



*V international scientific conference
Brussels. Belgium
10-11.02.2026*

DIALOGUE OF TIMES: PAST, PRESENT, FUTURE

Proceedings of the V International Scientific and Practical Conference

10-11 February 2026

BRUSSELS. BELGIUM

2026

UDC 001.1

BBC 1

V International Scientific and Practical Conference «Dialogue of times: past, present, future», February 10-11, 2026, Brussels. Belgium. 77 p.

ISBN 978-91-65424-59-3

DOI <https://doi.org/10.5281/zenodo.18663486>

Publisher: «SC. Scientific conferences»

Main organization: 

Editor: Hans Muller

Layout: Ellen Schwimmer

The conference materials are in the public domain under the CC BY-NC 4.0 International license.

The publisher is not responsible for the materials published in the collection. All materials are provided in the author's edition and express the personal position of the participant of the conference.

The sample of the citation for publication is Gugin Aleksandr, Lisnievska Yuliia ANTI-ADVERTISING IN THE HOTEL BUSINESS // V International Scientific and Practical Conference «Dialogue of times: past, present, future», February 10-11, 2026, Brussels. Belgium. Pp.9-11, URL: <https://sconferences.com>

Contact information

Website: <https://sconferences.com>

E-mail: info@sconferences.com

Content

Biological sciences

- Baghirova Rafiga, Huseynova Gulnara, Safarova Sevinj**
EFFECTIVE EFFECT OF REHABILITATION MEANS ON INCREASING PHYSICAL PERFORMANCE IN ATHLETES 3

Chemical sciences

- Nazarova Mushkunaz, Garayeva Irada, Muradov Mahal**
INTERACTION OF OXOHYDRONAPHTHALENES WITH METHANOL 8

Economic sciences

- Bela Goderdzishvili, Ana Svanidze**
NEW CHALLENGES OF PUBLIC ADMINISTRATION – USE OF NETWORK MARKETING TECHNOLOGIES 11
- Elvin Aliyev Mirismayil**
SUSTAINABLE SOCIAL DEVELOPMENT IN A POST-CAPITALIST AND ECOLOGICAL SOCIETY: A CONTEMPORARY ACADEMIC INTERPRETATION 16
- Huseynli Aylin Mehman**
THE ROLE OF EMOTIONAL INTELLIGENCE IN AN EFFECTIVE LEADERSHIP SYSTEM: THEORETICAL AND PRACTICAL APPROACH 20
- Sevinc Ibrahimova, Mayil Orujov, Azer Orujov, Nermin Orujova, Hafize Aliyeva**
CURRENT STATUS OF AGRICULTURE AND INNOVATION ACTIVITIES IN AZERBAIJAN 26

Journalism

- Yessenbekova Ulbossyn M., Stambekova Nazym D., Serkebaev Daurenbek Zh., Amangeldieva Gulmira S., Doskeeva Gulnur U., Mutarbek Ardak**
MASS COMMUNICATION AND POLITICAL DECISION-MAKING: MECHANISMS OF AUDIENCE PARTICIPATION AND GOVERNMENT TRANSPARENCY 40

Medical sciences

- Arman Khozhayev, Perizat Sovetkanova, Artem Gavrilenko, Yerkezhan Yerlanova, Ulzhan Zhanysbek, Nadezhda Kim**
PANCREATIC CANCER: MODERN REALITIES AND TRENDS 46

Pedagogical sciences

- Beisembayeva A.B, Otizbayeva ZH. K.**
ARTIFICIAL INTELLIGENCE AND GAME METHODS IN TEACHING ENGLISH TO PRESCHOOLERS 57

Technical sciences

- Bekirova Lale, Hasanzade Kamil**
OPTIMIZATION OF ELECTRONIC-OPTICAL SURVEILLANCE USING UNMANNED AERIAL VEHICLES AND ITS APPLICATION CAPABILITIES 62
- Hikmat Asgarov, Selvi Ismayilova**
CERTIFICATION TESTING TO ENHANCE THE LONGEVITY OF AUTOMOBILE TIRES 71

Biological sciences

EFFECTIVE EFFECT OF REHABILITATION MEANS ON INCREASING PHYSICAL PERFORMANCE IN ATHLETES

*Baghirova Rafiga
Huseynova Gulnara
Safarova Sevinj*

Azerbaijan Sports Academy, Baku, Azerbaijan

Abstract

The article reflects the complex results of the impact of rehabilitation measures selected to enhance recovery processes after performing intensive physical loads on the physical performance of volleyball players and the delay of the development of fatigue. The results obtained in the study clearly reflect the impact of physical rehabilitation tools on the adaptive systems of the body on the central indicators of hemodynamics and the size of physical performance. Of the rehabilitation tools, special breathing movements, gymnastic elements, autotraining, various types of massage, hydroprocedures were included in the rehabilitation complex. It was found that these rehabilitation tools have an effective effect on the recovery of athletes specializing in volleyball and create conditions for increasing their physical performance and reducing the recovery period.

Keywords: *physical rehabilitation, fatigue, recovery, rehabilitation tools, functional tests, physical working capacity.*

1. Introduction

Rehabilitation is a system of medical, physiological, psychological and social measures aimed at preserving and restoring health. The main task of rehabilitation is to strengthen the restoration of changes occurring in the body. In the process of functional recovery, the natural need for movement of a person should be taken into account, therefore, one of the main methods of rehabilitation of an injured or sick person should be adaptive physical education. Adaptive physical education is a therapy of using the body's own adaptive, protective and compensatory capabilities in an adequate way to biological laws. This process is restored with the help of movement functions, and health is preserved [1, p.24; 2, p.77; 3, p.29].

The development and improvement of adaptive physical education tools and methods used in the rehabilitation of injuries and pathological conditions in sports practice, and the orientation of all of them - adaptive physical education, physical recreation (recovery), physical rehabilitation, adaptive sports - to the protection and strengthening of human health is closely related to medical care, and the main tool is considered to be therapeutic physical education. The means of therapeutic physical education are used in a restorative, protective, prophylactic direction, and most of them benefit from therapeutic physical education in the form of restorative means [4, p.559; 6, p.386]. Physical rehabilitation is a pedagogical process aimed at the rapid resolution of treatment and rehabilitation issues through the combined use of physical education tools. Physical rehabilitation in the elderly is a combined form of medical, pedagogical and psychological effects. In short, physical rehabilitation helps to achieve recovery from a disease or pathological process through the use of physical education methods [3, p.29; 4, p.559].

In recent times, the intensification of struggles and competition in the world's sports arenas has also had its impact on sports training. The increase in the volume and intensity of training loads has led to an increase in injuries and pathological conditions. In order to return athletes to the field of competition more quickly, it creates the basis for the widespread use of physical rehabilitation measures, along with other restorative means. Therefore, the problem of rehabilitation of athletes remains one of the most urgent issues of restorative and sports medicine. It has been established that intensive training loads increase metabolism, energy sources are rapidly broken down and, along with energy, lead to the formation of a large number of intermediate and final products of decomposition, thereby disrupting homeostasis. Disturbance of the stability of the internal environment of the body leads to specific disorders and non-specific adaptive reactions in those who exercise - changes in the functional systems of the central nervous system, endocrine glands and many organs. Thus, as a result of chronic fatigue and

excessive exercise, the development of general fatigue is accelerated, creating additional conditions for the occurrence of injuries and diseases [4, p.559; 10, p.560].

The rapid development of modern sports, along with its positive results, also gives rise to a number of problems. The change in the severity of fights from maximum to severe injuries, situations arising during the games, ways out of them place great demands on the physical fitness of athletes, and makes the constant improvement of the training process urgent [10, p.560].

In the course of sports activities, changes occur in the functional state of the athlete's body, the transition of the activity of functional systems from one level to another occurs: from a state of calm to full tension, fatigue and subsequent recovery. In order to achieve a beneficial adaptation result in the body, regulatory mechanisms are activated during the implementation of physical loads, and during the recovery period, all parameters return to their original state thanks to self-regulation processes. In this case, the most important role falls on the vegetative nervous system, and nervous regulation plays the role of an indicator of the body's adaptive capabilities [7, p.62].

The leading indicator reflecting the adaptive capabilities of the body in the process of sports activity is the functions of the cardiovascular system. Sports training has a strong effect on the main links of the cardiovascular system of athletes: on the morphology of the heart, the hemodynamic system, the state of the blood bed, etc. As a result of adaptation to physical loads, a good model of the functional system is formed, optimizing the activity of the circulatory system in accordance with the type of training. The direction of the training process, maintaining its own set of rules in the regulation of blood circulation, forms long-term adaptation by influencing the type of blood circulation, a more economical type of blood circulation is strengthened, and the functional capabilities of the heart are increased [1, p.24; 12, p.224-231].

The training conditions and competitive activity inherent in modern sports are accompanied not only by progressive adaptive changes in the health of athletes, but also by maladaptive changes to physical loads. These maladaptive changes tend to accumulate against the background of sports loads, accumulate, become progressive and transform into a pathological stage, and subsequently give rise to chronic conditions. In this regard, the problem of physical rehabilitation, restoration of functional status and improvement of physical performance through intensive training is faced by sports specialists, scientists, sports doctors, coaches and physical rehabilitation specialists and is considered one of the issues awaiting solution [4, p.559; 5, p.304; 10, p.560; 11, p.120].

Since there are not many research studies on the application of rehabilitation to sports, scientists have begun to focus on improving the effectiveness of training and competition processes, since they have paid great attention to their medical and biological justification. Recently, scientific and research studies in this direction have increased significantly, and by applying new rehabilitation tools to different sports, athletes are trying to return to the field of competition more quickly and achieve faster recovery processes. However, it should also be noted that one of the reasons that threatens the health of athletes is that most coaches, when planning the volume and intensity of training loads, do not base their plans on the level of the athlete's functional readiness, but on the current level of sports achievements [3, p.29; 4, p.559; 8, p.154-159]. Thus, recovery processes after intensive training and competitions should take a central place in the preparation of athletes. This requires coaches to give more priority to individual approaches when applying practical tools and methods, which ultimately eliminates the additional effects that may arise on the health of athletes, and ensures more efficient recovery [1, p.24; 9, p.36-39; 12, p.224-231]. The use of physical rehabilitation tools to accelerate recovery processes after physical loads in sports training practice has a much older history, and the inclusion of these tools in training programs leads to effective results and meets the requirements of modern world sports. The confirmation and justification of these approaches in practice is one of the most urgent issues of modern sports. The main goal of the research work was to empirically substantiate and evaluate the effectiveness of the role of rehabilitation tools and methods of physical rehabilitation in increasing the working capacity of athletes and preventing fatigue.

II Methods

20 volleyball athletes (aged 19-23) participated in the study. They regularly trained in the team they represented for 10-12 hours a week, under the same program, in the same conditions. In accordance with the planned goal of the study, the following tasks were planned: 1) assessment of the physical performance of athletes specializing in volleyball; 2) analysis of scientific research and methodological materials on the topic; 3) application of complex rehabilitation measures related to the optimization of the physical performance of athletes and assessment of their effectiveness. The following methods were

used to solve these tasks: a) pedagogical experiment; b) medical-biological testing; c) methods of mathematical statistics.

III. Results and discussion

The athletes participating in the examination were divided into two groups (control and experimental) according to the indicators of functional readiness and the level of physical performance. It was also revealed that the state of adaptation to the training loads performed in them was different in the functional systems of the body. According to the results of medical-biological testing in both groups, the control group was assessed as a group with adequate activity due to the individual functional characteristics of adaptive systems, while in the experimental group this situation was assessed as a strained mechanism of adaptation and required the application of rehabilitation measures for their full recovery.

On the basis of the rehabilitation-restorative programs of the athletes included in the experimental group and attributed to the mechanism of high adaptation strain, purposefully formed pedagogical, medical-biological and psychological recovery tools were included and they were aimed at increasing physical performance. These include breathing exercises, yoga gymnastics elements, auto-training, various types of sports massage, vitamin foods, vitamins, hydroprocedures.

Regular performance of respiratory movements is of great importance in the recovery process. They positively influenced the increase in the reserve capacity of the athlete's respiratory system, expanded aerobic capacity, and increased adaptation to physical loads from the initial stages. Among the numerous respiratory movements, those were selected for the rehabilitation of volleyball players that affected the increase in the volume of external respiration indicators. The increase in external respiration indicators creates conditions for the increase in the resistance of the central nervous system to hypoxia and the strengthening of recovery processes.

The choice of a complex combination of autotraining, gymnastics and yoga elements in the recovery process was largely due to the fact that they create isometric tension, which then creates an effect called postisometric relaxation, which interacts with autogenic training in a relaxing way, increasing the expected effect. The duration of this complex effect should be 15 minutes. Before, during and after the exercises, pulse rates, respiratory rate, and arterial blood pressure were measured. Autotraining was carried out in the gyms where the exercises were held, in the "Shavasan" posture, lying down, using the I. Schulz method. In order to solve the task at hand more successfully, audio cassettes and melodic music were also used, on which autogenic sessions were distributed. All this created conditions for strengthening recovery processes and complete relaxation.

Restorative massage is performed with volleyball players according to an improved sports massage scheme, taking into account the specific characteristics of this sport. This also allows them to improve their working capacity, and their functional condition improves. Sports massage is performed in training and exercise settings for primary, restorative, and rehabilitative purposes.

The effect of physical rehabilitation before and after the implementation of rehabilitation programs was assessed using the following methods. With the help of physiological tests, the number of heart beats, systolic blood pressure, diastolic blood pressure, pulse pressure, stroke volume, and cardiac output, which are indicators of the functional state of the blood circulation, were determined. The indicator of physical performance in athletes was calculated according to the PWC170 test, and the level of maximal oxygen consumption (OMS) was calculated indirectly.

At the beginning of the study, the above-mentioned functional indicators were determined in the athletes of the experimental and control groups during rest and repeated examinations were carried out in order to determine the effect of training loads on them. According to the results obtained, it was found that the response of the cardiovascular system to physical loads in the athletes of the experimental group was hypotonic. Thus, it was observed that the central hemodynamic indicators and the mechanisms of regulation in the activity of the heart were slightly strengthened. The cardiac output increased due to the increase in the number of pulse beats, while the increase in systolic arterial pressure was not so significant, diastolic blood pressure practically did not change, and the cardiac stroke volume increased slightly. This indicates the inadequacy of the adaptation of the circulatory system to physical loads, the blood supply to the muscles deteriorated, and the aerobic energy consumption of the body decreased. In the athletes of the control group, a normotonic response to physical loads was observed, the average level of physical performance of the body and aerobic energy production were at the level typical for this type of sport.

The analysis of the results obtained after the implementation of rehabilitation measures showed that the selected rehabilitation tool played a modulator role in the activation of the adaptive and regulatory systems of the examined athletes, had a positive effect on the recovery processes. This is also

confirmed by the change in hemodynamics in the normotonic direction in all athletes of the experimental group. The analysis of the results obtained after repeated determination of physical performance after the implemented rehabilitation measures showed that in volleyball players of the experimental group its level closely approached the level of indicators of the control group. This was observed in both PWC₁₇₀ and OMS measurements. The absolute indicator of PWC₁₇₀ in athletes of the experimental group increased by 910.7 ± 150.50 kgm/min, or 5.20% (compared to the initial indicators), and the average value of the relative indicator of PWC₁₇₀ increased by 16.80 ± 2.30 kgm/min/kg, or 5.5%.

In the athletes included in the control group, no significant changes were observed in the indicators obtained during the determination of physical work capacity (PWC₁₇₀) at the beginning of the experiment and after the rehabilitation measures, but a tendency towards optimization was noted (the absolute indicator of PWC₁₇₀ was 900.50 ± 90.90 kgm/min, and then 925.55 ± 90.60 kgm/min, and the relative indicator of PWC₁₇₀ was 15.00 ± 1.50 kgm/min/kg at the beginning of the experiment, and then 16.20 ± 1.60 kgm/min/kg). This once again confirms the effective effect of the physical loads applied in the training process. From the analysis of the results, it is also noteworthy that the absolute indicator of maximal oxygen consumption (MOC) in the experimental group was 3.20 ± 0.40 l/min, or up to 5.4%, and the relative OMC indicator was 44.60 ± 8.60 ml/min/kg, or up to 5.80% (compared to the initial indicators at the beginning of the experiment). As can be seen from the results obtained from the volleyball players included in the control group, the OMS measurements (the absolute indicator of OMS at the beginning of the experiment was 3.20 ± 0.04 l/min, and at the end 3.80 ± 0.08 l/min, while the relative indicators of OMS were 50.20 ± 5.6 ml/min/kg at the beginning of the study, and 52.30 ± 5.80 ml/min/kg at the end).

Thus, the analysis of the indicators obtained during the study shows that, in addition to the effectiveness of the physical rehabilitation measures applied during the training process of volleyball players, they are also aimed at developing endurance and physical performance in their athletes. The effective development of endurance and general performance has a specific feature for this type of sport.

Conclusions: 1. The methodology used to assess the functional readiness and physical performance of athletes allows for earlier detection of the development of excessive fatigue and a more frequent reduction in the frequency of its development by implementing preventive measures at different stages of preparation for competitions. 2. The conducted studies once again confirm the high effectiveness of the applied physical rehabilitation complex methods, which is also proven by the analysis of the results obtained in the conducted examinations. 3. The application of a rehabilitation-restorative complex immediately after the performance of intensive physical loads significantly shortens the recovery period, increases the adaptive capabilities of the body in athletes and increases the level of physical performance. Therefore, it can be considered expedient to apply such restorative means in the training process of teams in conjunction with other methods (as well as independently). By using physical rehabilitation methods in volleyball and other sports, it is possible to maintain the functional state of athletes at a high level during the competition period.

Literature

1. Bocharov, M.V. Interrelationship of regulatory mechanisms of cardiac activity and blood system in young sportsmen and wrestlers. Autoref. diss... kand. biol. Science M., 2016. – 24 p.
2. Viryasov D.Yu. Methods of recovery of sportsmen after injuries of the locomotor apparatus in martial arts «Russian State Prof.-Pedagogical University» Institute of Humanitarian and Social and Economic Education, Department of Theory and Methods of Physical Culture. Yekateriburg, 2017, 77 pages.
3. Grechishkina, S.S. The influence of sports physical loads on the regulatory-adaptive possibilities of the cardio-respiratory system of the student body. Autoref. diss... kand. biol. Science - Maykop, 2012. - 29 p.
4. Epifanov, V.A. Therapeutic physical culture and massage. – M.: изд – во «ГЕОТАР – МЕД», 2017. – 559 с.
5. Karaulova, L.K. Fiziology of physical education and sport / L.K. Karaulova, N.A. Krasnoperova, M.M. Rasulov. - M.: izd - in "Akademiya", 2014. - 304 p.
6. Karaulova, L.K. Физиология / L.K. Karaulova, N.A. Krasnoperova, M.M. Rasulov. - M.: izd. Center "Akademiya", 2016. – 386 p.
7. Levashova A.D., Ekimova D.A., Manapova N.A., Tsydrina A.V. Rehabilitation of sportsmen after diseases and trauma // Science, education and culture. 2022. No. 2 (62). URL: <https://cyberleninka.ru/article/n/reabilitatsiya-sportsmenov-posle-zabolevaniy-i-travm> (access date: 14.02.2023).

