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Technological innovations in agriculture: Impact on production efficiency

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Abstract. The necessity to meet the food needs of Azerbaijan requires modernisation of the agricultural industry navigating the challenges associated with an innovative mode of progress. This process is accompanied by technical and technological optimisation of most of the production processes in agriculture. The aim of this research was to examine and assess the integration of technological innovations in Azerbaijan's agricultural sector. The investigation employed fundamental scientific methods, including system analysis, synthetic method, method of abstraction, deductive method, and methods of summarisation, and concretisation. During the investigation, the main objectives of technological modernisation of the agrarian sector were analysed, the dynamics of their impact on the efficiency of production depending on different factors was investigated, measures for optimisation of the situation with regard to the priority of innovative solutions were developed. Additionally, the research explored the potential application of contemporary management and technological strategies

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to mitigate the adverse environmental effects of agricultural production. This involved integrating environmental safety and economic efficiency through the adoption of cutting-edge innovative technological approaches. Their effectiveness as a viable tool for the transformation of the agrarian sector following the current social and economic requirements for the intensification of its development was determined. Implementing the ecosystem approach and adopting integrated agro-landscape management can pave the way for a renewed development of the agronomy industry in Azerbaijan. The results of this study carry significant practical implications for advancing and modernising the country's agricultural economy system, contributing to the formulation of targeted programs for technological innovations

Keywords: modernisation; agricultural sector; sustainable development; intensification; organic production

INTRODUCTION

Global processes of transformation of agriculture with orientation on innovative technologies, organic production, and minimisation of destructive impact on the environment in accordance with the tenets of sustainable development form new challenges for the agricultural sector of Azerbaijan. The prospective growth in demand for agricultural products with limited resources can be met only through effective technological modernisation of agricultural projects. Currently, human activities are actively shaping a distinct altered natural backdrop characterised by a considerable pollution index. Frequently, the upper limits surpass the officially designated maximum permissible concentrations of pollutants in the natural environment. Intensive farming in past historical periods has left a substantial footprint in the form of soil chemisation and salinity, erosion, and minimisation of organic matter. Under such conditions, there is a need to modernise the agricultural sector and develop a new conceptual approach to farming.

Numerous scientific articles and studies have delved into the issues of modernisation of the agricultural sector in Azerbaijan, which would allow increasing the efficiency of production while minimising the anthropogenic load on the environment. M. Aliyeva (2022) investigated the main theoretical aspects of the technological modernisation of the agrarian sector. The scholar concentrates on enhancing both the infrastructure and competitiveness of agricultural products. Recent findings by contemporary scientists A.A. Hasanov (2019) and Sh. Abdullayeva (2019) suggest that substantial accumulation of toxic substances in soils resulting from industrial processes is a key factor triggering numerous irreversible changes in agroecosystems. Researchers are convinced of the need for a gradual transition from conventional land use to an organic system that is gentle on the environment and allows for the regeneration of degraded landscapes.

The findings of the scientists complement the results of the studies by V. Rzayev *et al.* (2021) and A. Nasibov (2023), who investigate the innovative enhancing the industry of agriculture of Azerbaijan's economy and the role of technological transfers in the innovative development of the agricultural sector. Researchers study the impact of the growth of financing

of innovation processes on the economic effectiveness of production of agricultural industry, as well as the mechanism of implementation of technological developments in agricultural processes. The scientists substantiated the function of innovation providers in catalysing technology transfer and implementing innovations, along with an examination of the facets influencing the economic processes resulting from the technological transformation of the agricultural sector.

In the pursuit of strategies to optimise conditions and alleviate adverse effects, researchers E. Gulieva (2021) and A. Gurbanova (2021) assert that the most effective approach to agricultural production, minimising negative environmental impacts, involves the modernisation of existing technological solutions and the development of new environmentally friendly alternatives. They emphasize the importance of implementing an efficient monitoring system. Simultaneously, A.D. Ibragimov (2023) highlights that agricultural modernisation primarily entails updating fundamental technical assets while concurrently developing new infrastructure. This approach enhances industry competitiveness and elevates social well-being.

