 9%, 14% or 24%, respectively.
Uwamahoro et al., 2021	Issyk-Kul, Kygyzstan	Observed climate/MODIS snow data	SWAT	2015-2016	After modifying the model, the flood peaks increased for A and B by 49.42 and 43.87%, respectively, bringing them closer to the reality of the observation discharge. The contributions of snowmelt to stream flow increased by 24.26 and 31% for A and B, respectively.
Willkofer et al., 2018	Mindel River Basin	CCLM4.8 RACMO REMO	WaSiM	1971-2000 2021-2050	The long term yearly flow regimes of the CCLM and REMO differ from the reference. However, apart from the winter season, the raw RACMO model shows a good regime representation. For the Mindel catchment, the different correction approaches account for good adjustment of the modeled runoff to the reference of observed data when applied to raw CCLM and REMO data

According to the table 1, different hydrological models were employed to simulate the response of hydrological cycle to climate change, land use changes and environmental degradation. Accordingly, the studies were carried out in the various river basins, lakes and watersheds, where mostly impact of climate change on water resources was investigated using hydrological models, such as MIKE SHE, SWAT, HEC-RAS, SWIM-G, WaSiM (Table 1). In the studied we reviewed, impact of future climate change was researched and made prediction of its impact on water availability and human life. In the study conducted in Chirchik River Basin, MIKE SHE model was used to investigate change in evapotranspiration and its influence on water balance, where an average of 821 mm/year water loss was found [16]. Another such study was carried out in Ugam River Basin, where impact of future climate change was predicted using SWAT model (Table 1), and accordingly, the streamflow of the basin would decline by roughly 42% within thirty years [17]. In Tajikistan, the same hydrological research was conducted, where the SWAT model was used to see the response of hydrological cycle to climate change for two periods as 2022-2060 and 2061-2099 (Table 1). The results showed an increasing tendency of average annual streamflow, from 17.5% to 52.3% under both RCPs 4.5 and 8.5, by the end of 2099 [18].

According to the results of the SWOT analysis, hydrological modelling has benefits and limitations as shown in the figure 1. Clearly, the strength of modelling is capacity of covering larger spatial and temporal scales, which help to reduce cost of conducting a research. Besides, researchers can simplify complex system using models, and share model outputs with scientific community (Figure 1). The main opportunity that modelling brings are enhancement of scientific knowledge on hydrological cycle and critical thinking of complex system. It was reported that limitation of the modelling were issues with data sufficiency, software skill requirement and misinterpretation of model results by the end users. Moreover, modelling holds some threats that when there is uncertainty in input data leading overestimated values in model results. Another threat is lower model performance due to poor calibration and validation, and in addition, how decision makers accept model outputs can be one of the threats in modelling, hydrological modelling in particular (Figure 1). It was reported that in case of hydrological modelling, more than two or four objective functions (R2 and Nash-Sutcliffe efficiency) and several important parameters should be taken toward improving model performance and accuracy of model outputs.

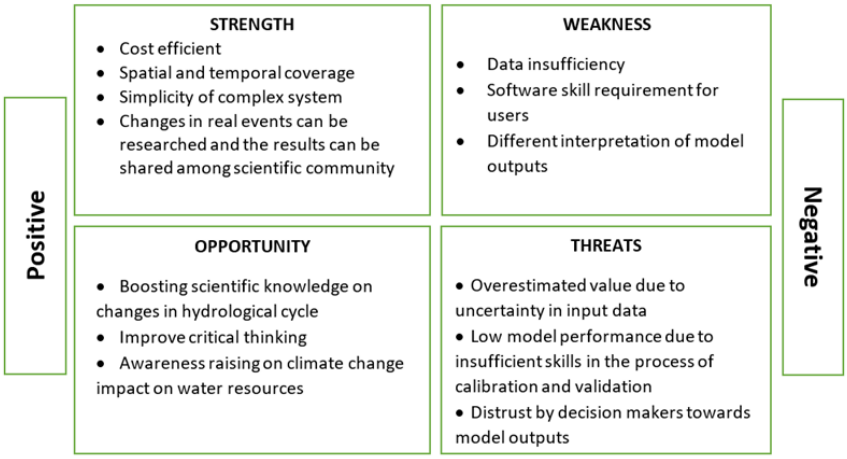

Figure 1. SWOT analysis of hydrological modelling (Compiled by the authors)

Conclusions. It was found that the studies were carried out in the various river basins, lakes and watersheds, where mostly impact of climate change on water resources was investigated using hydrological models, such as MIKE SHE, SWAT, HEC-RAS, SWIM-G, WaSiM. The results of the SWOT analysis showed that the strength of modelling was capacity of covering larger spatial and temporal scales, which would help to reduce cost of conducting a research.

It was reported that the main opportunity that modelling brings were enhancement of scientific knowledge on hydrological cycle and critical thinking of complex system. that limitation of the modelling were issues with data sufficiency, software skill requirement and misinterpretation of model results by the end users. Moreover, modelling holds some threats that when there is uncertainty in input data leading overestimated values in model results. Lower model performance due to poor calibration and validation is another threat.

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REQUIREMENTS ON REGISTRATION OF ARTICLES FOR PUBLICATION IN THE JOURNAL "SUSTAINABLE AGRICULTURE"

• There are published original experimental scientific articles in the journal "Sustainable Agriculture"They are about the sustainability of agriculture during a period of significant decline in water situation and increase of water sources pollution in anthropogenic climate change in the short and long term.
• There are not published articles that expound individual stages of research, which do not allow us to draw certain conclusions.
• All articles are published in English.
• All data must be accompanied by covering letter, which consists of 500 or fewer words, a summary of the significance of research, author's consent to publication, a number of pictures and tables, support for manuscripts (articles) and additional information. In addition, it should be indicated the current telephone and fax numbers, postal address and e-mail address of the respective author to keep in touch.
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• Abstract (summary) should not exceed 300 words (1-1.5 pages), it should be used as the standard nomenclature. There are not recommended to use any abbreviations in the title of the article or in the abstract. Keywords should be included.
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