8. Oleynik, E.A. *Comparative analysis of anthropometric indicators of students-athletes of cyclical sports / Uchenye zapiski universiteta im.P.F.Legaftha.* – 2013. - No. 3(97). – p. 154 – 159.
9. Ponomareva, A.G. *Development of criteria for evaluating the functional state of sportsmen and juniors for the creation of electronic medical cards / A.G. Ponomareva, Z.M. Kostyuk, A.I. Animenko, V.M. Krivoshepov // Remedium, 2016. - №7 - 8. - p.36 - 39.*
10. Solodkov, A.S. *Human physiology. General. Sports. Age: textbook.* - M.: Olympia Press. – 2017. – 560 pp.
11. Chinkin, A.S. *Физиология спорта / A.S. Chinkin, A.S. Nazarenko. textbook.* - Moscow: Sport, 2016. - 120 с.
12. Yakhontov, S.V. *Vegetative resistance in sport // Vestnik TGPU, 2015. - №3(156). - p. 224 - 231.*

Chemical sciences

INTERACTION OF OXOHYDRONAPHTHALENES WITH METHANOL

Nazarova Mushkunaz

Garayeva Irada

Muradov Mahal

Sumgait State University, Azerbaijan

The synthesis of 2-methyl-1-naphthol from 1-naphthol and methanol over Ni,H-mordenite has been systematically investigated, and results of considerable practical relevance have been obtained [Agayev, 2018]. Detailed examination of the reaction pathways, characterization of the catalyst composition, and comprehensive analysis of the reaction parameters demonstrate that the process is inherently complex and proceeds through multiple transformation steps. Consequently, elucidation of the primary and secondary transformations occurring during the reaction, including the identification of consecutive and parallel reaction pathways, represents a critical aspect of kinetic investigations.

The catalytic alkylation of 1-naphthol with methanol was selected as the object of the present study. The development of an efficient method for the synthesis of methyl homologues of naphthols using selected and well-justified catalytic systems, chosen from among the synthesized catalysts and modified H-mordenites, as well as the identification of intermediate transformations occurring during the process, were defined as the subject of the investigation.

The studies were conducted using modern equipment, instrumentation, and software. The experiments were carried out in a flow-type reactor under differential reaction conditions, and the physico-chemical properties of the reaction systems were subjected to detailed analysis.

Among the products formed in the interaction of 1-naphthol with methanol, 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene and 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene were identified. It is assumed that these compounds, together with 1-methoxynaphthalene, serve as intermediates in the formation of methyl homologues of naphthalene [Aghayev, 2019]. To test this hypothesis, the interaction of these proposed intermediates with methanol in the presence of a Ni,H-mordenite catalyst was investigated. The experimental procedures and analytical results are presented in Table 1.

Table 1

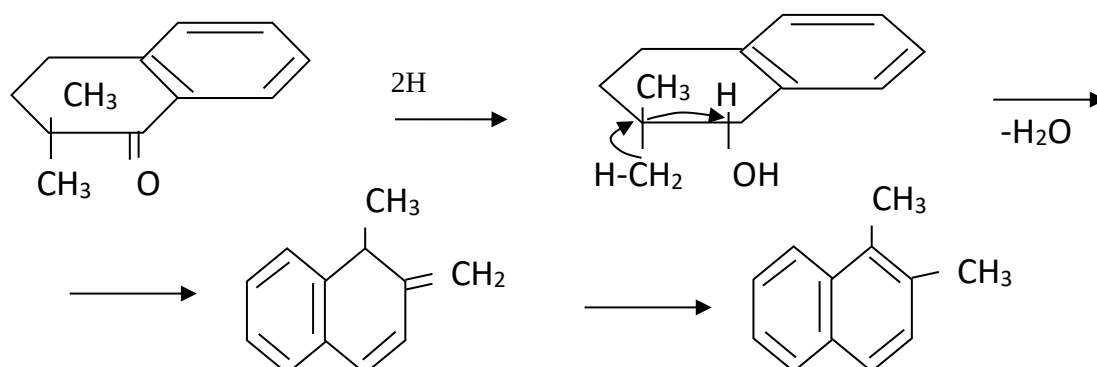
Results of the interaction of 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene with methanol in the presence of a Ni,H-mordenite catalyst

Reaction conditions: $u=1.0$ st-1, $v=1:10$ mol/mol

Parameters	Temperature, °C				
	320	340	360	380	420
Conversion of 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene, %	50.5	67.5	85.5	94.8	100
Chemical composition of naphthalene methyl homologues, wt. %					
2-Methylnaphthalene	-	0.9	2.2	3.5	5.2
1,2-Dimethylnaphthalene	99.4	97.3	93.7	90.8	84.7
1,2,3-Trimethylnaphthalene	0.6	1.1	3.0	4.0	7.5
1,2,4-Trimethylnaphthalene	-	0.7	1.1	1.7	2.6

The interaction of 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene, 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene, and 1-methoxynaphthalene with methanol was investigated at temperatures ranging from 320 to 420 °C, with the partial pressure of methanol in the initial mixture taken in excess (10–20 atm). The results of the interaction of 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene with methanol in the presence of a Ni,H-mordenite catalyst are presented. The main reaction product is a mixture of methyl homologues of naphthalene, with a mass fraction in the catalyst ranging from 12.7 to 50.0 %. Analysis of the chemical composition of this mixture indicates that the predominant isomer is 1,2-dimethylnaphthalene.

At lower temperatures (320–340 °C), its mass fraction in the mixture is 97.3–99.4 %, whereas at higher temperatures (380–420 °C), it decreases to 84.7–90.8 %. As the temperature increases, the content of 1,2-dimethylnaphthalene in the mixture decreases, while the proportions of other naphthalene methyl homologues, including 1,2,3- and 1,2,4-trimethylnaphthalenes, begin to increase. Concurrently, the conversion of the oxo compounds rises with increasing temperature, reaching 100 % at 420 °C.



Regarding the formation of trimethylnaphthalenes during the process, it is assumed that the reaction involves the simultaneous interaction of a 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene molecule with two methanol molecules, followed by subsequent water elimination [Balint E, 2013].

The interaction of 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene with methanol in the presence of a Ni,H-mordenite catalyst was also investigated. Analysis of the results indicates that this reaction predominantly yields two types of compounds: 1,1,3-trimethyl-1,2-dihydronaphthalene and methyl homologues of naphthalene. At lower temperatures (320 °C), 1,1,3-trimethyl-1,2-dihydronaphthalene is the main product. However, increasing the temperature negatively affects its content in the catalyst. Specifically, at 420 °C, its mass fraction decreases twelvefold compared to 320 °C, reaching 3.0 %.

Analysis of the obtained results indicates that, in the present case, oxo compounds are formed only in minor amounts, with 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene predominating. The mass fraction of this compound in the catalyst ranges from 0.4 to 1.0 %, and increasing the temperature from 320 °C to 360 °C reduces its content from 1.0 % to 0.4 %. At temperatures above 360 °C, this compound is no longer detected. As for 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene, only trace amounts are observed at 320 °C.

Under the selected conditions (300–340 °C), tetra- and pentamethylnaphthalenes are not formed at all; these naphthalene methyl homologues are produced only at temperatures above 380 °C. Another notable observation is that 1,1,3-trimethyl-1,2-dihydronaphthalene and 3,4-dimethyl-1-naphthol, obtained from the interaction of 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene with methanol over a Ni,H-mordenite catalyst, are not formed in the reaction of 1-naphthol with methanol under the same conditions. The small amount of 4-methyl-1-naphthol produced in the latter reaction is insufficient for the corresponding oxo compound synthesis.

Although quantifying the amount and consumption of 1-oxo compounds in the reaction of 1-naphthol with methanol over Ni,H-mordenite poses certain difficulties, this stage is of particular importance for the formation of 1,2-dimethylnaphthalene from 2-methyl-1-naphthol. Furthermore, 1-oxo compounds play a significant role in the formation of other naphthalene methyl homologues, including tri- and tetramethylnaphthalenes. In light of this, special attention was given to this factor in the kinetic studies, and the kinetic model was constructed based on the above scheme. Overall, the established regularities of the catalytic alkylation of 1-naphthol with methanol formed the foundation for the kinetic investigations.

Conclusions

1. Analysis of the results shows that the interaction of 1-oxo-4,4-dimethyl-1,4-dihydronaphthalene with methanol predominantly yields two types of compounds, including 1,1,3-trimethyl-1,2-dihydronaphthalene and methyl homologues of naphthalene.

2. The main product obtained from the alkylation of 1-naphthol with methanol, 2-methyl-1-naphthol, undergoes further methylation to form 1-oxo-2,2-dimethyl-1,2-dihydronaphthalene rather than dimethylnaphthols. This oxo compound then reacts with methanol to predominantly produce 1,2-dimethylnaphthalene, which subsequently forms trimethylnaphthalenes.

References

1. Agayev A.A. The Study of The Catalytic Convesion of 1-Ethoxy Naphthalene / P.V.Suleymanova, M.K.Nazarova, P.T.Shahtakhtinskaya // American Journal of Engineering Research (AJER), - 2018, 7(1), - p.217-220
2. Aghayev A.A, Nazarova M.K., Suleymanova P.V., Muradov M.M. Catalytic synthesis of 2-ethoxynaphthalene and 1-ethyl-2-naphthol combinatoin Advances in Synthesis and complexing // Book of

abstracts, The Fifth International Scientific Conference, Vol. 1, Organic Chemistry Section, RUDN University, -Moscow: -22-26 April, - 2019, - p.86.

3. *Balint E Microwave –assisted solid-liquid phase alkylation of naphthols / E.Balint, O.Kovacs, L.Drahoš, [et. al] // Letters in Organic Chemistry, - 2013. 10, - p.330-336*

Economic sciences

NEW CHALLENGES OF PUBLIC ADMINISTRATION – USE OF NETWORK MARKETING TECHNOLOGIES

Bela Goderdzishvili

*Doctor of Business Administration (Ph.D.)
Associate Professor at Georgia Institute of Technology,
Tbilisi, Georgia*

Ana Svanidze

*Doctor of Public Administration (Ph.D.)
Georgian Technical University,
Tbilisi, Georgia*

Abstract

This article offers a rationale for adopting modern network marketing technologies in public administration, a component of the management paradigm, to focus government efforts on meeting the needs of the Georgian population. The article explores the experiences of Georgia and other countries in adapting international marketing-technology practices in public administration, as well as specific aspects of modernizing and developing marketing tools in public services.

Keywords: *Public administration, internet marketing, state competitiveness, marketing technologies, citizen well-being.*

Introduction

Internet marketing, a modern marketing concept, relies on innovative technologies. In government marketing, creativity, grounded in a comprehensive study of the market and consumer demands, is no less important than clear organization and management.

In modern government information systems, management is accomplished through information flows. The quality of communication between government and the public has become a key factor in optimizing public administration, the electoral process, and electoral technologies, as well as developing new societal values.

Discussion

In Georgia, the range of digital communication platforms for dialogue, opinion exchange, and coordination of goals and ways to achieve them is constantly expanding.

There is a close connection between Georgian politics and the use of marketing technologies in public communication [4, p. 4015]. Therefore, it is necessary to explore the implementation of modern online marketing technologies in public administration.

In the context of globalization, the Internet is enabling the formation of a unified social, informational, and economic space. Online technologies, implemented by countries in public administration, have become a systemic determinant of national economic competitiveness.

Internet marketing is a new type of marketing aimed at generating profit or other benefits. It involves a combination of traditional and innovative tools and technologies on the global internet to identify and meet consumer needs [2, p. 6].

In general, although the adoption of modern online marketing technologies is increasing, they are not yet fully utilized in public administration. Often, their use is haphazard and unsystematic, or is carried out by insufficiently qualified specialists. However, the full integration of marketing into public administration created conditions to increase the state's competitiveness and improve citizens' well-being.

To remove barriers to the widespread adoption of online marketing technologies in public administration, it is important to develop recommendations for the use of internet marketing in government agencies and local governments, and to strengthen the state's role in stimulating business development and e-commerce.

Internet marketing combines traditional marketing functions and modern information technologies. This provides grounds for formulating its own definition. Modern online marketing technologies in public administration should be understood as the organization of government and local agency activities, carried out via the global internet to identify, process, and satisfy consumer needs.

The internet is a unique source of information and communication. Among the negative aspects of internet use is the risk of falling victim to manipulation and the malicious actions of fraudsters and propagandists. In

particular, online propagandists' traps are intrusive, often emotionally charged ideas that waste a person's time. Such traps can include erroneous attitudes, unproductive or obsessive thoughts, and obsessive feelings or ideas. When a person is caught up in so-called "information networks," both their physical and mental health suffer. Well-being, productivity, and relationships with others change.

Internet networks, as an inexhaustible source of communication, allow people to shape their environment, present themselves, and express themselves. The virtual illusion created is the feeling that virtual interlocutors understand and accept them, and sometimes even support them (through likes and comments). Unlike real-life interactions, virtual communication is perceived as a place where one can easily, pleasantly, and safely express oneself in any capacity. A person overly involved in virtual relationships tends to carry this over into real life.

People who are absorbed online can be manipulated by modern network marketing technologies. This is especially noticeable among young people, who have been raised in the age of technology. Certainly, information technology carries a certain destructive force and is the basis for the systemic programming of the human psyche. The negative ultimate goal of manipulating consciousness and controlling individuals and groups is waging organizational wars, destroying state foundations, and seizing control of these countries by a foreign aggressor [4, p. 4016].

Consequently, modern network technologies are based on programming the human psyche, which decisively influences the subsequent choice of cultural values and orientations.

Marketing in public administration resembles marketing in commercial organizations. However, marketing goals in the public sector should be more ambitious than those at the business level. While business marketing promotes a limited set of products, government marketing is diverse and requires a comprehensive, balanced approach to meet public needs. Since 1970, the United States has worked to incorporate marketing technologies into the public sector. administration. The goal of such testing was to create public administration mechanisms that would enable the president to govern the country effectively, much like managing a private company [1, p. 364].

The global internet is a place where new technologies are constantly being introduced, and tools and methods are used to improve the effectiveness of advertising campaigns. Online advertising is a universal means of promoting goods, works, and services; its use is beneficial and cost-effective for both private businesses and public administration goals.

In public administration, targeting is used to identify and meet public needs.

For example, Barack Obama's team won the 2018 presidential race thanks to online marketing technologies, so we believe that the beginning of his presidency ushered in the era of digital marketing and microtargeting. In the United States, microtargeting has completely changed the approach to voter engagement. The involvement of marketing specialists yielded fruitful results in this example. Something similar was gradually beginning to happen in our country. The last few elections in Georgia were emblematic. It turned out that old mechanisms and traditional means of reaching voters (TV and radio advertising, billboards, and campaign tents) were ineffective without new creative solutions.

The internet has reached a huge audience in a short time and has become an important part of many people's lives. If we imagine a situation in which the internet suddenly disappeared, many people's lives would change dramatically. The internet is of great importance because it influences not only the individual (one person) but also the life of an entire society. For example, it contributes to a change in people's mindsets.

Online advertising is changing public attitudes, which has both positive and often negative consequences in the real world. The use of modern network marketing technologies in public administration enables the effective delivery of important information to the public.

Government agencies and local governments, as representatives of the non-profit sector, must constantly address people's needs for security, self-realization, creative expression, and spiritual development. This segment is immeasurably broader than the commercial sector.

Public network marketing is constantly expanding its functions. The function of interacting with consumers has emerged alongside research, planning, sales promotion, and distribution.

Non-profit organizations typically use classic marketing techniques, including identifying market segments, researching supply and demand, organizing sales channels, and launching social advertising and PR.

We emphasize that introducing modern tools, namely non-profit network marketing, into public administration is intended to promote socially significant products. Consequently, the activities of the non-profit sector, unlike those of the commercial sector, are aimed not at generating profit but at satisfying social needs and achieving a high social impact. This means creating an intangible outcome,

including improving the standard of living and quality of life for the population, promoting the preservation and reproduction of the social order, and, in general, satisfying the vital needs of citizens.

A distinctive feature of applying network marketing in public administration is that its activities are grounded in classical marketing technologies. Government agencies such as healthcare, education, science, and social security operate without material profit yet compete in a competitive environment. Today, many private commercial entities in Georgia and abroad perform functions and tasks similar to those of government agencies.

Non-governmental organizations, particularly political parties, trade unions, and public foundations pursuing political goals, also promote their non-commercial products to society and influence public consciousness.

From this perspective, we highlight the goals of non-profit network marketing, such as shaping public perceptions of individuals and promoting political, religious, artistic, or scientific ideas.

Meeting a person's needs positively affects their cultural, political, social, religious, and work-related identities.

Furthermore, network marketing technologies can:

- increase public trust in government agencies and officials;*
- ensure social balance and healthy partnerships between different social groups;*
- promote interaction between the state and the public;*
- maintain a healthy public consciousness.*

Ultimately, this will have a positive impact on the production of goods and services, their distribution in domestic and international markets, profits for the non-profit sector, and, consequently, on tax revenues.

At the same time, many differences are revealed between marketing technologies in government agencies and those in other organizations:

- non-economic goals;*
- strict adherence to the law by PR in government agencies;*
- implementation of the information function – regularly informing citizens about important political and other events;*
- PR in government agencies is focused on the development of civil society.*

Government PR has a wider audience reach. This also depends on the level of government. At the federal level, the target audience is the entire state population, entitled to receive reports on government activities. Federal media broadcast a variety of information, employing propaganda and advertising methods. Public administration also employs many PR tools, methods, and various mobilization techniques. Public PR is often referred to as political PR. Such political campaigns depend on current events in the country. They are carried out through advertising, open dialogues and meetings, and coverage of significant deals and negotiations. PR also includes events related to upcoming elections and anti-corruption campaigns.

Governments in developed countries operate in ways that maximize the efficiency of all market processes. In particular, digital libraries and distance learning receive state support for information technology in education. Thanks to the internet, in the United States, consumers of government services can enroll in educational institutions and receive education through government websites. Thus, the introduction of online marketing technologies into public administration is transforming the internet into an accessible means of education and work for everyone. A significant advantage is that, firstly, the admissions process to an educational institution is significantly simplified; secondly,

Bribery in any form during admission is prohibited; and thirdly, admission is guaranteed if a person meets all requirements and possesses the necessary knowledge and qualities.

Following the example of developed countries, we believe our country's public strategy should focus on developing competitive market advantages.

Regarding the use of network marketing technologies in public administration to ensure the information transparency of government institutions, countries such as the United States, France, Japan, and others are particularly noteworthy.

The experience of countries such as the United Kingdom, Canada, Germany, France, Poland, and the Czech Republic also demonstrates the effectiveness of adhering to the principle of information transparency in public authorities as a tool for reorienting them toward citizens' needs. They have adopted the United States' successful experience with advanced marketing technologies in public-sector management [2, p. 8].

PR technologies are also partially used by government agencies in Georgia. Specifically, they foster a positive image of government agencies and their representatives, public support for government programs, and promote the country's advantages among other countries.

Global practice demonstrates that the systematic participation of competent commercial enterprises as marketing management experts in government agencies is becoming a necessary component of public administration. Providing conditions for the training and development of human resources in PR activities for government agencies will facilitate the closest possible rapprochement between the state and the population. In turn, this will ensure the quality and effectiveness of work and the interaction between government agencies and the population.

We believe that implementing modern network marketing technologies is the foundation of public administration within the management paradigm, focusing government activities on meeting the needs of the country's population. After all, the quality of life of the population and the effectiveness of government agencies should be paramount for the state. These indicators characterize how effectively emerging challenges are resolved and how clearly leadership is exercised. A state that is interested in and successfully addresses the above-mentioned conditions of interaction between government bodies and society will undoubtedly develop and thrive across all areas of activity.