Despite the current significance of the studied issue, numerous aspects still necessitate detailed examination, analytical processing, and the exploration of optimal solutions, specifically the introduction of precision and organic farming systems, the use of optimisation solutions at the regulatory level, the use of breeding opportunities, innovative approach to intensification of agricultural production, and cost reduction through technological modernisation. The aim of this investigation was to research the main areas of technological modernisation of the agrarian industry in the aspect of innovation activity.

MATERIALS AND METHODS

This study utilized various general scientific methods of inquiry. The deduction method was employed to ascertain the significance of the impact of technological innovation in agricultural production on performance indicators as a multifactorial process. Representative economic indicators for the industry under study were considered. The use of the method of analysis allowed performing

a comparative study of various modern approaches to technological modernisation of agriculture, the possibility of their application in the practice of agro-industrial production in Azerbaijan, as well as the impact on productivity and production efficiency indicators.

Using the generalisation method, the investigation unveiled distinct features and patterns related to the examined issues, as well as the potential for optimising the situation and identifying the most favourable solutions. The focus was on the most recent and credible research on the issue under study. Furthermore, the method of rising from abstract to concrete was applied in this study in a sequential progression, moving from general abstract data regarding the directions of innovative technological modernisation of the agricultural industry to concrete data on the impact of their introduction in the agriculture of Azerbaijan in the aspects of productivity growth, economic efficiency, and reduction of destructive impact on the environment.

A systematic methodology was employed to assess the effectiveness, characteristics, and advantages of specific measures within the studied process. Through this approach, the investigation aimed to uncover the overall structure of the subject, conduct a comprehensive exploration for optimising risk management, and devise a suitable strategy for the technological modernisation of agricultural production, aligning with the principles of sustainable development and a green economy. Special emphasis was placed on acknowledging the diversity of approaches and anticipating potential implementation challenges within the economic contexts of developing nations. The synthesis method was utilised to evaluate the viability of contemporary managerial decisions within the realm of innovation in the agro-industrial sector, both at regional and national levels. This evaluation was grounded in the principles of public management.

The abstraction method was utilised to construct a representation of the monitoring, management, and control processes concerning the impact of technological innovations on the quantitative and qualitative aspects, as well as the productivity of production processes in agriculture. This extended to the assessment of the anthropogenic load on the environment. In parallel, the concretization method was employed to identify the effectiveness and economic feasibility factors of innovative measures. This involved forecasting and modelling potential consequences and performance indicators. Notably, this approach underscored the pivotal factors in selecting viable management and production-technological solutions to mitigate adverse environmental impacts, adhering to the principles of sustainable agricultural production. The potential for an effective integration of innovative technological solutions with the development of a monitoring system for the innovative optimisation of production processes in the agro-industrial complex was explored.

Additionally, the formalisation method was employed to pinpoint the conclusive prospects of technological modernisation in Azerbaijan's agriculture and to shape the outcomes of this study.

RESULTS

In the dynamic evolution of economic processes and the increasing globalisation emphasising sustainable development, the primary focus for advancing Azerbaijan's economy lies in the modernisation of key production processes. This strategic approach guarantees the efficiency of a step-by-step shift towards a novel form of economic development grounded in innovation (Hamidova, 2020). Prolonged extensive use of land resources has led to an uncompromising need to replace conventional production processes with intensive methods and innovative technologies that uphold the principle of sustainable enhancement of agriculture (Kaldiyarov *et al.*, 2019). Thus, the wide utilisation of modern technological innovations in the agro-industrial complex is currently the main way to ensure food security and minimise the destructive impact on the environment. The priority of the task of reforming the traditional agricultural system is also conditioned by the need for sustainable use of agro-landscapes and bringing resource use in line with global climate change trends, and increasing food production (Nasibov, 2023; Strategic road map..., 2023).