The primary goal of government PR structures should be to build the government's prestige through modern network technologies and to project an image of effective leadership that possesses not only power but also the ability to resolve emerging issues.

The target of PR activities in public administration is the taxpayer and voter. This is recognized as a citizen who wants, should, and has the right to know all the information they need about the actions of government bodies at various levels.

In a democratic state, the government needs to inform the electorate and the public about its activities regularly. Any senior government body or leader wants to demonstrate their own successful work, and they use a wide variety of communication channels to do so. In Georgia, these network technologies will not produce the expected results. Thus, intensifying the processes associated with the introduction of new network marketing technologies into public administration is both a need and a challenge of our time, as it allows for the effective identification of public sentiment and expectations, influences public consciousness, and fosters common ground between the state and society.

As the experience of developed countries shows, government agencies can effectively use network marketing technologies to drive innovation in public administration. The introduction of modern network marketing technologies into public administration facilitates aligning government activities with consumer needs. For developed democratic countries, this should be a primary goal for further economic and strategic development and global competitiveness.

The following modern network marketing technologies can yield positive results from their introduction into public administration:

- Contextual advertising – displaying an ad to those interested in its content;*
- Remarketing – displaying ads from a website previously viewed by the user; Search Engine Optimization (SEO) – measures aimed at raising a website to the top positions in search engines;*
- creating videos and posting them on social media;*
- chatbots, sending out informational and promotional emails, and posting content on various resources for further promotion.*

Conclusion

Certainly, our country is not ready for this type of implementation for several reasons. Our further research will focus on identifying, studying, and analyzing their impact on the effectiveness and efficiency of government agencies and society, as well as potential obstacles to the development and implementation of effective modern network marketing technologies in public administration. It is necessary to define principles for integrating modern network marketing technologies into public administration, ensure training and professional development for specialists in public marketing, and legislate state standards for organizational, informational, and resource support for government information systems.

References

- 1. ClickZ. Marketing Technology Transformation. URL: <https://www.clickz.com/> David Meerman Scott. How My Site and Blog Redesign Resulted in 350 Percent Increase in Traffic, URL: <https://www.davidmeermanscott.com/blog>*
- 2. Heidi Cohen. Actionable Marketing Guide URL: <https://heidicohen.com/>*
- 3. Izea. Internet Marketing Resources URL: <https://izea.com/resources/>*
- 4. The Ultimate Guide to Small Business Keyword Research URL: <https://ducttapemarketing.com/blog/>*

5. Abu-Lughod J. *Going Beyond Global Babble // Culture, Globalization and the World-System*. Ed. by A.D. King. London, 2011.
6. 305. Adams E. *Developing Quality Productivity Ratio for Public Sector Personnel Services // Public Productivity Review*. 2011. V.5.
7. Bartelson J. *Three Concepts of Globalization // International Sociology*. 2000, N2.
8. Cuddington J.T. *Capital Flight: Estimates, Issues, and Explanations*. -Princeton Studies in International Finance. 1986. N°58.
9. Dooley M. *Country Specific Risk Premiums, Capital Flight and Investment Income Payments in Selected Developing Countries*. IMF. Wash. Marsh. 1986.
10. Fridman Th. *Understanding Globalization. The Lexus and the Olive Tree*. N.Y. 2000.
11. Gladden E.N. *History of Public Administration*. Frank Cass: London. 2012. V.l.
12. *Globalization Myth or Reality? Trends Special*. Dresdner Bank, April 2000.
13. *International Capital Markets, Developments, Prospects, and Key Policy Issues*. Wash.: IMF, August 2001.
14. Posner R. *The Appropriate Scope of Regulation in the Cable Television Industry// The Bell Journal of Economics and Management Science*. 2022. -Vol. 3. N°1.
15. Smoot D. *The Business End Government*. 2023.
16. Swiss J. E. *Monitoring and Managing Government Performance: Output-Oriented Management Systems*. Prentice-Hall, Englewood Cliffs, New Jersey. 2021.
17. Thomas C. *Improving Federal Work Quality // Bureaucrat*. 2016.

SUSTAINABLE SOCIAL DEVELOPMENT IN A POST-CAPITALIST AND ECOLOGICAL SOCIETY: A CONTEMPORARY ACADEMIC INTERPRETATION**Elvin Aliyev Mirismayil**

PhD Student of the Faculty of General Economics
 Azerbaijan State University of Economics (UNEC)
 ORCID:0009-0008-3153-2049

УСТОЙЧИВОЕ СОЦИАЛЬНОЕ РАЗВИТИЕ В ПОСТКАПИТАЛИСТИЧЕСКОМ И ЭКОЛОГИЧЕСКОМ ОБЩЕСТВЕ: СОВРЕМЕННАЯ АКАДЕМИЧЕСКАЯ ИНТЕРПРЕТАЦИЯ**Докторант Эльвин Алиев Мирисмаил оглу**

Факультета общего хозяйства
 Азербайджанский государственный экономический университет (UNEC)
 ORCID: 0009-0008-3153-2049

Abstract

Sustainable social development has become a central analytical concept in contemporary academic discourse due to intensifying ecological crises, structural social inequalities, and the growing limitations of growth-oriented capitalist models. This article provides a formal academic interpretation of sustainable social development within the context of post-capitalist and ecological societies. The study conceptualizes social development as a multidimensional and dynamic process grounded in the harmonization of three interdependent pillars: economic sustainability, environmental integrity, and social cohesion. Moving beyond traditional welfare and growth paradigms, the article emphasizes human well-being, social resilience, and ecological responsibility as core objectives of development.

Methodologically, the paper draws upon the New Social Contract Theory, Ecological Modernization Theory, and the Human Development approach as complementary analytical frameworks. These theories collectively provide a robust methodological foundation for examining institutional transformation, policy innovation, and normative change in pursuit of sustainable social outcomes. Particular attention is devoted to the reconceptualization of social development at the intersection of national values and global transformation processes, including digitalization, climate governance, and the Sustainable Development Goals. The article argues that sustainable social development in a post-capitalist and ecological context requires not only structural and policy reforms but also a fundamental reorientation of social values toward intergenerational justice, inclusiveness, and long-term ecological balance.

Аннотация

Устойчивое социальное развитие в условиях нарастающих экологических кризисов, структурных социальных неравенств и углубляющихся ограничений капиталистических моделей, ориентированных на экономический рост, занимает центральное место в современном академическом дискурсе. В статье представлена формально-научная интерпретация устойчивого социального развития в контексте посткапиталистического и экологически ориентированного общества. Социальное развитие рассматривается как многомерный и динамичный процесс, основанный на гармонизации трёх взаимозависимых компонентов: экономической устойчивости, экологической целостности и социальной сплочённости. Отходя от традиционных парадигм благосостояния и экономического роста, автор акцентирует внимание на человеческом благополучии, социальной устойчивости и экологической ответственности как ключевых целях развития.

Методологической основой исследования служат теория Нового социального контракта, теория экологической модернизации и подход человеческого развития, используемые в качестве взаимодополняющих аналитических рамок. Совокупно данные теории формируют прочную методологическую базу для анализа институциональных трансформаций, инноваций в государственной политике и нормативных изменений, направленных на достижение устойчивых социальных результатов. Особое внимание уделяется переосмыслению социального развития на пересечении национальных ценностей и глобальных трансформационных процессов, включая цифровизацию, климатическое управление и Цели устойчивого развития. В статье обосновывается тезис о том, что устойчивое социальное развитие в посткапиталистическом и экологическом контексте требует не только структурных и политических реформ, но и фундаментальной

переориентации общественных ценностей в сторону межпоколенческой справедливости, инклюзивности и долгосрочного экологического баланса.

Key words: Sustainable social development, Theories, Economics, Human Development

Ключевые слова: устойчивое социальное развитие, теории, экономика, человеческое развитие

1. Introduction

The concept of social development has historically been framed within paradigms emphasizing economic growth, industrial expansion, and rising material standards of living. While these approaches contributed to significant improvements in welfare in many regions, their structural limitations have become increasingly evident in the face of climate change, environmental degradation, global inequality, and socio-economic instability (Hickel, 2020; OECD, 2021). As a result, contemporary scholarship increasingly questions the adequacy of growth-centric development models and calls for alternative frameworks that integrate social equity and ecological sustainability.

Within this context, the sustainability paradigm has emerged as a comprehensive framework capable of addressing the complex interdependencies between economic systems, social structures, and natural environments (Raworth, 2022). Sustainable social development represents a conceptual synthesis that aligns social progress with ecological limits and long-term societal resilience. Furthermore, post-capitalist perspectives contribute to this debate by challenging the primacy of market-driven accumulation and advocating for development models centered on human capabilities, cooperation, and environmental stewardship (Fraser, 2021).

The social dimensions of the Sustainable Development Goals (SDGs) constitute the human centered core of the 2030 Agenda for Sustainable Development. While the SDGs collectively aim to balance economic development, environmental sustainability, and social inclusion, their social dimension specifically focuses on the promotion of equity, well-being, and social justice within and across societies. Social sustainability is commonly understood as the ongoing improvement of individuals' quality of life, the strengthening of social cohesion, and the expansion of equal opportunities for all, with particular attention to vulnerable and marginalized groups (Aliyev, E. 2025: p.532).

This article aims to provide a contemporary academic interpretation of sustainable social development within a post-capitalist and ecological society. It seeks to address three interrelated research questions: (1) How can the concept of social development be theoretically integrated with the sustainability paradigm? (2) What methodological contributions do the New Social Contract Theory, Ecological Modernization Theory, and the Human Development approach offer to the study of sustainable social development? (3) How can social development be reconceptualized in light of national values and global transformation processes?

2. Main Part

2.1 Social Development within the Sustainability Paradigm

The integration of social development into the sustainability paradigm reflects a paradigmatic shift from linear and growth-oriented development models toward holistic and systems-based approaches (UNEP, 2021). Sustainability emphasizes the capacity of social systems to ensure long-term well-being while preserving ecological systems and social cohesion for future generations. Consequently, sustainable social development extends beyond economic indicators to encompass social inclusion, institutional trust, and environmental responsibility (UNDP, 2022).

The three-pillar model of sustainability—economic, environmental, and social—serves as a foundational analytical framework in this regard. Economic sustainability refers to stable and inclusive economic structures capable of generating livelihoods without creating systemic vulnerabilities (Stiglitz et al., 2020). Environmental sustainability emphasizes the preservation of ecosystems, reduction of resource depletion, and mitigation of climate-related risks. Social sustainability focuses on equity, participation, cultural continuity, and access to essential services (Dillard et al., 2021).

The harmonization of these pillars represents a core challenge for contemporary development policy. Economic expansion that undermines environmental systems or deepens social inequalities cannot be regarded as sustainable. Similarly, environmental policies that neglect social consequences risk political resistance and limited effectiveness (Dryzek et al., 2023). Sustainable social development therefore requires integrated governance frameworks and cross-sectoral policy coherence.

2.2 Post-Capitalist Perspectives and Ecological Society

Post-capitalist theories argue that advanced economies are undergoing structural transformations that gradually weaken the dominance of traditional capitalist institutions (Mason, 2020). These transformations include the rise of digital economies, knowledge-based production, social enterprises, and cooperative economic models. Within this framework, social development is increasingly understood in terms of enhancing human well-being, social innovation, and collective resilience rather than maximizing capital accumulation.

In ecological societies, post-capitalist perspectives are closely linked to the recognition of planetary boundaries and ecological limits to growth (Rockström et al., 2021). This recognition challenges conventional measures of progress, such as gross domestic product, and encourages the adoption of alternative indicators focused on well-being, sustainability, and social quality (Fioramonti et al., 2022). Social development in this context involves redefining societal success through improvements in quality of life, environmental health, and social stability.

2.3 Methodological Foundations for Sustainable Social Development

The New Social Contract Theory provides a normative framework for understanding evolving relationships between individuals, the state, and markets under conditions of heightened risk and uncertainty. It emphasizes mutual responsibility, social trust, and inclusive governance as essential foundations for sustainable social development (Boyer, 2021). In a post-capitalist context, this approach supports the renegotiation of social obligations in line with ecological constraints and social justice principles.

Ecological Modernization Theory contributes an analytical perspective on how technological innovation, institutional reform, and policy learning can align economic development with environmental protection (Mol et al., 2021). Rather than treating economic growth and ecological protection as inherently contradictory, this theory suggests that modernization processes can be redirected toward sustainability through green technologies, circular economy practices, and regulatory innovation.

The Human Development approach, originally articulated by Sen and further developed in recent literature, places human capabilities and freedoms at the center of development analysis (Sen, 2020; UNDP, 2022). When combined with sustainability principles, this approach highlights the importance of intergenerational equity, long-term well-being, and social inclusion as integral components of sustainable social development (Alkire & Deneulin, 2021).

2.4 National Values and Global Trends in Social Development

Sustainable social development is deeply embedded in national contexts shaped by historical experiences, cultural norms, and institutional structures. National values influence social priorities, welfare arrangements, and public attitudes toward sustainability policies (Inglehart, 2021). At the same time, globalization, digital transformation, and global environmental governance frameworks increasingly shape national development trajectories.

The reconceptualization of social development thus requires balancing national priorities with global commitments, particularly those articulated in the United Nations Sustainable Development Goals (United Nations, 2023). Adapting global frameworks to local contexts while maintaining normative coherence is essential for ensuring both legitimacy and effectiveness. Sustainable social development therefore functions as a mediating concept that connects local identities with global responsibilities.

Conclusion

This article has examined the contemporary academic interpretation of sustainable social development within the context of post-capitalist and ecological societies. It has argued that social development can no longer be adequately understood through growth-centric or purely economic lenses. Instead, it must be conceptualized as a multidimensional process integrating economic sustainability, environmental integrity, and social justice.

By synthesizing the sustainability paradigm with post-capitalist perspectives, the study highlights the necessity of harmonizing structural transformation with normative change. The discussion of the New Social Contract Theory, Ecological Modernization Theory, and the Human Development approach demonstrates that sustainable social development requires both analytical pluralism and value-based orientation. Ultimately, achieving sustainable social development demands institutional innovation, policy coherence, and a fundamental reorientation of societal values toward solidarity, responsibility, and long-term ecological balance.

References

1. Alkire, S., & Deneulin, S. (2021). Individual agency and sustainable human development. *Journal of Human Development and Capabilities*, 22(1), 1–16.
<https://doi.org/10.1080/19452829.2020.1848136>

2. Aliyev, E. (2025). *United Nations Sustainable Development Goals (SDGs) and Their Social Dimensions*. *Akademik Tarih ve Düşünce Dergisi*, 12(6), 531-541. <https://doi.org/10.5281/zenodo.18030476>
3. Boyer, R. (2021). *The political economy of the new social contract*. *Socio-Economic Review*, 19(2), 435–460. <https://doi.org/10.1093/ser/mwaa033>
4. Dillard, J., Dujon, V., & King, M. C. (2021). *Understanding the social dimension of sustainability*. Routledge.
5. Dryzek, J. S., Norgaard, R. B., & Schlosberg, D. (2023). *Climate change and society: Approaches and responses*. Oxford University Press.
6. Fioramonti, L., Coscieme, L., Costanza, R., Kubiszewski, I., Trebeck, K., & Wallis, S. (2022). *Wellbeing economy: An effective paradigm to mainstream post-growth policies?* *Ecological Economics*, 192, 107261. <https://doi.org/10.1016/j.ecolecon.2021.107261>
7. Fraser, N. (2021). *Cannibal capitalism: How our system is devouring democracy, care, and the planet*. Verso.
8. Hickel, J. (2020). *Less is more: How degrowth will save the world*. Penguin Random House.
9. Inglehart, R. (2021). *Cultural evolution: People's motivations are changing, and reshaping the world*. Cambridge University Press.
10. Mason, P. (2020). *Postcapitalism: A guide to our future*. Farrar, Straus and Giroux.
11. Mol, A. P. J., Sonnenfeld, D. A., & Spaargaren, G. (2021). *The ecological modernization reader: Environmental reform in theory and practice* (2nd ed.). Routledge.
12. OECD. (2021). *Beyond growth: Towards a new economic approach*. OECD Publishing. <https://doi.org/10.1787/33a25ba3-en>
13. Raworth, K. (2022). *Doughnut economics: Seven ways to think like a 21st-century economist* (Updated ed.). Chelsea Green Publishing.
14. Rockström, J., Gupta, J., Lenton, T. M., Qin, D., Lade, S. J., Abrams, J. F., ... Winkelmann, R. (2021). *Identifying a safe and just corridor for people and the planet*. *Earth System Governance*, 7, 100083. <https://doi.org/10.1016/j.esg.2021.100083>
15. Sen, A. (2020). *The idea of justice*. Harvard University Press.
16. United Nations. (2023). *The Sustainable Development Goals report 2023*. United Nations.
17. United Nations Development Programme. (2022). *Human Development Report 2021/2022: Uncertain times, unsettled lives*. UNDP.
18. United Nations Environment Programme. (2021). *Making peace with nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies*. UNEP.

THE ROLE OF EMOTIONAL INTELLIGENCE IN AN EFFECTIVE LEADERSHIP SYSTEM: THEORETICAL AND PRACTICAL APPROACH

Huseynli Aylin Mehman

Abstract

This article examines the relationship between emotional intelligence (EI) and leadership effectiveness based on current scientific research and meta-analyses. Based on the results of more than 100 empirical studies conducted between 2018 and 2025, it is demonstrated that emotional intelligence plays a critical role in leadership success. Research shows that leaders with high levels of emotional intelligence achieve up to 40% higher performance in their teams, up to 50% lower turnover, and 2.5 times greater success in change management. According to a meta-analysis, the distinguishing feature of high-performing leaders in almost 90% of their profiles is the emotional intelligence component, not technical skills. Research conducted by McKinsey & Company, Harvard Business Review, and TalentSmart confirms that emotional intelligence is one of the most in-demand skills in today's workplace. The original theoretical contribution of the paper is the inclusion of the first empirical data from the Azerbaijani context – a local study conducted in the logistics sector by Novruzov (2024) and a comparative study of Norwegian-Azerbaijani SMEs by Mammadov and Wald (2025).

Keywords: emotional intelligence, leadership effectiveness, Azerbaijani work environment, SME internationalization, team performance, self-awareness, empathy, meta-analysis

1. INTRODUCTION

In the 21st century, the leadership paradigm has undergone significant changes. While traditional leadership models emphasized IQ and technical skills, modern research shows that emotional intelligence (EI) plays a more significant role in leadership success. The concept of emotional intelligence, developed by John Mayer and Peter Salovey in the 1990s and introduced to a wider audience by Daniel Goleman in 1995, revolutionized leadership research.

Goleman's 1998 Harvard Business Review article, "What Makes a Leader?", became the most cited article in the journal's history (Goleman, 1998). The research presented in this article shows that, in a study of nearly 200 large international companies, nearly 90% of the factors that distinguish outstanding performers from average ones in high-level management positions are not technical skills but components of emotional intelligence (Goleman, 2004).

A comprehensive systematic review by Gerhardt, Bauwens, and van Woerkom (2024) confirms the growing influence of emotional intelligence on leadership outcomes, given the complex challenges leaders face in the context of the COVID-19 pandemic, rising mental health problems, and technological change (Gerhardt et al., 2026). In the context of Azerbaijan, research on leadership styles in the context of post-Soviet economic transformation has grown significantly in recent years.