Notably, one of the priority areas of modernisation of the agro-industrial complex in Azerbaijan is a proficient government strategy for fostering innovation in the agricultural industry. Its purpose should be the development of mechanisms and methods of stimulating innovation activity, renewable resource use, use of technological developments (Kizi, 2020). The concept of modern agricultural modernisation is based on integration and diversification processes, cost minimisation through increased production efficiency, the use of biotechnology to ensure competitiveness, and organic production within the framework of green economic development. It also involves the introduction of multi-operator, multi-tasking technological equipment and ways to stimulate yield and productivity indicators while maintaining a sustainable environment (Glover *et al.*, 2019; Kovalenko, 2021; Domaratskiy *et al.*, 2023).

In 2016, "Strategic road map for the production and processing of agricultural products in the Republic of Azerbaijan" (2023) was adopted, which is a forward-looking approach to the development of the sector. The main objectives formed in the document include increasing agricultural production capacity, strengthening institutional capacity, preservation of the environment, responsible utilisation of natural resources, and improving the efficiency of management processes in the industry (Clapp & Ruder, 2020). Therewith, the development of research areas in the agricultural industry within the context of the worldwide trend of wide introduction of innovative production technologies is an

essential resource for influencing the level of competitiveness and production efficiency.

Modernisation of the agricultural sector mainly implies the introduction of innovative agro-technologies, improvement of agricultural machinery, optimisation of the fertiliser and chemicalisation system with priority given to biological methods of plant protection and organic fertilisers, selection of high-performance varieties (Kizi, 2020; Herrero *et al.*, 2020). The concept of effective modernisation of agriculture is based on the principles of alternativeness and comprehensiveness, as well as preventive insurance against possible risks, which determines the increase in the efficiency of agricultural production. It allows agriculture to develop in an intensive way, encouraging investment in modernised machinery and the adoption of sustainable agricultural production (Hasanov, 2019). The implementation of modernisation also encompasses the practical application of research and development (R&D) capabilities, exerting a direct influence on the expansion of the export potential within the agro-industrial complex.

The process of innovation in the agriculture industry takes place in stages: scientific solution – technology – production – consumption (Curry *et al.*, 2021). Therewith, this process is influenced by a set of specific features of agrarian production, including functional, regional, managerial, and other factors (Ibragimov, 2023). Some of these factors determine the pace of agricultural modernisation. Specifically, they include the level of integration (availability of innovation infrastructure), readiness to absorb functional change, resource capacity (managerial, material, information, human resources) (Aldieri *et al.*, 2021).

Notably, modernisation and innovation are inextricably linked processes, with innovation involving the creation of novel technologies and modernisation involving the introduction of the most progressive and efficient ones of their totality (Clapp & Ruder, 2020). Currently, there is a significant focus on advancing agrarian science in Azerbaijan. Under the auspices of the Azerbaijan State Agrarian University and the Centre for Agrarian Science, 13 research institutes are functioning, where research projects are being carried out, oriented towards effective practical implementation: selection of resistant varieties and crops, improvement of agricultural technologies, development of optimal sparing methods of plant protection and stimulation of production performance (Rose *et al.*, 2021). Modernisation of the industry of agriculture is inextricably linked to the optimisation of logistics infrastructure. A good-working logistics system can substantially influence competitiveness and good governance (Rzayev *et al.*, 2021). It implies the use of effective methods of rational use of resources, including information resources.

The ongoing phase of economic advancement in Azerbaijan is marked by an escalating demand from domestic consumers and favourable trends in investment

processes. These factors, coupled with the distinctive elements of the current global situation, underscore the imperative of prioritising the modernization of the agricultural sector. The goal is to foster synergistic development in technology, innovation, and management processes within the framework of sustainable agricultural development. This strategy ensures a substantial enhancement in overall factor productivity within the industry, consequently leading to an upturn in agricultural production (Steinke *et al.*, 2021). For Azerbaijan, such performance is particularly desirable due to the considerable depletion of the main production factors and resource potential. Furthermore, modernisation of agriculture, based on the above principles, can, simultaneously with productivity improvements, stimulate an increase in the level of resilience of the agricultural sector to negative global climate trends. Therewith, the main principles of modernisation of agricultural production still include ensuring economic and production security, ecological and economic balance, priority of innovation, state support, and compliance with the principles of sustainable development (Fleming *et al.*, 2021).

Using modern technological opportunities for modernising agriculture, it is possible to increase the competitiveness of exported products substantially, as well as improve their quality while minimising costs. Moreover, it is crucial to identify the unique characteristics of the agricultural sector within the context of regions, which will allow using the synergy of the resource base and technological modernisation most effectively (Abdullayeva, 2019; Gulieva, 2021). For instance, Azerbaijan has specific types of soil that are best for growing pomegranate, which is in considerable export demand, and modern farmers are making effective use of the situation to increase production efficiency by investing in technological modernisation of production. Along with the specific climatic features of Azerbaijan, the innovative technological approach allows for harvesting in modernised greenhouses 3-4 times a year.

Modernisation of the agricultural industry through technological innovations makes it possible to switch from exporting raw materials to exporting finished products, which considerably increases the indicators of economic efficiency of production processes (Kaldiyarov *et al.*, 2019). Furthermore, certification to international standards is becoming available, increasing access to markets on a global scale (Kizi, 2020). Significantly, technological progress in the agricultural sector entails an enhancement of energy efficiency in the use of the main types of resources. Such a goal can be achieved through basic strategic solutions in the form of innovative optimisation of irrigation equipment and systems, genetic breeding, precision farming concepts, and organic chemicalisation of agricultural processes (Rolandi *et al.*, 2021; Ibragimov, 2023). Bioenergy strategies are also becoming popular as an additional aspect of technological modernisation, due to the emphasis on

the principles of sustainable development takes precedence across all sectors of production, including agricultural production.

In Azerbaijan, organic farming is a highly promising avenue for the development of the agro-industrial sector. This trend is associated with increased demand for organic food and growing public awareness of the benefits of organic products (Rzayev *et al.*, 2021; Gurbanova, 2021). Organic farming technology utilises natural resources and methods that are environmentally tolerant and preserve biodiversity. Unlike conventional industrial farming, organic farming does not actually use chemical fertilisers and pesticides, nor does it use genetic modification (Kaldiyarov *et al.*, 2019). This makes it possible to produce quality and environmentally friendly food products that do not pollute the environment and are essential for people's health. To ensure a systematic approach to the study of organic farming processes in Azerbaijan, it is necessary to consider its sectoral characteristics and guidelines that form a model of effective biological land use (Strategic road map..., 2023). Thus, organic farming is a complex production complex, the effective management of which requires considering the specifics of sectoral functioning in terms of resource potential indicators, as well as ensuring its reproduction at the suitable level (Clapp, 2021). Compliance with the principles of sustainable development requires ensuring a technological closed cycle of production in an agricultural enterprise. That is, organic farming should be implemented under the influence of reproduction algorithms using available factors of production – organisational, economic, production, material and technical, ecological, and social.

Long-term intensive farming has led to substantial environmental problems in the agricultural sector of Azerbaijan. Agro-ecosystems, by their nature, are extremely energy intensive, with poor adaptive capacity, and potentially high levels of soil fertility depletion. The situation is particularly difficult in the field of

irrigated vegetable production. Organic land use technologies, which make provision for covering the soil cover with vegetation for as long as possible, are a relevant alternative. Innovative technological methods and algorithms that allow implementing a step-by-step transition from an over-intensified farming system to a science-based biologisation of agrarian processes will help translate the European standards of sustainable development into practical reality. In the agricultural sector, these standards are positioned by the world community as alternative or renewable farming.