2. EMOTIONAL INTELLIGENCE: THEORETICAL BASIS AND COMPONENTS

2.1 Definition of emotional intelligence

Mayer and Salovey (1990) define emotional intelligence as "the ability to recognize and manage one's own emotions and the emotions of others." In the context of leadership, emotional intelligence means understanding how emotions influence team dynamics and performance and using this understanding to lead effectively (Salovey and Mayer, 1990). According to Goleman's model, emotional intelligence consists of four main areas:

Component	Description and meaning
Self-awareness	The ability to deeply understand one's own emotions, strengths, and weaknesses. According to McKinsey research, organizations with self-aware leaders achieve 41% higher shareholder returns (McKinsey, 2020).
Self-governance	The ability to regulate emotions, control impulses, and adapt to changing circumstances in stressful situations. Leaders with high levels of self-control lead with clarity and purpose (Goleman et al., 2013).
Social consciousness	The ability to recognize and understand the emotions of others and demonstrate empathy. According to DDI research, leaders who demonstrate empathy demonstrate over 40% better performance in coaching, engagement, and decision-making (DDI, 2021).
Relationship Management	The ability to communicate effectively, resolve conflict, inspire and influence others is one of the cornerstones of effective leadership.

Source: Compiled by the author based on (3-7)

3. Empirical data: results of meta-analysis

3.1. Fundamental research on leadership effectiveness

A 2024 meta-analysis by Narendran et al. confirms a strong positive correlation between emotional intelligence and leadership effectiveness (Narendran et al., 2024). The study includes dozens of empirical studies published between 2016 and 2023 and shows that emotional intelligence plays a critical role in leadership success.

A landmark cross-cultural meta-analysis published in 2018 found that leaders' emotional intelligence exerts an additional and independent influence on employee task performance and organizational citizenship behavior, after five core personality traits and cognitive abilities (Miao et al., 2018). This study also examined cross-cultural differences, revealing that leaders' emotional intelligence exerts a stronger influence in collectivist, feminist, and uncertainty-avoidant cultures. This finding is directly relevant to the Azerbaijani context, which is characterized by a high power distance index (PDI).

The most recent systematic literature review, published in January 2025, critically examines the relationship between emotional intelligence and transformational leadership. All studies confirm that the higher the level of emotional intelligence, the more effective leaders will be (MDPI, 2025).

3.2. Quantitative indicators and results of the company's activities

Empirical research demonstrates the link between emotional intelligence and specific, measurable business results:

Indicator	Conclusion
Difference in performance	Efficiency associated with EZ methods explains 58% of success (TalentSmart).
Team performance	15-25% growth for EZ market leaders (McKinsey, 2023)
Employee engagement	20% increase in engagement with high EZ levels (McKinsey, 2021)
Changes in staff	Reduction in turnover by 50% (WEF, 2020; McKinsey, 2023)
Changes to Success	The probability of success is 2.5 times higher (McKinsey, 2023).
Salary difference	Earn \$29,000 More Per Year (TalentSmart, VEF)

Source: Compiled by the author based on (11-15)

4. Examples from real-life practices of organizations

4.1 Microsoft: Satya Nadella's Transformation

Since Satya Nadella's appointment as CEO of Microsoft in 2014, his emotional intelligence-driven leadership approach has radically transformed the company's culture and performance. Nadella's empathetic leadership style is rooted in listening, understanding, and valuing employees' contributions. From 2014 to mid-2021, Microsoft's market capitalization grew from \$300 billion to \$2.5 trillion. This result is directly linked to his emotional intelligence-driven leadership strategy (HBS, 2023).

4.2. PepsiCo: Investing in Emotional Intelligence

Under former CEO Indra Nooyi, PepsiCo focused on emotional intelligence in its leadership development programs. Leaders were trained in self-management, empathy, and social skills. The result was a 10 percent increase in productivity, a significant increase in employee engagement, and an 87 percent reduction in leadership turnover (Aura AI, 2025).

4.3. Google: Project Aristotle

Google's Project Aristotle study examined the factors that determine team effectiveness. The study found that psychological safety—a key outcome of emotionally intelligent leadership—is the most important factor in team success (Google Research, 2017).

5. Empirical analysis of companies from Azerbaijan

While most contemporary management research focuses on Western economies, recent years have seen a growing number of empirical studies examining the business environment in Azerbaijan. This section summarizes the findings of three important empirical studies relevant to the Azerbaijani context.

5.1. Post-Soviet Context of Azerbaijan: Framework for Leadership

Azerbaijan gained independence in 1991 and rapidly accelerated its economic diversification. The signing of the "Deal of the Century" in 1994 necessitated a synthesis of Western work culture models with the local mentality. Research using Hofstede's cultural dimensions model shows that Azerbaijan exhibits a cultural profile characterized by high power distance (PDI), strong uncertainty avoidance (UAI), and collectivist values. Miao et al. (2018) demonstrated that the positive impact of leaders' emotional intelligence on employee performance is stronger in such cultures—this finding provides an important starting point for leadership research in Azerbaijan.

5.2. Leadership in the logistics sector: research by Novruzov (2024).

Among local academic studies of leadership styles in Azerbaijan, the work of Novruzov (2024) is particularly noteworthy. Published in the Open Journal of Business and Management, the author examined a company in the logistics and trade sector in Azerbaijan. The study, which employed a mixed methodology—a survey of 43 employees and interviews with three senior managers—revealed significant findings.

Key findings of the study:

- The company studied is dominated by a transactional management style motivated by financial incentives. This finding reflects the economic realities of Azerbaijan—employees prioritize income stability over alternatives to the greatest extent possible.
- The highest level of commitment to continuing work was observed among employees, that is, they prefer to stay with the company due to the high opportunity costs associated with leaving (economic situation, general conditions in the labor market).
- The components of transformational leadership are relatively rare; however, leaders who exhibit a transformational style are able to generate significantly higher emotional commitment (voluntary commitment) in employees.
- Azerbaijan's post-Soviet cultural context—power distance, respect for hierarchy, and informal individualism—has a significant impact on leadership dynamics.

The author concludes that emotional intelligence competencies—especially empathy, social awareness, and relationship management—are key mechanisms for developing transformational leadership in the Azerbaijani context. However, this transition is difficult to achieve without integrating financial and incentive structures (Novruzov, 2024).

5.3. Internationalization of SMEs: Mamedov and Wald (2025) Research

The most rigorous international empirical study examining the relationship between emotional intelligence and the work environment in Azerbaijan was published in the journal *Management International Review* by Mammadov and Wald (2025). This study, published by Springer, conducts a structured comparative analysis between Norway (an advanced economy) and Azerbaijan (an emerging economy).

Research methodology:

- A total of 399 owner-managers of small and medium-sized enterprises from Norway and Azerbaijan were surveyed online; the sample from both countries met the same methodological standards.
- For the Azerbaijani portion of the survey, it was translated into Azerbaijani, and a forward and backward translation method was used to verify accuracy. The pilot phase was conducted with 10 small and medium-sized business owners in Azerbaijan.
- In collaboration with a specialized research and consulting firm in Azerbaijan, fully completed questionnaires were collected from 115 small and medium-sized enterprises (response rate: 12.3%). Average size: 53 employees; average international experience: 16 years.
- The influence of cultural intelligence (CQ), emotional intelligence (EQ) and global mindset (GM) on the degree of internationalization (DOI) was measured using structural equation modeling (SEM).

Key findings of the study:

- Both cultural and emotional intelligence statistically significantly predict the degree of internationalization of small and medium-sized enterprise (SME) owners in Azerbaijan. Compared to Norway, the positive impact of emotional intelligence on internationalization in Azerbaijani SMEs is stronger through global mindset (GM).
- Managers of small and medium-sized enterprises in Azerbaijan with high levels of emotional intelligence demonstrate the ability to effectively manage conflicts and misunderstandings arising from cultural differences in international markets. Emotional intelligence is more effective in managing emotional dynamics in foreign markets, and when combined with global intelligence, this sensitivity can be applied to global business practices.
- As several researchers have noted, the lack of high-level skills has been identified as one of the main obstacles to the internationalization of small and medium-sized enterprises in Azerbaijan. The authors emphasize this deficiency as a structural feature of developing economies.

The authors note, given Azerbaijan's status as a developing economy, that due to the weakness of mature market institutions, the emotional competencies of SME managers can partially replace formal institutional mechanisms. This argument suggests that emotional intelligence is of greater strategic importance in transition economies such as Azerbaijan (Mammadov and Wald, 2025).

5.4. PASHA Bank: An example of investment in human capital in Azerbaijan

The management approach of PASHA Bank, a leading corporate financial institution in Azerbaijan, can be seen as a practical example of a leadership culture based on emotional intelligence. Recognized as the "Best Bank in Azerbaijan" by Euromoney magazine in 2025, PASHA Bank is an important empirical example in terms of both institutional effectiveness and human capital management strategy (Euromoney, 2025).

The Bank's approach to human capital management is based on the following elements:

- Zibeyda, appointed Chief Human Resources Officer (CHRO) in 2024, focused her leadership philosophy on "strengthening teams, supporting organizational effectiveness, and creating a culture of inclusive development" (PASHA Bank, 2024). This philosophy directly reflects the relationship management component proposed by Goleman.

- The bank's team consists of more than 1,425 qualified professionals; internationally, it includes representative offices in Georgia and Turkey. This scale elevates the requirements for emotionally competent leadership beyond national standards.

- The increase in net profit from 199.5 million manat (2023) to 210.5 million manat in 2024, return on equity reaching 24.2%, as well as the growth of the loan portfolio by 16.5% to 3.3 billion manat indicate that the effectiveness of corporate governance is reflected in the figures (Euromoney, 2025).

It's worth noting that there is currently no formal, longitudinal study publicly available measuring the specific, independent impact of PASHA Bank's emotional intelligence development programs on employee performance. However, the bank's demonstrated institutional success—particularly in terms of talent retention—can be attributed to the potential contribution of an emotionally intelligent leadership environment.

5.5. Leadership Environment in Azerbaijan: A Comparative Context

A comparative analysis of the results of the above-mentioned empirical studies using Hofstede's concept of cultural dimensions allows us to more accurately characterize the working environment in Azerbaijan:

Cultural feature	Azerbaijan in context	Conclusion for EZ
Long Power Displacement (PDI)	High respect for the leader's status; hierarchical approach to decision making.	Leaders need to make more of an effort to show empathy.
Collectivism	Group cohesion is at the forefront; the feeling of oneness is very strong.	The social awareness component of the EZ program produces the best results.
High Uncertainty Avoidance (UAI)	Stress during periods of change is difficult to control.	The strategic role of the self-government component is increasing.
Conditions of economic transition	Building Commitment to Sustainable Development through Financial Motivation	Emotional intelligence can influence not only financial incentives but also emotional commitment.

Source: Compiled by the author based on the works of Miao et al. (2018), Novruzov (2024) and Mammadov and Wald (2025)

A meta-analysis by Miao et al. (2018) found that leader emotional intelligence has a stronger positive impact on employee performance in collectivist, feminist, and high-uncertainty-avoidance cultures. This finding suggests that the Azerbaijani workplace is a particularly favorable context for emotional intelligence-based leadership. It is worth noting that this structural factor also requires overcoming additional negative behavioral tendencies for transformational change. Thus, developing an economic zone in Azerbaijan presents both great potential and significant challenges.

6. The Relevance of Emotional Intelligence in the Modern Work Environment

6.1. Hybrid Business Model and Virtual Leadership

A 2024 McKinsey report emphasizes the importance of empathic leadership to ensure clear communication and trust in the digital environment (McKinsey, 2024). Leaders with high emotional intelligence bridge these gaps through empathy and active listening, maintaining trust and engagement even in a remote work environment. In the Azerbaijani context, the spread of the hybrid business model following COVID-19 has necessitated a change in leadership style in local companies.

6.2 Technological Change and the Age of Artificial Intelligence

As artificial intelligence and automation transform the workplace, emotional intelligence becomes even more crucial. A McKinsey report estimates that demand for social and emotional skills in the United States will grow by 26% by 2030 (McKinsey, 2020). This trend is becoming increasingly important for the local market as technological transformation accelerates under Azerbaijan's "Digital Azerbaijan" strategy.

6.3. Inclusion, Diversity and Mental Health

In 2025, organizations will increasingly focus on inclusion, diversity, and employee well-being. Emotional intelligence plays a key role in all of these areas. McKinsey research consistently shows that companies with diverse workforces are more likely to outperform their less diverse peers financially (McKinsey, 2023). In the Azerbaijani context, Mammadov and Wald (2025) emphasize the strategic role of emotional competencies, which can partially compensate for informal institutional mechanisms in this developing economy.

7. DEVELOPING EMOTIONAL INTELLIGENCE: PRACTICAL STRATEGIES

One of Goleman's key findings is that emotional intelligence is a skill that can be learned and developed. This principle is particularly important for leadership development programs in Azerbaijani companies.

7.1. Increasing self-awareness

- Mindfulness practice and meditation
- Receive regular feedback from colleagues and mentors.
- Identifying patterns in emotional responses through journaling.
- Understanding your values and sources of motivation

7.2 Strengthening empathy

- Using active listening techniques
- Asking open-ended questions
- Recognition and respect for diverse points of view
- Investments in the personal and professional development of team members.

7.3 Recommendations specific to the Azerbaijani context

The results of Novruzov's (2024) study serve as the basis for a number of specific recommendations for companies in Azerbaijan:

- By developing emotional intelligence components from within without eliminating transactional leadership structures—especially an empathic approach to individual problems and the practice of providing developmental feedback—this hybrid approach fits the economic realities of the Azerbaijani environment.

- Creating channels that guarantee anonymity (digital surveys, 360-degree assessment systems) to foster a culture of bottom-up feedback in conditions of high power distance.

- For small and medium-sized enterprises seeking to enter international markets, Mammadov and Wald (2025) particularly recommend the combination of emotional intelligence and global thinking as a priority development area: together, these two competencies are a greater predictor of the degree of internationalization.

7.4. Implementation at the organizational level

- Incorporating EZ modules into leadership development programs
- Professional coaching and mentoring programs
- Assessing emotional intelligence in the recruitment process
- Creating a corporate culture that supports emotional intelligence.

8. CONCLUSION

The presented empirical data and meta-analysis convincingly confirm the crucial role of emotional intelligence in the effectiveness of modern leadership. In the 30 years since Daniel Goleman introduced this concept in 1995, hundreds of studies have proven that emotional intelligence is more important than IQ and technical skills for achieving leadership success.

In the Azerbaijani context, the empirical studies reviewed in this article—Novruzov (2024) and Mammadov and Wald (2025)—identify unique characteristics of the local work environment. High power distance, collectivist values, high uncertainty avoidance, and the dominance of financial motivation are factors that may hinder the direct transfer of global research findings on economic stability to the Azerbaijani context. At the same time, the fact that a meta-analysis by Miao et al. (2018) found that leader emotional intelligence has a stronger impact in collectivist cultures with a high uncertainty index points to a potential opportunity for Azerbaijan: the right leadership development strategies can leverage local cultural dynamics to achieve better results.

Future research should further explore how emotional intelligence can respond to the new challenges of the era of artificial intelligence and automation, as well as the specifics of its cultural adaptation in transition economies such as Azerbaijan. Comparative longitudinal studies systematically covering Azerbaijani companies remain a key priority in this area.

Bibliography

1. Coronado-Maldonado, I., & Benítez-Márquez, M. D. (2023). Emotional intelligence, leadership, and work teams: A hybrid literature review. *Heliyon*, 9(10), e20356. <https://doi.org/10.1016/j.heliyon.2023.e20356>
2. DDI. (2021). *Global Leadership Forecast 2021*. Development Dimensions International.
3. Euromoney. (2025). Awards for Excellence national winners 2025: Azerbaijan's best bank — PASHA Bank. Euromoney.

<https://www.euromoney.com/article/aa93h19cm74kw444wkcw4wwco/awards/awards-for-excellence/awards-for-excellence-national-winners-2025-azerbajians-best-bank-pasha-bank>

4. Gerhardt, K., Bauwens, R., & van Woerkom, M. (2026). *Emotional Intelligence and Leader Outcomes: A Comprehensive Review and Roadmap for Future Inquiry*. *Human Resource Development Review*. <https://doi.org/10.1177/15344843251342689>

5. Goleman, D. (1998). What makes a leader? *Harvard Business Review*, 76(6), 93-102.

6. Goleman, D. (2004). What makes a leader? *Harvard Business Review*, 82(1), 82-91.

7. Goleman, D., & Cherniss, C. (2024). *Optimal leadership and emotional intelligence. Leader to Leader*, 2024(113), 15-22. <https://doi.org/10.1002/ltl.20813>

8. Goleman, D., Boyatzis, R., & McKee, A. (2013). *Primal leadership: Unleashing the power of emotional intelligence*. Harvard Business Press.

9. Google Research. (2017). *Project Aristotle: Understanding team effectiveness*. Google Inc.

10. Harvard Business School. (2023). *Emotional intelligence in leadership: Why it's important*. HBS Online. <https://online.hbs.edu/blog/post/emotional-intelligence-in-leadership>

11. López González, J., Fernández Espinosa, V., & Ortiz de Montellano, S. (2024). *Study of emotional intelligence and leadership competencies in university students*. *Cogent Education*, 11(1), 2411826. <https://doi.org/10.1080/2331186X.2024.2411826>

12. Mammadov, A., & Wald, A. (2025). *The role of cultural intelligence and emotional intelligence in the internationalization of SMEs: Does global mindset matter?* *Management International Review*, 65(1), 115-144. <https://doi.org/10.1007/s11575-024-00561-5>

13. McKinsey & Company. (2020). *The future of work after COVID-19*. McKinsey Global Institute.

14. McKinsey & Company. (2021). *Psychological safety, emotional intelligence, and leadership in a time of flux*. McKinsey Quarterly.

15. McKinsey & Company. (2023). *The state of organizations 2023*. McKinsey & Company.

16. McKinsey & Company. (2024). *Reimagining the office and work life after COVID-19*. McKinsey & Company.

17. MDPI. (2025). *A systematic literature review on the relationship between emotional intelligence and transformational leadership — A critical approach*. *Behavioral Sciences*, 5(1), 4. <https://doi.org/10.3390/bs5010004>

18. Miao, C., Humphrey, R. H., & Qian, S. (2018). *A cross-cultural meta-analysis of how leader emotional intelligence influences subordinate task performance and organizational citizenship behavior*. *Journal of World Business*, 53(4), 463-474.