Innovative precision farming technology involves determining agrochemical and agrophysical characteristics of fields, drafting electronic maps, and applying agrochemicals considering the different needs of crops in certain parts of the field. The application of this technological approach implies the use of GPS system, based on which the system of mechanisation of soil cultivation, fertilisation, sowing, plant protection is developed without direct involvement of the operator. Precision farming involves inseparable monitoring of crop and soil conditions to promptly plan a set of actions to optimise the condition of problem areas (Raihan *et al.*, 2022). The characteristic trait of contemporary technologies in production of agricultural industry is the active influence on plants in different phases of their vegetation and soil fertility by performing an algorithm of biological-technological techniques, which unfailingly affects the yield, productivity, and efficiency of farming (Kerneck *et al.*, 2021).

The adoption of precision farming technologies within the Azerbaijan's agricultural domain involves measures to increase production efficiency, improve product quality, rational use of chemicals, prevention of destructive impact on environmental elements implies an algorithm of data collection and analytical processes, compilation of electronic maps of fields, effective system of management decision-making, development of technology for agricultural production processes (Fig. 1).

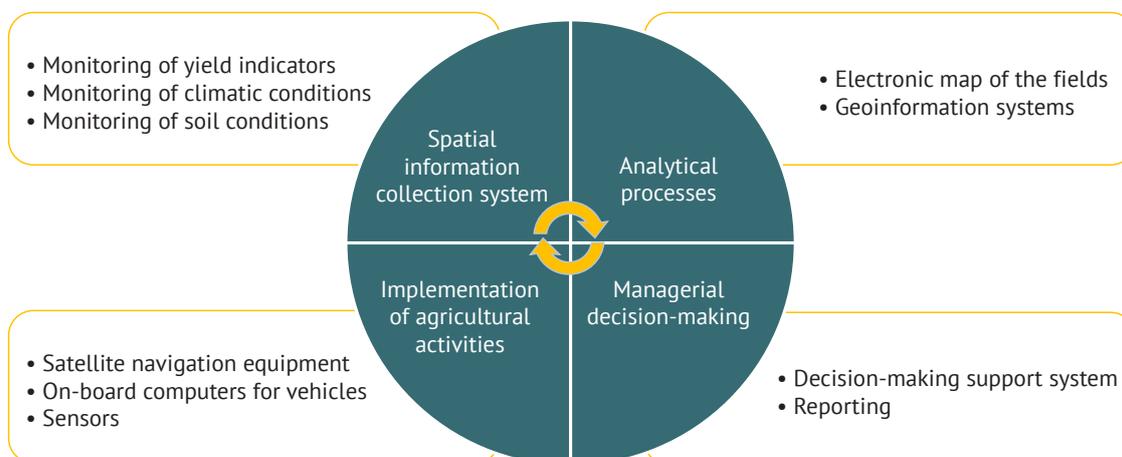


Figure 1. Components of precision farming technology

Source: compiled by the authors

Evaluating the economic effectiveness of incorporating modern technologies involves examining indicators such as yield growth and enhanced productivity, cost recovery and profitability level, annual economic effect per unit area, determined based on informative data on qualitative and quantitative indicators of yield are used (Lacoste *et al.*, 2022). Analysing the statistical data regarding the indicators of economic efficiency of agricultural enterprises (Table 1), which fully reflect the efficiency of technological modernisation of the industry, we can state a significant positive effect of innovative technological optimisation of agro-industrial

processes. The concept of increasing total profit and profitability according to the gradual transition from extensive to intensive agricultural activities reflects the positive dynamics of the impact of innovative technological approaches in crop and livestock production. Particularly indicative of the nature of changes is the ratio between enterprises operating at a loss and at a profit, which is characterised by pivotal dynamics in the 2005-2022 period (Table 1). It can be argued that, in the majority, there are still enterprises actively practising an innovative approach to farming technologies in the market.

Table 1. Financial results of agricultural enterprises in Azerbaijan

	2005	2010	2015	2018	2019	2020	2021	2022	2023
Number of operating enterprises, units	1,782	2,043	1,659	1,641	1,471	1,024	1,035	1,047	1,055
Including:									
Those working for profit	1,579	1,869	1,530	1,560	1,376	880	880	836	853
Those working at a loss	203	174	129	81	95	61	70	48	43
Total profit, thousand AZN	5,892	27,658	39,763	96,917	92,696	104,016	171,197	310,012	375,015
Total profitability, %	9.1	16.7	11.3	20.1	17.2	19.4	27.2	37.9	38.8
Profit (loss (-)) in crop production, thousand AZN	2,769	8,855	20,241	56,577	68,795	69,321	127,159	170,174	155,120
Profit (loss (-)) in livestock breeding, thousand AZN	3,117	13,021	19,993	19,048	10,481	27,180	32,557	113,751	108,745
Agricultural products Return on sales, %	9	13.4	11.3	16.2	15.3	19	26.4	35	38.5
Including:									
In crop production	41.5	30	36	40.4	35.7	29.2	51.7	51.9	52.5
In livestock production	5.4	10.5	7.1	5.9	3.4	9.5	8.5	23.6	24.7

Source: G. Curry *et al.* (2021)

Therefore, the technological modernisation of Azerbaijan's agricultural sector is oriented towards systematically transitioning from extensive to intensive methods of agricultural production. This shift aligns with the principles of sustainable development and the green economy. These benchmarks advocate for the widespread adoption of innovative technological systems that integrate technical, informational, and intellectual resources.

DISCUSSION

Modern technological modernisation of agriculture accumulates vectors of innovative optimisation of spheres of agrarian activity, including material and technical support, production organisation, innovation management, information flows, and technological processes. Political support for agrarian reforms, diversification, preventive protection of the ecological state of agro-landscapes, along with active technological modernisation of the agricultural sector, can provide favourable environment for optimal development of Azerbaijan's sustainable agriculture. The synergy of technological modernisation and innovative solutions

are the factors of intensive growth in the aspect of agro-industrial complex development, as well as the basis for guaranteeing food security of the state and leading positions in the export segment of the market.

Numerous scientific studies substantiate the economic impracticality and profoundly adverse effects associated with extensive methods of agricultural production on the environment in modern conditions. L. Rocchi *et al.* (2020) believe that agricultural modernisation is a gradual transition from traditional production to technological production and should be in line with the priorities of green economic development. This standpoint encapsulates the core scientific concept of the present study, making it challenging to dispute the researchers' conclusions. The acquired results align with the outcomes of various scientific investigations, reinforcing the notion that the degree of modernisation acts as a significant gauge for the practical application of research and development (R&D) advancements. Furthermore, this process is oriented towards enhancing the export potential of the agricultural sector within the economy.

According to the research of S. Ruzzante *et al.* (2021), innovative technological modernisation of agricultural

production contributes to the development of a new organisational and management mechanism in the agricultural industry. F. Farrokhi and H. Pellegrina (2023), however, contend that the enduring outcomes of such processes include an increased local demand for skilled labour, the commercialisation of scientific processes, and increased rates of urbanisation. The findings of the present study have demonstrated that the innovative framework of agricultural knowledge, in synergy with other links of the production process, reveal new opportunities for the implementation of methods of technological modernisation of agriculture, which was confirmed by E. Sadik-Zada (2021). According to scientists, the main principles of the innovative approach to technological modernisation of agriculture include rationality, competent economic planning, transformation of public opinion, and scientific approaches to agricultural production. This fact is also emphasised by modern scientists A. de Janvry and E. Sadoulet (2020), arguing the need for a radical reorientation of strategic vectors of economic activity.