19. Narendran, S., Jaiswal, R., Rekha, S., Rai, P., Haralayya, B., Yadav, A. S., & Mishra, A. K. (2024). *Exploring the impact of emotional intelligence on leadership effectiveness: A meta-analysis in management studies*. *Educational Administration: Theory and Practice*, 30(4). <https://doi.org/10.2139/ssrn.5000233>

20. Novruzov, S. (2024). *The impact of leadership styles on organizational commitment: A study in the trading and logistics company in Azerbaijan*. *Open Journal of Business and Management*, 12, 3572-3622. <https://doi.org/10.4236/ojbm.2024.126196>

21. PASHA Bank. (2024). *About us*. PASHA Bank OJSC. https://www.pasha-bank.az/about_us/lang,en/

22. Salovey, P., & Mayer, J. D. (1990). *Emotional intelligence. Imagination, Cognition and Personality*, 9(3), 185-211.

23. TalentSmart. (2023). *Emotional intelligence statistics and research*. TalentSmart.

24. World Economic Forum. (2020). *The Future of Jobs Report 2020*. World Economic Forum.

CURRENT STATUS OF AGRICULTURE AND INNOVATION ACTIVITIES IN AZERBAIJAN

*Sevinc İbrahimova**Associate Professor of Odlar Yurdu University, Baku, AZ, 1072, Azerbaijan
<https://orcid.org/0009-0004-3670-2132>**Mayil Orujov**Honorary Professor of SMBS (Swiss Montreux Business School),
Odlar Yurdu University, Baku, AZ, 1072, Azerbaijan
<https://orcid.org/0009-0001-8177-3851>**Azer Orujov**Social Services Agency, Baku, Azerbaijan
<https://orcid.org/0009-0008-5638-8020>**Nermin Orujova**Social Services Agency, Baku, Azerbaijan
<https://orcid.org/0009-0007-1222-4238>**Hafize Aliyeva**Odlar Yurdu University, Baku, AZ, 1072, Azerbaijan***Abstract**

This article focuses on the state of agricultural and innovation activities in the Republic of Azerbaijan. It analyzes key macroeconomic indicators for agriculture in 2019-2024 and compares these indicators with previous years.

The article also examines the role and main forms of agricultural innovation in modern conditions, as well as the development of innovation systems in the agro-industrial sector, and explores ways to stimulate innovation. Modern approaches to stimulating innovation are analyzed. In this regard, the selection of priority areas for measures implemented within the framework of innovation policy and their implementation are explained. Progress in the application of innovation in Azerbaijan's agriculture in modern conditions is also analyzed, as well as the development of incentive mechanisms implemented in this area.

Based on this research, the article outlines paths for the innovative development of the Republic's economy.

Keywords: *agriculture, agrarian policy, innovative development, industry, agrarian industrial complex, investment, gross domestic product, population consumption, agrarian food market.*

Introduction

The expansion of globalization processes makes the solution of the problems of ecologically clean production and competitiveness in various spheres of the economy, including agriculture, even more urgent. The production of competitive and high-quality local products is mainly ensured by the innovative development of production. In this regard, agriculture, characterized by the diversity of agro-climatic conditions, has a great need for the application of innovations aimed at the economic development. The application of innovative techniques and technologies in agricultural production is mainly associated with the centralized management of science and the dissemination of its achievements among producers. In general, the existence of effective systems for the application of innovations in the agricultural sector is extremely important, since the efficient use of innovative resources has a decisive impact on the sustainable development of agriculture. This requires the organization of scientific activities in the field of innovation and the operation of large-scale innovation transfer systems based on public-private partnerships. The organization of scientific activities and the application of its results in agricultural production necessitate the intensification of measures envisaged in this area. The need for scientific research in agricultural production is determined by the special importance and characteristics of innovative processes in agriculture, the need to create interconnected mechanisms for supporting science and disseminating innovations.

The "Strategic Roadmap for the Production and Processing of Agricultural Products in the Republic of Azerbaijan" devotes special attention to the issues of "transferring the results of scientific research (technologies, new plant varieties and animal breeds, management mechanisms) to farmers through information and advisory services, and the application of scientific achievements and innovations in the agricultural sector" [7].

Discussion

Agricultural production is one of the most important life-sustaining sectors of the national economic complex of Azerbaijan. The food supply and standard of living of the population depend on its condition and economic efficiency.

At the same time, the agricultural sector of the Azerbaijani economy faces global and national challenges that necessitate the renewal of the scientific-information, technical, and technological base of the AIC on a qualitatively new basis. The nature and quality of the systemic challenge are determined by the following set of global and national challenges:

- increasing global competition in the agri-food economy, which includes commodity, service, capital markets, and other components of the economic development of the agri-industrial complex (AIC);*
- low labor productivity in the agri-food sector of the country's economy;*
- inefficient use of means of production, which leads to low efficiency of economic activity of most subjects of the agri-industrial complex (AIC);*
- insufficient level of human capital development in rural areas;*
- The impossibility of solving the problem of providing the population with affordable and high-quality local food products in a volume and structure in accordance with scientifically substantiated nutritional standards defined in the Food Security Doctrine of Azerbaijan by maintaining the current trends in the development of agriculture and state support mechanisms for it.*

Therefore, it is necessary to transition to carrying out agricultural production with progressive technologies and forms. At the same time, the lack of sufficient information, scientific and human resources for the development of agriculture and rural areas is one of the important factors hindering the transition of agriculture to sustainable development. The existing mechanisms currently operating do not contribute to the creation and commercialization of scientific and technical achievements in the agri-food sector and to expanding Azerbaijan's participation in the international scientific research and technology market. The formation of competitive agricultural production is the main goal of the state's agri-food policy.

Ensuring the dynamic development of agriculture in modern conditions is associated with the adoption of innovations in this area. Innovations play a key role in increasing productivity and expanding the production of competitive products based on the renewal of technical, technological and organizational foundations of production in the agrarian sector of the economy. Innovative development of agriculture also creates favorable opportunities for solving sustainable development issues related to activities in the agrarian sector, primarily for the protection and efficient use of land and water resources. In this regard, the widespread dissemination of innovations in agriculture is included in the list of important factors for ensuring food security on a global scale, as well as maintaining ecological balance [1].

Currently, innovative development processes in Azerbaijan's agriculture are being accelerated. At this stage, within the framework of the development strategies of the sector, it is considered an important task to implement necessary measures to develop the potential in terms of expanding the education and research system and application of innovations in the agrarian sector, developing a network of dissemination of innovations, and increasing the level of awareness and use of agricultural producers about the use of innovative technological solutions and methods.

In the long term, the development of the agricultural sector will be associated with further expanding the scope of application of innovations and developing the potential in this direction. In this regard, the study of issues of increasing the innovation potential of the country's agriculture, improving the innovation environment and improving the mechanisms for stimulating the application of innovations is scientifically and practically relevant.

Each innovation applied in the agricultural sector increases productivity, incomes and, as a result, ensures faster development of this sector. In recent years, a number of innovative methods and techniques have begun to be used in the agriculture of Azerbaijan. The use of drones in agriculture, smart gardening, modern sowing methods, organization of modern biological control against pests, growing virus-free seeds and seedlings in biotechnology laboratories, determining the coordinates of the fields and which crops are planted in the field using satellites, etc. can be attributed to this. The Electronic Agricultural Information System implemented by the Ministry of Agriculture of the Republic of Azerbaijan includes information on the business activities carried out by farmers and the production of agricultural products. all processes from the initial stage to the final stage of production will be reflected. This system will also allow achieving many goals. This includes increasing transparency and efficiency in state support of the agrarian sector, innovative support for the implementation of state policy in all directions, ensuring the management and efficient use of lands suitable for agriculture and other natural resources,

increasing the effectiveness of information and advisory services, etc. The creation of a single database in the agrarian sector is a very important factor in the future development and management of this sector.

The role of structural reforms in agriculture in the successful implementation of agrarian policy in our republic is also great. The structural reforms carried out in the agrarian sector of our country involve fundamental changes in the structure of the economic system, the creation of mutually optimal relations between the parts that make up this structure, and thereby increasing the efficiency of agricultural production [2].

It is important to take into account the strategic interests of the state at all stages of reforms in the agricultural sector, since the main goal of implementing these reforms is to ensure the country's food security. When implementing structural changes in the agricultural sector, the seasonal nature of agriculture, the dependence of crop and livestock farming on weather conditions, the low investment attractiveness of agriculture and other factors must be taken into account.

As a result of the systematic structural changes carried out in the agricultural sector in our Republic in recent times, elements of the market mechanism have been formed in the agricultural sector, which is one of the leading sectors of the country's economy, and favorable conditions have been created for free competition and entrepreneurial activity. Structural changes carried out in agriculture show the relationship between all elements of the agricultural sector, production, processing, and product sales. The reforms carried out in the agrarian sector in our country are aimed at eliminating the discrepancies that arose in previous periods between the elements of agriculture, adapting this sector to the newly created economic environment, and, taking into account the specific characteristics of agriculture, creating a favorable production environment to provide the population with food products of the required quality and quantity, and agricultural product processing enterprises with raw materials, providing the agro-food market with agricultural products, and concentrating the available opportunities to solve the problems of the rural population. The reforms carried out are not the goal, but the necessary means to achieve the set goals.

According to the Food and Agriculture Organization of the United Nations (FAO), in the 21st century, food security for the world's population will be carried out mainly in five priority areas based on innovative resources and agricultural technologies:

- Significantly increasing investments in agricultural science and innovative development of agriculture;*
- Increasing the efficiency of the use of land, energy, water and other resources;*
- Improving the use of irrigated lands;*
- Further expansion of breeding and seed production, selection;*
- Implementation of an integrated plant and animal protection system.*

The conclusions and proposals of FAO experts are fully consistent with the basic principles that form the basis of the state's agricultural policy, among which the Decree of the President of the Republic of Azerbaijan No. 3099 dated July 14, 2017 on approval of the "State Program on the Development of Agricultural Cooperation in the Republic of Azerbaijan for 2017-2022", the Decree of the President of the Republic of Azerbaijan No. 640 dated March 2, 2001 on approval of the "Food Security Program of the Republic of Azerbaijan", the "Strategic Roadmap for the Production and Processing of Agricultural Products in the Republic of Azerbaijan", approved by the Decree of the President of the Republic of Azerbaijan on December 6, 2016, are of great importance.

Currently, intensive work is being carried out to develop a strategy for the development of innovation activity and create an innovation system. In our country, the Ministry of Economy has prepared a draft law "On Innovation Activity" and is currently in the process of being agreed upon with other state bodies.

Unfortunately, if 1-2% of the innovative potential of the agro-industrial complex is used in our country, then in Russia it is 4-5%, and in the USA it is 50%. In Azerbaijan, the share of high-tech products in the agro-industrial complex does not exceed 0.3% of the total volume, while in developed countries this figure exceeds 20%.

The economy and business entities of the Republic of Azerbaijan are currently in the process of moving towards an innovative path of development. This process is associated with fundamental changes in socio-political life, as well as in public consciousness in the course of systematic modernization. Modernization, in turn, aims to achieve a certain level of competitiveness, a high standard of living, high human quality, and sustainable socio-economic development rates that ensure positive changes in the mentality of the Azerbaijani people.

Table 1

Main socio-economic indicators of the development of the Republic of Azerbaijan

	<i>Indicators</i>	<i>2019</i>	<i>2020</i>	<i>2021</i>	<i>2022</i>	<i>2023</i>	<i>2024</i>
1	<i>Population (end of year) million people</i>	9974	10026	10063	10127	10191	10222
2	<i>Gross Domestic Product (GDP) Total, million manats.</i>	81896.2	72578.1	93203.2	133972.7	123128.4	126337.0
3	<i>GDP per capita, manat</i>	8247.0	7262.8	9269.3	13292.2	12114.5	12382.5
4	<i>Average annual number of people employed in the economy, thousand people</i>	4786	4721	4831	4901	4963.3	5029.8
5	<i>Nominal income of the population, million manats</i>	57035.0	55726.1	57181.5	68914.6	78050.2	89916.0
6	<i>Average monthly nominal wages of employees, man.</i>	635.1	707.7	732.1	840.0	923.1	996.8
7	<i>Investments in fixed assets, million manats</i>	18539	17226.1	16815.3	17878.2	20296.6	21435.1
8	<i>Fixed assets (at the end of the year) billion manats</i>	227220.6	240694.0	269438.4	269438.4	281691.1	292732.3
9	<i>Trade turnover, million US dollars</i>	33302.7	24464.6	33911.2	52686.5	41187.0	42813.7
10	<i>Export</i>	19635.2	13732.6	22208.0	38146.6	25374.3	24042.0
11	<i>Import</i>	13667.5	10732.0	11703.2	14539.9	15812.7	18771.7
12	<i>Money supply M2 at the end of the year, million manats</i>	18238.6	20305.5	23874.9	29565.6	35371.8	36652.0
13	<i>Retail turnover in million manats</i>	39391.7	40166.5	44217.5	52171.0	58997.7	62202.9

Source: Statistical indicators of Azerbaijan 2025 [3]

The main macroeconomic indicators of the socio-economic development of the Republic of Azerbaijan for 2019-2024 are given in Table 1. As can be seen from the data in Table 1, growth dynamics were observed in almost all indicators of the country's socio-economic development during this period.

During 2019-2024, growth dynamics in Gross Domestic Product (GDP) was evident. Thus, compared to 2019, GDP increased by 44440.8 mln. manat increased to 126337.0 million manat and increased by 1.5 times.

As can be seen from the data in Table 1, the average monthly nominal wages and nominal incomes of the population increased during 2019-2024. During this period, the average monthly nominal wages of the population increased from 635.1 manat in 2019 to 361.7 manat and increased by 996.8 manat in 2024, an increase of 57.0% compared to 2019. The nominal incomes of the population increased by 32881.0 million manat during this period and amounted to 89916.0 million manat in 2024 and increased by 57.7% compared to 2019. We can also see this from the almost identical 57.9% increase in retail trade turnover in 2024 compared to 2019. In 2024, imports of goods increased by 5204.2 million USD, or 37.3%, compared to 2019, while exports increased by 4406.8 million USD, or 22.4%, during this period, industrial production remained at the same level as last year, i.e. the 28.5% increase in trade turnover was mainly due to an increase in imp.

In 2024, the consumer price index in the country increased by 13.9%, and the money supply increased by 2 times. Loans in the banking sector are still very expensive: from 15% to 25% per annum for the real sector, and even higher for small businesses.

Table 2.

Share of local agricultural products, raw materials and agricultural products in the total volume of their resources (by product type), %

Nº	Product name	The threshold of the food security doctrine. %	2015	2020	2021	2022	2023	2024	To the limit of 2024 +;
1.	Wheat	95	54,8	57,1	61.5	56.7	60.4	56.1	-38.9
2.	Potato	95	89,1	90,6	88.8	89.0	89.8	88.8	-6.2
3.	Vegetables (all kinds)	85	103,4	110,4	106.6	106.8	107.2	105.8	+20.8
4.	Fruits and berries	85	113,7	116,3	122.9	123.9	135.5	128.5	+14.8
5.	Milk and dairy products	90	84,3	83,5	84.8	83.3	84.0	83.9	-6.1
6.	Egg	85	99,7	100,0	99.1	100.3	102.2	103.7	+4.0
7.	Flour (all types)	95	95,1	95,4	95.0	93.3	90.4	93.7	-1.3
8.	Sugar	80	192,9	69,4	100.7	103.9	84.4	93.0	+13.0
9.	Sugar confectionery	80	17,8	30,7	34.2	30.6	27.2	35.6	-44.4
10.	Beef and meat products	85	91,8	87,4	91.9	93.0	88.4	88.5	+3.5
11.	Sheep and goat meat.	85	99,3	97,3	98.2	97.0	94.9	96.5	+11.5
12.	Poultry and meat products	85	98,6	79,0	79.6	78.3	81.7	76.6	-8.4
13.	Fish and fish products	80	77,6	81,7	78.2	76.7	75.4	77.3	-2.7
14.	Butter	80	69,2	62,7	66.7	62.0	64.7	69.8	-10.2
15.	Vegetable oil	80	60,5	34,8	73.2	66.7	54.9	55.6	-24.4
16.	Margarine	80	292,2	98,6	99.6	99.3	99.2	97.7	+17.7
17.	Pasta products	95	53,2	42,3	47.2	64.3	73.2	71.1	-23.9
18.	Tea	80	40,2	45,5	89.5	91.1	89.5	87.1	+7.1

Source: Statistical indicators of Azerbaijan 2024

The development of the agro-industrial complex is carried out in accordance with the priority areas provided for in the State Program. In accordance with the State Program, special attention is paid to creating conditions for the development of rural areas, increasing employment and income from entrepreneurial activity of the population, developing cooperation in rural areas, and supporting small business initiatives. The main priority is to maintain the investment attractiveness of agricultural production, primarily through the fulfillment of obligations by the state on attracted and attracting investment loans. The agricultural sector should use existing land and water resources, including natural resources, more sustainably to protect biodiversity and respond to climate change. In order to overcome these challenges and respond to opportunities, the agricultural sector needs to adopt innovative approaches to sustainably increase productivity. Innovation stems not only from technological development, but also from new ways of connecting farmers with the information they need.

Innovation in agriculture encompasses all stages of the production cycle and processes throughout the value chain, from crop production to management of production assets and market access [4].

In recent years, the positive dynamics of agricultural production have led to an increase in the country's food independence in a number of product types - grain, potatoes, vegetable oil and sugar (Table 2).

As can be seen from the data in Table 1, the production of wheat, potatoes, flour, poultry and meat products, butter, vegetable oil, among the main food products included in food security, still lags behind the limits of the food security doctrine, which poses a threat to the country's food security.

A relatively stable situation has been maintained in the agro-food market, which is ensured by the demand for solvency of the population, and this stability has been ensured mainly by imported supplies of agricultural products, raw materials and food products, which constitute almost a third of the consumption of agricultural products.

The share of local products in the structure of population consumption has not increased, and has even decreased from 67.0 percent to 66.0 percent in the last 6 years. The volume of imports of food products and agricultural raw materials amounted to 2.7 billion dollars and was the highest in all previous years.

Table 3.

Gross agricultural output by farm category (in actual prices, million manats)

Nº	Product name	2005	2010	2015	2020	2021	2022	2023	2024
1.	All farm categories, total	1844.8	3877.7	5635.3	8428.9	9163.4	10984.2	12210.6	12995.2
	including: plant growing	988.2	1999.2	2761.1	4028.4	4511.0	5538.0	5933.9	6162.3
	animal husbandry	856.6	1878.5	2874.2	4400.5	4652.4	5446.2	6276.7	6832.9
2.	In agricultural enterprises and other organizations, total	68.8	192.6	410.1	834.5	885.9	1094.0	1351.1	1488.7
	including: plant growing	13.9	60.0	132.5	438.3	467.3	509.2	693.7	818.7
	animal husbandry	54.9	132.6	277.6	396.2	418.6	584.8	657.4	670.0
3.	Individual entrepreneurs, family farms and households, total	1776.0	3685.1	5225.2	7594.4	8277.5	9890.2	10859.5	11506.5
	including: plant growing	974.3	1939.2	2828.6	3590.1	4043.7	5028.8	5240.2	5343.6
	animal husbandry	801.7	1745.9	2596.6	4004.3	4233.8	4861.4	5619.3	6162.9

Source: Statistical indicators of Azerbaijan 2024

As can be seen from the data in Table 3, there was a constant growth dynamics in the gross agricultural product for all economic categories during 2005-2024. Thus. In 2005, the gross agricultural product increased from 1844.8 million manats by 11150.4 million manats to 12995.2 million manats. During these years, the share of crop products in the gross agricultural product in the territory decreased from 53.6% in 2005 to 47.4% in 2024, while the specific weight of livestock products increased from 46.4% to 52.6%.

Table 4.

Key economic indicators of agriculture in Azerbaijan for 2000-2024 (in million manats)

Years	Investments in fixed assets	Commissioning of fixed assets	Total product production
2000	7	21	1061
2001	9	4	1207
2002	19	5	1272
2003	38	11	1367
2004	35	14	1477
2005	41	48	1732
2006	58	37	1970
2007	243	117	2765
2008	337	141	3308
2009	267	120	3566
2010	431	111	3878
2011	437	98	4525
2012	649	234	4845
2013	574	172	5245
2014	364	210	5226
2015	355.5	964.2	5635
2016	325.1	152.7	5632
2017	617.8	326.3	6580
2018	764.4	356.7	7010
2019	769.5	662.0	7837
2020	520.6	491.9	8429
2021	341.9	1196.3	9163
2022	408.0	430.1	10984
2023	578.3	122.7	12210.6
2024	283.1	104.2	12995.2
2024/2000	40.4 times	5 times	12.2 times
2024/2010	0.65	0.94	3.3 times
2024/2015	0.79	0.11	2.3 times

Source: Statistical indicators of Azerbaijan 2024

As can be seen from the data in Table 4, during the years 2000-2024, investments in fixed capital in the agricultural sector increased from 7.0 million manat in 2000 to 283.1 million manat in 2024. During this period, the commissioning of fixed production funds in agriculture increased from 21.0 million manat in 2000 to 104.2 million manat in 2024. The total agricultural output increased by 12.2 times during this period and amounted to 12995.2 million manat. As can be seen from the data in Table 4, investments in fixed capital in agriculture increased from 2009 to 2019 and amounted to 769.5 million manat. manat, and from 2020 it began to decrease and amounted to 283.1 million manat in 2024. During this period, there were decreases and increases in the commissioning of fixed production funds. Thus,

the increase in fixed production funds increased until 2021 and after constituting 1196.3 million manat in 2021, it began to decrease and already fell to 104.2 million manat in 2024. Despite the decrease in investments in agriculture and fixed funds commissioned during this period, the gross agricultural product has always shown a growth rate.

The increase in the gross agricultural product, despite the decrease in investments directed to this area and the decrease in fixed production funds commissioned, was possible due to the increase in the productivity of agricultural products as a result of intensive development in agriculture as a result of the use of innovative methods in agriculture, which is an indicator of the use of innovations in agriculture in our country.

The most difficult situation remains in animal husbandry, especially in cattle breeding (Table 5).

Table 5

Production of livestock products by farm categories, thousand tons

	Göstəricilər	2003	2013	2020	2021	2022	2023	2024
Ətin növlər üzrə istehsalı, kəsilmiş çəkiddə, təsərrüfat kateqoriyalarına üzrə, min ton								
1	Across all farm categories - Total	185.6	286.9	346.0	357.6	368.2	379.7	386.3
	Including:							
	Beef	92.0	120.8	143.1	145.0	148.6	152.8	152.9
	Sheep and goat meat	54.1	70.9	87.0	87.7	89.0	88.9	89.7
	Pork	2.1	0.7	0.5	0.5	0.5	0.5	0.5
	Poultry meat	37.4	94.5	115.4	124.4	130.1	137.5	143.2
2	On agricultural enterprises	11.7	56.7	52.7	60.2	65.3	63.3	65.8
	Beef	0.5	1.1	2.5	3.3	2.8	3.4	2.0
	Sheep and goat meat	0.3	0.4	0.6	0.7	0.3	0.4	0.4
	Pork	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Poultry meat	10.8	55.2	49.6	56.2	62.0	59.5	63.4
3	Individual entrepreneur, family village. By household	173.9	230.2	293.3	297.4	302.9	316.4	320.5
	Beef	91.5	119.7	140.6	141.7	145.8	149.4	150.9
	Sheep and goat meat	53.8	70.5	86.4	87.0	88.5	88.5	89.3
	Pork	2.0	0.7	0.5	0.5	0.5	0.5	0.5
	Poultry meat	26.6	39.3	65.8	68.2	68.1	78.0	79.8
Milk production, by farm category, thousand tons								
4	Across all farm categories	1167.8	1796.7	2192.5	2223.4	2264.7	2284.0	2298.5
	Agricultural enterprises	6.3	32.6	96.9	89.8	103.1	106.4	102.5
	Individual entrepreneur, family farmer and household	1161.5	1764.1	2095.6	2133.6	2161.6	2177.6	2196.0

Source: Statistical indicators of Azerbaijan 2024

For 2003-2024, the growth dynamics of meat and dairy production in all categories of farms showed a positive trend. While the share of agricultural enterprises in the total share of meat products in all farm categories was 17.0%, this figure was 83.0% for individual entrepreneurs and households. For dairy products, these percentages were 4.4% for agricultural enterprises and 95.6% for individual farms.

Agricultural innovation is the process of introducing new or existing products, processes or organizational methods into use in a specific context for the first time in order to contribute to food security, economic development and sustainable management of natural resources by increasing the operational efficiency, competitiveness, resilience to shocks or environmental sustainability of individual economic entities or organizations/institutions [4]

Agricultural innovations include new or improved inputs and methods used in agricultural production. Examples include a new type of seed, a new type of fertilizer, and a new method of soil management. These are all factors and applications that increase production or efficiency. Agricultural innovation generally results from the dynamic interactions between multiple actors involved in the production, processing, packaging, distribution, and consumption or other use of agricultural products [5].

Agricultural innovations typically include one or more of the following areas [6]:

- Breeding - includes new varieties and hybrids of agricultural crops, new breeds, animal species, and birds, and the selection of plants and animals resistant to diseases and pests.

- Management practices - management of changes in production regimes and other management related to agricultural activities: land ownership and inheritance; plot size; availability of labor; transition to surplus production, etc.

- The digitalization of agriculture is considered the fourth revolution, expressed in the broad application of digital technologies and data in the agricultural sector.

The Agricultural Innovation System (AIS) approach includes a number of conditions and relationships that promote innovation in agriculture [5].

An Agricultural Innovation System (AIS) is a network of organizations, enterprises and individuals aimed at the use of new products, new processes and new organizational forms, together with institutions and policies that influence their behavior and activities [5]. That is, it is the rules by which different agents interact, acquire, share, exchange and use information. AIS consists of four main components:

- research and education,
- trade and enterprises,
- bridging institutions
- enabling environment.

Table. 6.

Defining Characteristics of the Agricultural Innovation System

Defining features	Feature content
Purpose	Strengthening the capacity to innovate throughout the agricultural production and marketing system
Participants (actors)	All potential participants in the public and private sectors involved in the creation, dissemination, adaptation and use of all types of knowledge related to agricultural production and marketing
Conclusion	a combination of technical and institutional innovations across production, marketing, policy research, and enterprise sectors
The principle of organization	New uses of knowledge for social and economic change
Innovation mechanism	Interactive learning
Quality of capacity building	Strengthening interactions between participants (actors); institutional development and change to support interaction, learning and innovation; creating an enabling environment.

As the context of agricultural development has changed, ideas about what constitutes innovation have changed and, accordingly, approaches to investment have changed. In the context of agricultural development, ideas about creating "research capacity" have developed alongside approaches to investing in the capacity to innovate.

The defining characteristics of AIS are listed in Table 6 below..

The legislation of the Republic of Azerbaijan reflects provisions aimed at stimulating innovation activity. At the same time, the issues of promoting and supporting innovation activity are reflected in the relevant state programs and documents on strategic development.

The "Strategic Roadmap for the Perspective of the National Economy of the Republic of Azerbaijan", approved by the Decree of the President of the Republic of Azerbaijan "On Approval of Strategic Roadmaps for the National Economy and Key Sectors of the Economy", defines a number of measures related to innovation policy and the establishment of an innovative economy. This document defines innovation activity as the main driving force for increasing labor productivity and competitiveness in the fields of production and management, ensuring continuity in the development of human capital, and it is intended to pay attention to the importance of this activity when preparing action plans and state programs that will stimulate the promotion of innovation in the country [7].

In the "Azerbaijan 2030: National Priorities for Socio-Economic Development" approved by the Decree of the President of the Republic of Azerbaijan dated February 2, 2021, the formation of a competitive human capital and a modern innovation space is included among the main priorities to be implemented in the next decade [8].

As already mentioned, selection work in the agricultural sector is an important direction of innovations. According to the current legislation, in Azerbaijan, selection work, production of original, super-elite and elite seeds are carried out in experimental farms of scientific research and educational institutions under the control of the variety author or patent holder. Plant varieties produced in the country and imported into the country are registered in the "State Register of Selection Achievements Allowed and Protected for Use in the Production of Agricultural Products in the Territory of the Republic of Azerbaijan". Currently, the State Register contains 1,753 varieties, hybrids and breeds of agricultural plants, including 455 of cereals, cereal legumes, technical and fodder crops, 877 of vegetables, melons and root crops, 378 varieties/hybrids of fruits, berries, decorative flowers and ornamental plants, 3 breeds of sheep and 40 hybrids/breeds of silkworms.

The share of local varieties in the total number of new varieties and hybrids registered in 2019 was 10.7 percent, and in 2024 it was 8.1 percent.

In 2019, 28.6 tons of original seeds were produced in the country, and in 2024, 43.8 tons. Currently, in Azerbaijan, in addition to traditional selection, the cultivation of seeds and seedlings using the in vitro method has begun. In 2021, the Biotechnology Laboratory of the Scientific Research Institute of Fruit Growing and Tea Growing of the Ministry of Agriculture in Guba began the in vitro propagation of blueberry and tea plants for the first time. In 2021, 5 types of rootstocks of stone fruit plants were also propagated in vitro. Although such rootstocks have been imported to the country since 2003, their production was first started by the Scientific Research Institute of Fruit Growing and Tea Growing.

A modern biotechnology laboratory is also operating at the Scientific Research Institute of Vegetable Growing to obtain virus-free mini-tubers of potatoes in vitro. In 2021, potato seed materials were obtained by the Scientific Research Institute of Vegetable Growing using the in vitro method.

Currently, support measures are being implemented by the state to stimulate the production of agricultural products using innovative methods. Thus, in order to expand the application of modern water-saving irrigation systems, the current subsidy rules stipulate the application of these systems for intensive gardens as a condition. At the same time, in order to compensate for a certain part of the investment costs of farmers for the installation of modern irrigation systems, 40% of the cost of the equipment is subsidized by the state. Modern irrigation infrastructure has been created on approximately 75 thousand hectares of arable land in the country. A discount of 20.5 million manat was applied for this purpose in 2024.

Also, a 40% discount is applied by the state to the sale of drones, robotics and technological equipment for smart management intended for use in agriculture.

At the same time, in order to promote the innovation environment in the country and expand the scope of innovation activities, according to Article 102.1.31 of the Tax Code, the income of startups that are micro or small business entities and operate as individual entrepreneurs from innovation activities is exempt from income tax for 3 years from the date they receive the "Startup Certificate" [8].

In general, the country produces innovative products. The organization and implementation of the system is a field that requires high investment. In addition, the application of innovative approaches is considered to be a financially intensive as well as a science-intensive field. However, in the future, sustainable development of the agrarian sector in Azerbaijan will be possible precisely through the application of innovative technologies. From this point of view, the expansion of the application of innovative technologies in the context of agricultural producers is directly related to state support. In other words, the development of the agrarian sector in the country through the application of innovative technologies depends on the incentive measures implemented by the state in this area [10].

According to the research conducted, it is advisable to implement state support measures in the following areas to stimulate the expansion of the application of innovations in the agrarian sector in Azerbaijan.

Creation of an agro-innovation park

It is intended to create a single space in the country for the state, academic institutions and the private sector to work together for the purpose of applied research and economic development. For governments, innovation parks are a tool for economic development. For the private sector, innovation parks are a tool that minimizes labor and capital costs, and allows them to use highly qualified employees and researchers of universities, physical and laboratory facilities. For academic institutions, innovation parks are a tool for obtaining grants from the government and the private sector to finance research [11]. All three parties are interested in reducing costs by working closely with each other.

There are three forms of state intervention in innovation parks:

- Science policy*
- Technology policy*
- Innovation policy*

The main focus of science policy is new scientific discoveries, and the state regulates the implementation of this policy through such means as research funds, tax breaks for entrepreneurs, higher education and intellectual property rights.

Technology policy is broader than science policy and is aimed at improving and commercializing sectoral technical knowledge. The state achieves these goals through public procurement, state aid to strategic sectors, employment and professional skills development, standardization, and the provision of performance measurement tools to industrial sectors.

Innovation policy, which is a combination of science and technology policies, aims to develop the overall innovative performance of the economy. Innovation policy aims to create synergy between

corporate law, competition regulation, consumer rights protection, which shape industrial policy, and education, labor, and the environment [12].

Increasing the use of innovative technologies that increase efficiency in the production of agricultural products (plowing, sowing, harvesting, storage, transportation, etc. operations) includes the implementation of incentive measures by the state to stimulate the application of new techniques and technologies in the production process, especially to accelerate the transition to intensive farming methods. Incentive measures include the provision of information and advisory services to farmers on the introduction, use, and benefits of new techniques and technologies, the provision of certain benefits for the acquisition of these techniques and technologies, and the formation of a service sector in the field of application of innovative technologies. This could also include the creation of model farms through the application of innovative technologies.

Conclusion

The application of innovations in agriculture is one of the main factors determining the dynamic development of the agrarian sector. Agrarian innovations also play an important role in terms of the implementation of the principles of sustainable development.

The innovative development of agriculture is a science-intensive process that also requires large investments. In this regard, there is a need to create an innovation environment in the agrarian sector of the country's economy, increase accessibility to innovative techniques and technologies, and accelerate adaptation to new technologies [14].

In the indicated directions, at the current stage, stimulating the application of innovative technologies in irrigation, as well as the use of drones and other innovative tools through a subsidy mechanism, providing tax breaks to startups operating in the field, and organizing information and advisory services related to the dissemination of innovations have the potential to have a significant impact.

At the same time, it is advisable to expand the scope of state support measures in terms of accelerating the innovative development of agriculture. Taking into account relevant world experience, the main directions of measures to be implemented in this area include, first of all, supporting the creation and operation of agro-innovation parks, promoting the expansion of the scope of application of NDVI technologies, and strengthening the stimulation of the use of innovative technologies that increase the efficiency of operations in the production of agricultural products.

References

1. 4. Orucov M.M, Modern development model of the national economy, Scientific and Pedagogical News of Odar Yurdu University, 2020, № 54, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
2. S.R. İbrahimova. Diversification of the non-resource sector of the economy of the Republic of Azerbaijan based on sustainable development and analysis of the experience of foreign countries in this area. I international scientific conference, **Brussels. Belgium. 15-16.04.2025**, ISBN 978-91-65424-16-6 DOI <https://doi.org/10.5281/zenodo.15256023>
3. Azərbaycan Respublikası Dövlət Statistika Komitəsinin 2025-ci il üzrə məlumatları.
4. [FAO, 2018. FAO's work on agricultural innovation, Sowing the seeds of transformation to achieve the SDGs 20 pages, pp.5.](#)
5. [World Bank. 2012. Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank , Azərbaycan 2030: sosial-iqtisadi inkişafa dair Milli Prioritetlər](#)
6. M.M. Orucov. Azerbaijan's economy in the new international realities. II international scientific conference. Helsinki. Finland. 29-30.05.2025, ISBN 978-92-44514-56-6 DOI <https://doi.org/10.5281/zenodo.15622437>
7. "Azərbaycan Respublikasının milli iqtisadiyyat perspektivi üzrə Strateji Yol Xəritəsi", 2016.
8. "Azərbaycan 2030: sosial-iqtisadi inkişafa dair Milli Prioritetlər"
9. [Azərbaycan Respublikasının Vergi Məcəlləsi, Bakı 2000.](#)
10. M. Orucov, S.R. İbrahimova. Evaluation of the membership process of the Republic of Azerbaijan to the world trade organization, XIII international scientific conference. Toronto. Canada.14-15.01.2025. ISBN 978-91-65424-03-6 DOI <https://doi.org/10.5281/zenodo.14699449>
- 11.M. Orucov, S.R. İbrahimova. Impact of the oil and gaz industry on the economy of the Azerbaijan Republic. XV international scientific conference. Vienna. Austria. 16-17.01.2025. ISBN 978-92-44514-37-5 DOI <https://doi.org/10.5281/zenodo.147182310>

12. M. Orucov, S.R. İbrahimova. ÜTT-yə üzlük ərəfəsində Azərbaycanın aqrar-ərzaq bazarının hazırlıq səviyyəsinin qiymətləndirilməsi, OYU-nin Elmi və Pedaqoji xəbərləri, 2023, № 62, ISSN: 1682-9123
13. M. Orucov, S.R. İbrahimova, Diagnostiks of the main therats to agro-food industry and food safety. OYU-nin Elmi və Pedaqoji xəbərləri, 2020, № 58, ISSN: 1682-9123
14. M. Orucov, S.R. İbrahimova. Milli aqrar sahədə struktur dəyişikliklərinin təhlili və idxaldan asılılığın qiymətləndirilməsi, OYU-nin Elmi və Pedaqoji xəbərləri, 2023, № 62, ISSN: 1682-9123
15. Orucov M.M. İbrahimova S.R. G7 and BRICS+: Economic growth efficiency. V international scientific conference. Bern, Switzerland, ISBN 978-91-65424-58-6 DOI <https://doi.org/10.5281/zenodo.18547764>
16. Orucov M.M. Directions for improving the new insurance consortium for the development of agricultural leasing in the Republic of Azerbaijan, Scientific and Pedagogical News of Odlar Yurdu University, 2018, № 49, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
17. Orucov M.M, The current state of the Azerbaijani economy against the backdrop of changes in the world economy, Scientific and Pedagogical News of Odlar Yurdu University, 2018, № 50, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
18. Orucov M.M, Characteristics of preparatory measures for membership in the World Trade Organization, Scientific and Pedagogical News of Odlar Yurdu University, 2019, № 51, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
19. Orucov M.M. Modernization of marketing improvement in the oil refining industry in Azerbaijan, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 62, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
20. Orucov M.M. Prospects for the development of marketing in the management of market processes in the oil refining sector, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 62, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
21. Orucov M.M. Diagnostics of the agri-food market and main threats to food security in the Republic of Azerbaijan, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 62, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
22. Orucov M.M. Import substitution in the agri-food sector in Azerbaijan, Heydar Aliyev-100. Import substitution, localization of production. Sustainable and preventive development. OYU. Scientific research work
23. Orucov M.M. Fundamentals of National Security of the Republic of Azerbaijan, Textbook -2024
24. Orucov M.M. The Wreath of Victory, a book dedicated to Mr. İlham Aliyev's 20 years as President-2024
25. Orucov M.M. Parameters for long-term forecasting of the world economy, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 63, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
26. Orucov M.M. Azerbaijani economy during İlham Aliyev's presidency: a long way traveled in 20 years, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 63, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
27. Orucov M.M. Theoretical and methodological aspekts, characterizing innovative development of the agricultural industry, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 63, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
28. Orucov M.M. Foreign experience in stimulating the development of innovation activity in agriculture, Scientific and Pedagogical News of Odlar Yurdu University, 2023, № 63, ISSN: 1682-9123 DOI: 10.0318/OYU.2023735552
29. Orucov M.M. The concept of the "energy trilemma" as an expression of the energy aspect of sustainable development of Azerbaijan, International Conference on Smart Environment and green Technologies İCSGET2024, Springer.ISBN978-3-031-81563-8 https://doi.org/10.1007/978-3-031-81564-5_43
30. Orucov M.M. "Green economy" in the Republic of Azerbaijan: prerequisites and directions of development, International Conference on Smart Environment and green Technologies İCSGET2024, Springer ISBN-978-3-031-81567-6 <https://doi.org/10.1007/978-3-031-81567-6>
31. Orucov M.M. Algorithm for determining priority directions of innovative development of agricultural production, XV International Scientific and Practical Conference «New problems of science and

ways of their solution», October 22-23, 2024, Paris. France, ISBN 978-91-65423-91-6. DOI <https://doi.org/10.5281/zenodo.14003470>.