The findings of I. Cisternas *et al.* (2020) suggest the need to intensify agricultural production through organic technologies, biological sparing methods of plant protection, minimising the use of aggressive chemicals. Scientists are considering ways of levelling the negative effects on agro-landscapes by introducing protective buffer zones within agricultural areas, imposing restrictions on the use of heavy agricultural machinery, and breeding sustainable species. Such conclusions of scientists align with the results of this investigation, emphasising the expectation of a considerable productivity surge and improved quality of agricultural products in case of consistent and full replacement of conventional agricultural technologies with more sparing organic ones.

X. Yang *et al.* (2021) follow up on this issue by highlighting the priority of closed-loop technologies that minimise the environmental impact of agro-industry. Scientists are convinced that the development of sustainable agriculture requires large-scale support in the form of investments and lending to support natural landscape systems, preserve biodiversity, and reduce greenhouse gas emissions. Furthermore, sustainable agricultural production contributes to optimising the main components of food security: availability, utilisation, access, stability. This is what G.K. Kurmanova *et al.* (2022) are convinced of in their research. They also assert that numerous studies overlook information pertaining to the three dimensions of sustainability – social, economic, and environmental. According to the authors, a more extensive adoption of modern precision farming methods, particularly electronic field maps and geographic information systems, will enable the proactive safeguarding of agro-landscapes and positively influence the efficiency of agricultural production.

Practical aspects of technological modernisation of agriculture in Azerbaijan in the conditions of transition

economy require further research. Most scientists, whose studies are discussed above, are united in the system of requirements for effective innovative modernisation of the agricultural sector. In their opinion, it should be carried out systematically, stemming from the introduction of innovative solutions, while being directed at increasing competitiveness, increasing export potential, and developing the structural elements supporting the agricultural part of the economy. Utilising contemporary environmental monitoring capabilities is essential for an impartial evaluation, formulation of preventive measures, and implementation of regeneration actions to mitigate environmental impact. Achieving this objective necessitates the modernisation of the functionalities embedded in agricultural production management tools and streamlining their operations in alignment with the digital economy's prerequisites. C. Gras and D. Cáceres (2020) share a similar perspective, highlighting the inadequacies in the current monitoring system within the agricultural sector.

Y. Gao *et al.* (2020) advocate for a future paradigm in which biological technologies take precedence in agricultural production. This approach relies on understanding the regularities of physiological and biochemical processes that facilitate ecosystem self-purification. The research, including the present study, suggests that it is prudent to incrementally embrace closed-loop technologies. The primary focus should be on gradually halting soil degradation and maximising the separation of economic ties within agro-industry from natural ones. Integrated management in agricultural production is crucial for effectively addressing strategic objectives, including optimising resource utilisation, enhancing the sustainability of agro-ecological systems, monitoring quality, and responding effectively to environmental risks. To improve the situation, it is imperative to curtail activities leading to chemical and other hazardous forms of natural resource pollution and destruction, while also regulating the impact of agricultural production processes.

Summarising the findings of modern scientists and conclusions obtained in the current study, we can highlight the primary features of technological modernisation of agriculture: modernisation increases the competitiveness of agricultural production; introduction of technological innovations stimulates the growth of productivity and efficiency indicators of agricultural processes; modernisation creates a need for qualified personnel and development of scientific potential; the successful optimisation of the agricultural sector yields an expansion of export opportunities for the industry and attracts investment.

Therewith, a pivotal factor contributing to the successful technological modernisation of the agricultural sector is the establishment of a mechanism for state support in agricultural innovation. This involves the creation of a unified investment system and the global

integration of a network of agricultural innovation transfer centres. Thus, enhancing the effectiveness of the agro-industrial complex and ensuring food security become possible only based on technological renewal of basic production processes, a balanced approach to mechanisation and automation, considering the principles of sustainable agricultural development. Optimal technological modernisation makes it possible to transition to an innovative development model, increase production efficiency, and minimise destructive processes in agro-landscapes.