32. Orucov M.M. Analysis of structural change in the national agricultural field and assessment of dependence imports, XV International scientific conference Madrid Spain 29-30/ 10/2024, ISBN 978-91-65423-92-3 DOI <https://doi.org/10.5281/zenodo.14040024>

33. Orucov M.M. Analysis of foreign investment in Azerbaijani economy and directions to increase, XVII International Scientific Conference. Dortmund. Germany. 07-08.11.2024, ISBN 978-92-44514-27-6 DOI <https://doi.org/10.5281/zenodo.14136799>

34. Orucov M.M. Formation of the consumer market in the Republic of Azerbaijan as a factor in ensuring food security, XII International Scientific Conference Beijing China. 12-13.11.2024, ISBN 978-91-65423-94-7 DOI

<https://doi.org/10.5281/zenodo.14178599>

35. Orucov M.M. The role of the consumer market in ensuring food safety of the Republic of Azerbaijan, The scientific heritage No 149 (2024) ECONOMIC SCIENCES, ISSN 9215 — 0365

36. Orucov M.M. Diversification of economy the Republics Azerbaijan on the base sustainable development of non-oil sector, XIV international scientific conference. Toronto. Canada. 14-15.11.2024, ISBN 978-92-44514-28-3 DOI <https://doi.org/10.5281/zenodo.14199182>

37. Orucov M.M. Elements of credit policy and stimulation of credit investments in the real economy, Sciences of Europe (Praha, Czech Republic) No 153 (2024, ISSN 3162-2364

38. Orucov M.M. Efficiency problems of the energy sector of Azerbaijan in the background of the green economy, XVII international scientific conference. Philadelphia. USA. 21-22.11.2024, ISBN 978-92-44514-22-1 DOI

<https://doi.org/10.5281/zenodo.13929032>

39. Orucov M.M. Current status of education in the Republic of Azerbaijan in the context of global education challenges, XII international scientific conferences Roma, Italy. 19-20. 2024, ISBN 978-91-65423-95-4 DOI <https://doi.org/10.5281/zenodo.14218224>

40. Orucov M.M. Increasing the competitiveness of agricultural production, XIX International Scientific Conference. London. UK. 12-13.12.2024, ISBN 978-92-44514-32-0 DOI <https://doi.org/10.5281/zenodo.14518424>

41. Orucov M.M. Priority directions of state regulation of the agricultural and food market, XVI International Scientific Conference Madrid. Spain 17-18 2024, ISBN 978-91-65423-92-3 DOI <https://doi.org/10.5281/zenodo.14040024>

42. Orucov M.M. Concept, theories and legal basis of the succession of states, XIII International Scientific Conference Beijing China. 30-31.12. 2024, ISBN 978-91-65424-01-2 DOI <https://doi.org/10.5281/zenodo.14609837>

43. Orucov M.M. Civil legal contractual relations in the field of entrepreneurial activity in the Republic of Azerbaijan, XVIII international scientific conference - Philadelphia. USA. 09-10.01.2025, ISBN 978-92-44514-36-8 DOI <https://doi.org/10.5281/zenodo.14646632>

44. Orucov M.M. New trends and challenges to the global economy, XIV international scientific conference. Stockholm. Sweden. 21-22.01.2025, ISBN 978-91-65424-04-3 DOI <https://doi.org/10.5281/zenodo.14749265>

45. Orucov M.M. Methods of assessing the impact of education on economic growth, XVIII international scientific conference. Tallinn. Estonia. 23-24.01.2025, ISBN 978-92-44514-38-2 DOI <https://doi.org/10.5281/zenodo.14754776>

46. Orucov M.M. Reducing transaction costs in the digital economy, XVII International Scientific and Practical Conference 28-29. 01. 2025, Paris. France, ISBN 978-91-65424-05-0 DOI <https://doi.org/10.5281/zenodo.14794434>

47. Orucov M.M. Artificial systems in today's economic environment, XIX international scientific conference. Dortmund. Germany. 13-14.02.2025, ISBN 978-92-44514-41-2 DOI <https://doi.org/10.5281/zenodo.14894330>

48. Orucov M.M. Forecast of global economy development, I international scientific conference. Marseille. France. 20-21.02.2025, ISBN 978-92-44514-42-9 DOI <https://doi.org/10.5281/zenodo.14932296>

49. Orucov M.M. Application of money supply targeting regime within the framework of monetary policy, I international scientific conference. Seoul. South Korea. 06-07.03.2025, ISBN 978-92-44514-44-3 DOI <https://doi.org/10.5281/zenodo.15020702>

50. Orucov M.M. *Prospects for the formation of economic multipolarity, I international scientific conference.* Helsinki. Finland. 13-14.03.2025, ISBN 978-92-44514-45-0 DOI <https://doi.org/10.5281/zenodo.15075323>
51. Orucov M.M. *Prospects for international settlements in digital currencies of Central Banks on a platform basis in foreign countries and Azerbaijan, XVIII International Scientific and Practical Conference.* Paris. France. 18-19.03.2025, ISBN 978-91-65424-12-8 DOI <https://doi.org/10.5281/zenodo.15095044>
52. Orucov M.M. *Global dynamics of socially responsible investing (SRI): analysis motivating MNCS to use SRI strategies. XVIII international scientific conference.* Madrid. Spain. 25-26.03.2025. ISBN 978-91-65424-13-5 DOI <https://doi.org/10.5281/zenodo.15115723>
53. Orucov M.M. *Formation of investment climate in the oil and gas industry of Azerbaijan and its impact of the development of the non-oil sector. I international scientific conference.* Singapore. Singapore. 01-02.04.2025. ISBN 978-91-65424-14-2 DOI <https://doi.org/10.5281/zenodo.15165189>
54. Orucov M.M. *Economic effect of foreign direct investments in the oil and gas sector of Azerbaijan. XVI international scientific conference.* Vienna. Austria. 03-04.04.2025. ISBN 978-92-44514-48-1 DOI <https://doi.org/10.5281/zenodo.15181208>
55. Orucov M.M. Ibrahimova S.R., *Mechanisms of international financial relations in the conditions of the globalization crisis, I international scientific conference.* Lisbon. Portugal. 22-25. 2025, ISBN 978-91-65424-17-3 DOI <https://doi.org/10.5281/zenodo.15305608>
56. Orucov M.M., *Digitalization of international settlements: Tradecoin vs US dollar. II international scientific conference.* Sydney. Australia. 15-16.05.2025. ISBN 978-92-44514-54-2 DOI <https://doi.org/10.5281/zenodo.15473751>
57. Orucov M.M., *World trade in the conditions of the globalization crisis, XX international scientific conference.* Philadelphia. USA. 12-13.06.2025, ISBN 978-92-44514-58-0 DOI <https://doi.org/10.5281/zenodo.15691366>
58. Orucov M.M., *Crowdfunding as a financing tool a conceptual analysis, II international scientific conference.* Singapore. SINGAPORE. 17-18.06.2025, ISBN 978-91-65424-25-8 DOI <https://doi.org/10.5281/zenodo.15773933>
59. Orucov M.M., *State Policy on Green Economy in Azerbaijan, II International Conference on Smart Environment and green Technologies ICSGET2025,*
60. Orucov M.M., *Public investment and global economic resilience, II international scientific conference.* Lisbon. Portugal. 08-09.07.2025, ISBN 978-91-65424-28-9 DOI <https://doi.org/10.5281/zenodo.15861641>
61. Orucov M.M., *Energy relocation in the context of the change in the international economic paradigm, XVIII International Conference.* Tokio, Yapan. 10-11.07.2025. ISBN 978-92-44514-58-0 DOI <https://doi.org/10.5281/zenodo.16087743>
62. Orucov M.M. Ibrahimova S.R. *Structural shifts in global production activities of MNCs,, XVI international scientific conference.* Rome. Italy. 29-30.07.2025. ISBN 978-91-65424-31-9 DOI <https://doi.org/10.5281/zenodo.16736662>
63. Orucov M.M. Ibrahimova S.R. *Price mechanisms of the digital economy: divide et impera, III international scientific conference.* Sydney. Australia. 31.07-01.08.2025, ISBN 978-92-44514-61-0 DOI <https://doi.org/10.5281/zenodo.16751595>
64. Orucov M.M. Ibrahimova S.R. *U.S. Protectionism against China's mercantilism. XVI International Scientific and Practical Conference «Questions. hypotheses. answers: science XXI century», August 05-06, 2025, Toronto. Canada. SBN 978-91-65424-32-6 DOI <https://doi.org/10.5281/zenodo.16813182>*
65. 69. Orucov M.M. Ibrahimova S.R. *Wetting of contradictions between China and the prospects for bilateral economic relations. III international scientific conference. "Advancing science with collaborative innovation". Seoul. South Korea. August 07-08. 2025. ISBN 978-92-44514-62-7 DOI <https://doi.org/10.5281/zenodo.16871369>*
66. Orucov M.M. Ibrahimova S.R. Orucov M.M. Ibrahimova S.R. *New trends in the development of the, global economy, XVII international scientific conference Stockholm, Sweden. 12-13.08.2025. ISBN 978-91-65424-33-3 DOI <https://doi.org/10.5281/zenodo.16892861>*
67. Orucov M.M. Ibrahimova S.R. *Entrenchment of neo-protectionism in global economy of XXI century. III international scientific conference.* Helsinki. Finland. 14-15.08.2025, ISBN 978-92-44514-63-4 DOI <https://doi.org/10.5281/zenodo.16912767>

68. Orucov M.M. Ibrahimova S.R. *Fragmentation of global social capital*. XX international scientific conference. Paris. France. 19-20. 2025, ISBN 978-91-65424-34-0 DOI <https://doi.org/10.5281/zenodo.17005326>

69. Orucov M.M. Ibrahimova S.R. "Reserve currencies: Are changes possible?" XXI International Scientific and Practical Conference November 4-5, 2025, Paris, ISBN 978-91-65424-45-6 DOI <https://doi.org/10.5281/zenodo.17574617>

70. Orucov M.M. Ibrahimova S.R. *Changes in Azerbaijan's Energy Efficiency Sector Against the Backdrop of a Green Economy*. The International Journal of Information Technologies and Innovative Economy (IJITIE)

Vol. 1, No. 1, 2025, pp. 35-39,

71. Orucov M.M. Ibrahimova S.R. *Analysis the current state of the world economy and the financial-monetary system and forecast for 2026*. XX international scientific conference. Toronto. Canada. 22.01.2026. ISBN 978-92-44514-86-3 DOI <https://doi.org/10.5281/zenodo.18405372>

72. Orucov M.M. Ibrahimova S.R. *Global dominance of dollar. Theory and prospects*. V international scientific conference. Singapore, Singapore. 27.01.2026. ISBN 978-91-65424-57-9 DOI <https://doi.org/10.5281/zenodo.18469674>

73. Orucov M.M. Ibrahimova S.R. *Current trends in the global economy and the state of the global financial system*. XXIII international scientific conference. Philadelphia. USA. 30.01.2026, ISBN 978-92-44514-87-0 DOI <https://doi.org/10.5281/zenodo.18472454>

Journalism

MASS COMMUNICATION AND POLITICAL DECISION-MAKING: MECHANISMS OF AUDIENCE PARTICIPATION AND GOVERNMENT TRANSPARENCY

Yessenbekova Ulbossyn M.

*Candidate of Philological Sciences, Associate Professor,
L.N.Gumilyov Eurasian National University
Kazakhstan, Astana*

Stambekova Nazym D.,

*Master's Degree Candidate, L.N. Gumilyov Eurasian National University
Astana, Kazakhstan*

Serkebaev Daurenbek Zh.,

*Master's Degree, PhD Candidate, L.N. Gumilyov Eurasian National University
Astana, Kazakhstan*

Amangeldieva Gulmira S.,

*PhD, Senior lecturer
L.N.Gumilyov Eurasian National University
Republic of Kazakhstan, Astana*

Doskeeva Gulnur U.,

*Senior lecturer of the Department of TV, Radio and Public Relations
L.N.Gumilyov Eurasian National University
Republic of Kazakhstan, Astana*

Mutarbek Ardak,

*Senior lecturer of the Department of TV, Radio and Public Relations
L.N.Gumilyov Eurasian National University
Republic of Kazakhstan, Astana*

БҰҚАРАЛЫҚ КОММУНИКАЦИЯ ЖӘНЕ САЯСИ ШЕШІМ ҚАБЫЛДАУ: АУДИТОРИЯ ҚАТЫСУЫНЫҢ ТЕТІКТЕРІ МЕН БИЛІК АШЫҚТЫҒЫ

Есенбекова Ұлбосын Мейірбекқызы,

*филология ғылымдарының кандидаты, қауымдастырылған профессор,
Л.Н. Гумилев атындағы Еуразия ұлттық университеті
Астана, Қазақстан*

Стамбекова Назым Дауталиевна,

*магистрант, Л.Н. Гумилев атындағы Еуразия ұлттық университеті
Астана, Қазақстан*

Серкебаев Дауренбек Жубаевич,

*магистр, PhD докторанты,
Л.Н. Гумилев атындағы Еуразия ұлттық университеті
Астана, Қазақстан*

Амангелдиева Гүлмира Сабырқызы,

*PhD докторы, аға оқытушы,
Л.Н.Гумилев атындағы Еуразия ұлттық университеті
Қазақстан, Астана*

Доскеева Гүлнұр Омарханқызы,

*Телерадио және қоғаммен байланыс кафедрасының аға оқытушысы,
Л.Н.Гумилев атындағы Еуразия ұлттық университеті
Қазақстан, Астана*

Мүтәрбек Ардақ,

*Телерадио және қоғаммен байланыс кафедрасының аға оқытушысы,
Л.Н.Гумилев атындағы Еуразия ұлттық университеті
Қазақстан, Астана*

Abstract

The article analyzes the ways and mechanisms through which a mass audience participates in the adoption of politically significant decisions. It examines the processes of political-economic and social differentiation taking place under the influence of the new media environment.

From a critical perspective, the authors substantiate the need for continuous improvement of the forms of organizing dialogue between mass communication media and social forces. The article also identifies the relationship between the scale of the audience involved in discussing key issues and the quality of the decisions adopted.

The study demonstrates that the formation of mutual trust between the state and the mass audience within the information space creates the conditions for ensuring the transparency of public policy and its alignment with national interests.

Түйін

Мақалада бұқаралық аудиторияның саяси маңызды шешімдер қабылдауға қатысу жолдары мен механизмдері сарапталған. Жаңа медиа ортаның ықпалымен жүріп жатқан саяси-экономикалық, әлеуметтік жіктелу үдерістері талданған.

Бұқаралық коммуникация құралдары мен қоғамдық күштердің арасындағы диалог ұйымдастыру формаларын ұдайы жетілдіріп отырудың қажеттігін авторлар сыни тұрғыда тұжырымдаған. Маңызды мәселелерді талқылауға қатысатын аудитория ауқымы мен қабылданатын шешімнің сапасының өзара байланысы да мақалада анықталған.

Авторлар ақпараттық кеңістіктегі мемлекет пен бұқаралық аудиторияның екіжақты сенімінің нәтижесінде биліктің саясатының ашықтығы мен елдік мүддеге сәйкестігін қамтамасыз етуге болады деген қорытынды жасайды.

Keywords: *mass communication media, media potential, political processes, public consciousness, communication model.*

Түйін сөздер: *коммуникация құралдары, медианың әлеуеті, саяси процестер, қоғамдық сана, коммуникациялық модель.*

KIPICPE

Қазақ елінің ақпараттық нарығы мемлекет пен қоғамдағы процестерден, өзгерістер мен трансформациялардан нақты көрініс береді. Мемлекеттің саяси-экономикалық және әлеуметтік салалардағы дамуы да тұтастай ақпараттық коммуникациялардың эволюциялық бағытын, кәсіби дәрежесін айқындайды. Мемлекеттік бұқаралық коммуникация құралдарымен бәсекеде коммерциялық медиа құралдары да заман талабына сай жұмыс істеу формаларын, технологияларды жақсы меңгергенін көрсетуде. Бұл процестер қоғамның танымы мен талғамының өсуіне жақсы ықпал етері анық.

Елдегі саяси күштер мен қаржылық топтардың қолдарында шоғырланған коммуникация құралдары қоғамдағы саяси-әлеуметтік процестердің ортасында болуға ұмтылып, өз меншік иелерінің мүддесіне барынша пайдалы болуды көздейді. Олардың басты мақсаты – аудиторияның сеніміне ие болу, өздеріне тапсырылған саяси модельдерді насихаттау үшін халықтың санасына әсер ететін тиімді технологиялық әдістерді анықтау және іс жүзінде қолдану.

XXI-ғасырдың басынан бері саяси манипуляцияның әбден жетілдірілген, сынақтан өтіп тексерілген әдіс-тәсілдері қолданылуда және бұндай саяси технологиялар тек электоралды науқандарда адамның саяси санасын бұрмалаумен шектелмейді. Қазіргі PR технологиялар адамдардың күнделікті өмірін, оның әдет дағдыларын зерттеу арқылы да тұлғаны толық басқаруға күш салуда. Болашақта бұқаралық коммуникация құралдары саяси күрестің ең жойқын құралына айналып, өз ықпалын күшейтетін жаңаша әдістемелерді жалпы аудиторияға ғана емес элиталық топтарға да қолданып сынайтын болады. Біздің ғылыми зерттеуіміз бұқаралық коммуникация құралдарының (БКҚ) саяси-экономикалық және әлеуметтік реформаларға деген оң көзқарастарды қалыптастыруда рөлінің өсуін көрсетті.

НЕГІЗГІ БӨЛІМ

Цифрлық дәуірдегі адамзат қоғамының трансформациясын зерттеген ғылыми мақаламыздың өзектілігі мемлекеттік билік пен ақпараттық технологиялардың ықпалдасу модельдерінің түрлі аспектілерін талдаумен де тығыз байланысты. Халықаралық ғылыми қауымдастық мойындаған, бұқаралық коммуникация тұжырымдарына арналған ғылыми

зерттеулердің хронологиясынан да тарихи кезеңдерге сәйкес қоғамдар мен бұқаралық коммуникацияның әсерлі ықпалдасуына түрткі болған критерийлердің аралуандығын көреміз.

«Бұқаралық коммуникация» ұғымын 1909 жылы ғылыми айналымға қосқан америкалық әлеуметтанушы Чарльз Кули болғаны белгілі. Ал, америкалық әлеуметтанушы және журналист У.Липпманның «Қоғамдық пікір» атты еңбегі бұқаралық коммуникацияның алғашқы тұжырымдық негізін қалады. Бұл еңбекте алғаш рет «әлеуметтік стереотип» термині қолданылды, бұқаралық коммуникация құралдарының аудиторияға әсерінің шектен тыс қуаты болжанды. БКҚ-ны қоғамдық сананы бұрмалаудың жақсы құралы деп таныған У.Липпман «коммуникацияны» әлеуметтік қатынастар түрінде зерттеуді ұсынды [1].