CONCLUSIONS

During this study, a comprehensive analysis of the efficient operation of agrolandscape complexes was conducted through a multifactorial approach grounded in the principles of sustainable development. The study successfully delved into the present state of technological modernisation in Azerbaijan's agriculture, examining existing resources, and identifying potential opportunities in this domain. The statistical data of indicators of economic efficiency of agricultural enterprises of Azerbaijan, which are representative of the efficiency of technological modernisation of the industry, were analysed. Considerable positive effect of innovative optimisation of technological processes of agro-industrial processes was recorded.

The study substantiated the necessity of introducing innovative solutions in the agrarian sector of the Republic, identifies the main features of gradual transition from extensive to intensive, organic and biological technologies. It was found that the development of biological renewable land use and precision farming systems is a considerable factor in increasing economic performance in crop production, strengthening the priorities of ecologization of agriculture, and optimising the state of agro-ecosystems in the aspect of restoration and recreation. It was substantiated that the technological modernisation of the agricultural sector of the economy of Azerbaijan should be oriented towards the gradual

replacement of extensive methods of agricultural production with intensive ones in accordance with the principles of sustainable development and green economy. The study also found that the main approaches to the modernisation of the agricultural industry are based on the principles of diversification and rationalisation of production processes. It was established that significant reduction in environmental impact and improvement in both quantitative and qualitative aspects of agricultural production can only be achieved through the combined implementation of technological and managerial measures, alongside the adoption of innovative control methods. The information gleaned from this study can be effectively applied in practical scenarios.

Adherence to stringent environmental load regulations, aligning current norms of agricultural production with those of developed nations, and the incorporation of modern innovative technological solutions rooted in a closed resource utilisation cycle will play a pivotal role in optimising Azerbaijan's agricultural sector. This optimization, coupled with efficient management strategies and the implementation of an innovative monitoring system, is anticipated to contribute positively to the country's economic landscape. The potential of wide introduction of geoinformation technologies, satellite navigation devices and electronic mapping into the processes of agricultural activities requires further research. Active implementation of a modern management decision support system is also expected to be promising. In combination, such measures will substantially improve the efficiency of agricultural production in the country, expand export opportunities, ensure food security and stimulate economic development towards a green sustainable economy.

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CONFLICT OF INTEREST

None.

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Технологічні інновації у сільському господарстві: вплив на ефективність виробництва

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Анотація. Необхідність забезпечення продовольчих потреб Азербайджану потребує модернізації аграрного сектора у напрямі інноваційного типу розвитку. Такий процес супроводжується технічною та технологічною оптимізацією більшості виробничих процесів у сільському господарстві. Мета роботи – дослідження та аналіз запровадження технологічних інновацій в аграрній галузі Азербайджану. Дослідження проводилися з використанням загальнонаукових методів пізнання, зокрема системного аналізу, синтезу, абстрагування, дедукції, узагальнення, конкретизації. У ході дослідження проаналізовано основні завдання технологічної модернізації аграрної галузі, вивчено динаміку їх впливу на ефективність виробництва залежно від різних факторів, розроблено заходи для оптимізації ситуації з урахуванням пріоритетності інноваційних рішень. Крім того, розглянуто можливості застосування сучасних управлінських та технологічних заходів щодо мінімізації деструктивного впливу сільськогосподарського виробництва на навколишнє середовище, що ґрунтуються на синергії екологічної безпеки та економічної ефективності, з впровадженням сучасних інноваційних технологічних підходів. Визначено їх ефективність як дієвий інструмент для трансформації аграрної галузі відповідно до актуальних соціально-економічних вимог для інтенсифікації її розвитку. Встановлено, що застосування екосистемного підходу, а також запровадження інтегрованого управління агроландшафтами здатні забезпечити сталий розвиток агрономічної галузі в Азербайджані. Результати дослідження мають суттєву практичну значущість для розвитку та модернізації системи сільського господарства у країні, створення векторних програм технологічних інновацій.

Ключові слова: модернізація; аграрний сектор економіки; сталий розвиток; інтенсифікація; органічне виробництво