Бұқаралық коммуникацияны зерттеуді жаңа белеске көтерген Пауль Феликс Лазарсфельд болды. Әріптестері ПФЛ деп атап кеткен америкалық әлеуметтанушы бұқаралық медианы жеке құбылыс ретінде зерттеген және қоғамдық ғылымдардың тұжырымдарын дәлелдеуде математикалық аппаратты қолданған. Ғылымды идеологиялық қысымнан арылтып, идеологиялық мазмұннан ажыратып қарау керектігін қолдаған. Бір қызығы, ПФЛ-дің алғашқы ғылыми ізденістері әлеуметтанудан тыс болған және ол 1924 жылы өзінің докторлық диссертациясын математикадан қорғаған.

1925-1929 жылдары Венадағы мектептердің бірінде математика пәнінің мұғалімі бола жүріп, Вена университетінің жанындағы Психология институтында психологияны оқыған. Математикалық аппарат пен психологияның көмегімен Лазарсфельд өзінің әлеуметтік зерттеулерінде эмпирикалық проблемаларға барынша назар аударды. Ғалым электоралды мінез-құлықтың «әлеуметтік» тұжырымын жасады. Бұл тұжырым бойынша дауыс беру процесі кезінде сайлаушының шешімі оның қандай үлкен әлеуметтік топқа жататынымен анықталады деп көрсетілген. ПФЛ-ға дейін бұқаралық коммуникацияның тиімділігі мен әлеуеті ойша сарапталып, ой-бағамдау әдістеріне негізделіп жасалып келсе, П.Лазарсфельд эмпирикалық зерттеулер арқылы коммуникациялық құралдармен қоғамдық пікірді қаншалықты өзгертіп бұрмалауға болатынын дәлелдеді [2].

Бұл XX-ғасырдың 30-40 жылдары болатын. Ал, өткен ғасырдың 60-80 жылдары бұқаралық ақпарат құралдарының адамдардың саяси ұстанымдарын саяси жарнаманың көмегімен өзгертетін механизмдерді түсіндіретін бірнеше ғылыми теориялар өмірге келді. Осы ғылыми теорияларды Э.Ноэль-Нойманның «Қоғамдық пікір: үнсіздік шиыршығының ашылуы» атты монографиясында, Т.Блумердің «Әлеуметтік проблемалар ұжымдық әрекет түрінде» атты ғылыми еңбегінде, С.Ленарттың «Адамдар арасындағы қарым-қатынас пен бұқаралық ақпарат құралдарының әсері» ғылыми зерттеу жинағынан көре аламыз.

Жаңа ғасырда да бұқаралық коммуникация феноменіне деген қызығушылық философтар, саясаттанушылар, психологтар мен әлеуметтанушылар тарапынан еселеніп өсуде. Олар аталған құбылысты жан-жақты зерттеуге құлшыныс танытуда. Бүгінгі зерттеулердің басты нысаны – бұқаралық коммуникация құралдарының қоғамдық-саяси процестерге әсер ету дәрежесін өсіру, тиімді технологиялар мен механизмдерді анықтау [3].

Нарықтық қатынастардың дамуымен бірге бұқаралық коммуникация құралдарының меншік түрлері де өзгерді. Меншік нысандарының өзгеруімен қатар прогрессивті қоғамдық сана қалыптастыру бағытындағы ашық технологияларды қоғамдық сананы бұрмалауды мақсат еткен «лас технологиялардан» ажырату, қорғау проблемасы туындады [4].

Цифрлық дәуірдегі бұқаралық коммуникация феноменін объективті сипаттау үшін мына мәселелерді сараптаудың маңызы жоғары:

1. Қоғамның саяси өміріндегі БКҚ қызметінің ерекшеліктерін талдау, БКҚ қызметін заңнамалық реттеуді саралау, нормативтік-құқықтық базаның әлсіз және күшті тұстарын анықтап ұсыныстар әзірлеу;

2. Қоғамдық сананы бұрмалау механизмдерін қолдануды билік жүргізудің, басқарудың тәсілі деген көзқарастың теориялық негіздерін жинақтау. БКҚ объектілері деп танылған қоғамдық сананы бұрмалау үшін көзделген жиынтық компоненттердің аппроксимациялық көлемін анықтау;

3. Қоғамдық сананы қажетті арнаға бұру және халықты қажетті электоралдық таңдауға икемдеу мақсатында БКҚ-ыны тиімді қолдану жолдарын оңтайландыру формаларын ұсыну. Саяси жарнамада қолданылатын манипуляциялық механизмдерді бірыңғай жіктеудің негіздемесін жасау;

4. Ақпараттық қоғамдардағы мемлекет пен қоғамның арасындағы коммуникативтік қатынастардағы дезинтеграциялық процестердің себебін талдау;

5. Дамыған қоғамдардағы «басқарушыдан – бағыныштыға» деген формуланың орнына цифрлық технологиялар мүмкіндік беретін «бұқара халықты саяси шешімдерге қатыстыратын» саяси коммуникациялық модельдердің қоғамдық қатынастарға әсерін, енгізілу жылдамдығын сараптау [5].

Қазақстандық бұқаралық коммуникация құралдарының саны ұдайы өсуді көрсетеді: 2014 жылы – 22100, 2015 жылы – 2711, 2016 жылы – 2973 құрады. Олардың 23% – мемлекеттік БҚҚ, 77% – мемлекеттік емес, құрылымдық жағынан 84% – баспа БҚҚ, 8,8% – электрондық БҚҚ, 7,2% – ақпараттық агенттіктер мен Интернет басылымдар. Тілге байланысты жіктелу көрсеткендей 20% – қазақтілді, 28,9% – орыстілді, 26,8% – қазақ және орыс тілдерінде, ал, 24,5% – қазақ, орыс және басқа тілдерде.

2018 жылдың 1 қаңтарындағы мәліметтер бойынша елімізде 2915 БҚҚ тіркелген. Олардың: 2543 (88,3%) – баспасөз құралдары, 178 (5,6%) – электрондық БҚҚ, 194 (6,3%) – ақпараттық агенттіктер мен желілік басылымдар. Ақпарат тарату тілі бойынша қазақ тілінде – 502, орыс – 780, қазақ және орыс тілдерінде – 956, үш тілде және одан басқа да тілдерде – 677. Меншік нысаны бойынша 31% газет-журналдар мемлекеттік, 71% жекеменшік.

Отандық БҚҚ-ның жаңартылған даму стратегияларының нәтижесінде «Егемен Қазақстан» және «Казахстанская правда» газеттерінің жұмыстары тың серпін алды, олардың цифрлық технологияларға негізделген интернет-редакцияларының қызметі жаңартылды. Екі басылымның да iOS платформасында, сондай-ақ Android операциялық жүйесінде жұмыс істейтін мобильдік қосымшалары әзірленді. Нәтижесінде «Егемен Қазақстан» мен «Казахстанская правда» газеттерінің сайттарына кіру көрсеткіші 3-5 есеге артқан. Аймақтық баспаларды қолдау бойынша облыстық, аудан және қалалық газеттердің 200 интернет-ресурстары ашылып, олар жаңаша дизайнға көшірілді.

Электрондық БҚҚ-ның бірыңғай ақпараттық кеңістіктегі ауқымы мен әлеуеті өсуде. Елдегі ақпараттық агенттіктердің жалпы саны – 193, 4 ақпараттық агенттік (3 %) мемлекеттік болса, 189 агенттік (97%) жекеменшік. Тілдік сипаты бойынша: 26 – қазақ тілінде, 31 – орыс тілінде, 57 – қазақ және орыс тілінде, 79 – қазақ, орыс және басқа тілдерде хабар таратады. Бұлардан басқа ақпарат нарығында 12 интернет басылым жұмыс істейді, олардың 6-ы қазақ және орыс тілдерінде, 6-ы қазақ, орыс және басқа тілдерде.

«Қазинформ» ақпараттық агенттігі республикада жаңалықтар тарататын Интернет-ресурстардың ТОП-10-ына енген. Порталға күніне 46,0 мың адам кіреді. «Қазинформ» БАҚ және ақпарат саласындағы 8 халықаралық ұйымның мүшесі. Kaztube.kz порталы арқылы отандық киноиндустрия өнімдерін жарнамалау, тұтынушыға жақындату жұмыстары іске асырылған. Мемлекеттік билік тарапынан қолға алынған осындай ауқымды істер Қазақстанның Интернетті дамыту мен ресурстар қауымдастығымен ынтымақтаса жүргізілуде. Осының өзі цифрлық технологиялардың әлеуеті мемлекет, қоғам мен адам арасындағы алшақтықты жойып, саяси-әлеуметтік саладағы әріптестіктің нығаюына жол ашары анық [6].

Тәуелсіздік жылдарында мемлекеттің ақпараттық саясатын жетілдіру бойынша ауқымды шаралар атқарылған. «Қазмедиа орталығы», «Хабар» Агенттігі, «Білім және мәдениет», «Балапан», «KazSport» телеарналары құрылды. Ұлттық медианың өндірістік және технологиялық дамуына жағдай жасау үшін «Қазмедиа орталығы» ашылды. «Қазмедиа орталығының» басты қызметі – телевизия өндірісін цифрлық жабдықтармен қамтылған телестудиялар ұсыну, оларды технологиялық жағынан сүйемелдеу және телесигналды кідіріссіз жіберу. Бұл орталықта еліміздің негізгі 8 телеарнасы мен 3 радиосы орналасқан: «Хабар» Агенттігі («Хабар», «24 KZ», «Білім және мәдениет», «Kazakh TV» телеарналары), «Қазақстан» («Қазақстан» ҰТА, «Балапан», «KazSport» телеарналары, «Қазақ радиосы», «Шалқар» және «Астана» радиолары), «Еуразия» Бірінші арнасы, «МИР» ТРК. «Қазмедиа орталығында» отандық журналистер семинар-тренингтер, конференциялар өтетін медиа-мектеп ашылған.

«Қазақстан» РТРК – еліміздегі ең ірі медиа холдинг. Оның құрамында бүгінгі таңда 3 республикалық және 14 аймақтық телеарна, 4 радио және 36 интернет сайт кіреді. Телерадио корпорацияның технологиялық жабдықтануы оның хабарларын республиканың 100% аймағына, сондай-ақ Ресей, Қырғыз, Өзбекстан, Түркіменстан, Қытай Республикасы және Моңғолияның шекаралас аймақтарына таратуға мүмкіндік береді.

1995 жылы құрылған «Хабар» Агенттігі – Қазақстанда ғана емес, аймақтағы заманауи медиахолдинг. Әрбір жарты сағат сайын екі тілде жаңалық тарататын елдегі жалғыз тәуелдік «24 Хабар» телеарнасы осы агенттіктің құрамында. Ал, «Kazakh TV» – Қазақ елінің насихатын

халықаралық ақпарат кеңістігінде жүргізеді, ұлт имиджін ілгерілетуге ұшталған қазақ, орыс және ағылшын тілдерінде әлемнің 118 елінде тарататын телеарна.

Қазақстандық БКҚ-ның қызметіндегі сапалы өзгерістер мемлекеттің даму деңгейіне, саяси-әлеуметтік, экономикалық жағдайға қатысты жетіліп келеді. Еліміздің әлеуметтік-саяси саласында қалыптасқан ақпарат тарату құралдарының қызметіндегі өзгешелік біздегі тарихи қалыптасқан ақпаратты тарату мен қабылдау каналдарының, тәсілдерінің сипаттарымен, меншік түрлеріне, мемлекеттік қолдау мен қоғамның мәдени дәрежесіне байланысты түсіндіріледі.

ҚОРЫТЫНДЫ

Тәуелсіздік алғаннан бері Қазақ еліндегі әлеуметтік-саяси өзгерістер мен аралуан трансформациялық процестерді, қоғамдық санаға ықпал ететін институттардың қызметін зерттеудің өзектілігі артуда. Елді басқару құрылымындағы айтарлықтай өзгерістер саяси жүйенің түбегейлі реформалануымен байланысты болды. Қоғамдағы коммуникациялық әрекеттесудің сипаттары әрбір елдің саяси жүйесіне тән түрленіп отырады. Демократиялық қоғамдарда коммуникациялық құралдар саяси ережелерді заңдастыруда маңызды функция атқарады. Осы аталған мәселелерді зерттеу бойынша мынандай тұжырымдар жасалды:

- ақпараттық дәуірдің талабы бойынша қоғамдағы қатынастарды қалыптастыру және бұқара халықтың ауқымды бөлігін саяси маңызды шешімдер қабылдауға белсенді тарту құралдары мен механизмдерін ұдайы жетілдіріп отыру қажет;
- Қазақ еліндегі саяси саладағы ескі конструкциялардың өзара шиеленісі мен даму перспективалары толық анықталмаған жаңа модельдердің үдей түсуінен туындаған саяси-экономикалық, әлеуметтік жіктелу үдерістеріне жан-жақты талдау жүргізу қажеттігі туындады;
- бұқаралық коммуникация құралдары мен қоғамдық күштердің арасындағы диалог ұйымдастыру проблемалары өзекті сипат алды;
- бұқаралық медиа мен саяси институттарға деген әлеуметтік сенімнің өспелі тапшылығын аталған субъектілердің қарым-қатынасын конструктивті арнаға түсіру арқылы ғана жоюға болады.

Қазақстанның цифрлық технологиялық әлеуеті өсе бастаған кезеңде мемлекет, қоғам және медиа сияқты үштіктің әрекеттесуін зерттеген 2019-2020 жылдардағы ғылыми еңбектерімізде болжанғандай, биліктің саяси және экономикалық реформаларын әлеуметтендіруде, халыққа жақындатуда бұқаралық коммуникация құралдарының қабілеттілігі өсіп келеді. Ақпараттық кеңістіктегі екіжақты сенімнің нәтижесінде биліктің саяси-экономикалық, әлеуметтік ниеттерінің стратегиясы мен тактикасы қоғам үшін түсінікті тілде, ыңғайлы формада насихаттала бастады.

Бұл саяси процестің тұтастығы мен заңдылығын күшейтіп қана қоймай, қазіргі қазақстандық бұқаралық коммуникация құралдарының көмегімен билік саясатының ашықтығы мен елдік мүддеге сәйкестігін қамтамасыз етуде. Екінші жағынан, маңызды шешімдер қабылдауға қатысатын аудиторияның ауқымын едәуір өсіруге көмектесті.

Біздің ғылыми гипотезамызға сәйкес цифрлық дәуірде бұқаралық коммуникация құралдарының күш-қуаты азаматтарды әлеуметтік белсенді топтардың құрамына қосып, оның саяси белсенділігін арттыруға, қоғамдық сананы позитивті бағытта өзгертуге игі әсерін тигізеді. Жеке тұлғаның әлеуметтік кемелденуі, елдегі саяси жүйенің ашықтығы мен прогрессивті даму көрсеткіштерінің бір-біріне тәуелділігі де біз ұсынған болжамның құрамдас бөлшегі түрінде қаралады.

Қаржыландыру

Бұл зерттеу мақаласы ҚР Ғылым және жоғары білім министрлігі Ғылым комитетінің ғылыми гранты есебінен қаржыландырылды (грант №AP32723927).

Библиография

1. Lippmann, Walter (1922). *Public Opinion* / New York: Harcourt, Brace & Co., 1922. – p.231. ISBN 0029191300 [in USA]
2. Lazarsfeld, P., Merton, R. & Bryson, L. (ed.) (1948). *Mass Communication, Popular Taste and Organized Social Action / The Communication of Ideas: A Series of Addresses*, New York. – 1948. – p.316. [in USA]
3. Gorohov V.M., Shilina M.G., (2009). *Paradigmy razvitiya teorii media v XXI veke: konceptual'naya revolyuciya ili?..* [Paradigms of development of media theory in the XXI century:

conceptual revolution or? ..] // *Vestnik Moskovskogo universiteta. Ser. 10. Zhurnalistika.* – 2009. – №3. – c. 17-23. [in Russian]

4. Seslavinskij M.V., (2005). *My dolzhny ustranit' informacionnoe neravenstvo [We must eliminate the information inequality] / Broadcasting. Televidenie i radioveshchanie.* – 2005. – №1(45). – s. 106-123. [in Russian]

5. Marcuse, H. & Yudin, A.A., (2016). *Eros and civilization. One-dimensional man: studies in the ideology of advanced industrial society / (transl.) Moscow.* – 2016. – 526 p. [in Russian]

6. Yessenbekova U.M., (2019). *Transformation of human and society in the digital age (media-psychological aspect). Scientific monograph / Approved by the Academic Council of L.N.Gumilyov ENU, Printing house of L.N.Gumilyov ENU.* – Astana. – 2019. – p.226. [in Kazakhstan]

Medical sciences

UDC: 616.37-006.6

PANCREATIC CANCER: MODERN REALITIES AND TRENDS

Arman Khozhayev

Professor of the S.N. Nugmanov Department of Oncology,
Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Perizat Sovetkanova

Endocrinologist,

City Clinical Hospital No. 5, Almaty, Kazakhstan

Artem Gavrilenko

Resident of the Department of Plastic Surgery

Aesthetic Medicine and Laser Cosmetology,

Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Yerkezhan Yerlanova

Gastroenterologist,

City Clinical Hospital No. 5, Almaty, Kazakhstan

Ulzhan Zhanyzbek

Head of the Prevention Department,

City Clinical Hospital No. 5, Almaty, Kazakhstan

Nadezhda Kim

Endocrinologist,

Limited Liability Partnership «DAMED», Almaty, Kazakhstan

Abstract

This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality and five-year survival rate of pancreatic cancer, a serious oncological disease. The issues of etiology and pathogenesis, modern approaches and principles of complex diagnostics, prospects for improving treatment results, as well as the prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of the regions of the country.

Keywords: oncology, endocrinology, pancreatic cancer, pancreatic neoplasms, biomarkers, diagnostic markers, RNA, miRNAs, single-cell RNA sequencing, DNA, cell-free DNA, genetics, screening, epidemiology, incidence, mortality, lethality, five-year survival rate, prognosis.

Pancreatic cancer (PC) is a malignant neoplasm originating from the epithelium of the glandular tissue or pancreatic ducts [1]. The following diagnostic criteria are identified for PC:

Complaints and anamnesis: characteristic symptoms in the clinical picture of PC include pain, jaundice, itching, weight loss, loss of appetite, and fever. Pain is the most common symptom, observed in 70-85% of patients. Pain most often occurs as a result of tumor invasion or compression of nerve trunks; less commonly, it is caused by obstruction of the bile duct or Wirsung duct or peritoneal phenomena due to exacerbation of concomitant pancreatitis. With head cancer, pain is felt in the right hypochondrium or epigastric region; cancer of the body and tail is characterized by pain in the left hypochondrium and epigastric region, but can also manifest as a pain-like sensation in the right hypochondrium. Diffuse lesions are characterized by diffuse pain in the upper abdomen. In some patients, the pain remains localized in one area. In others, it radiates to the spine or interscapular region, and less commonly, to the right scapula. Tumors that obstruct the Wirsung duct and are accompanied by pancreatitis cause paroxysmal, encircling pain. The pain is noted to most often appear or intensify in the evening or at night, when the patient is supine, after large, especially fatty, meals, and after drinking alcohol. The pain is more severe with PC, especially when the tumor invades or compresses the solar plexus. In this case, the pain becomes extremely severe, unbearable, and may become encircling. Patients adopt a forced position, bending their spine forward, leaning against the back of a chair, or leaning over a pillow pressed to the abdomen. This "hook" position is quite common in patients with advanced PC. Jaundice is the most prominent symptom of pancreatic head cancer. It occurs in 70-80% of patients. It is caused by tumor invasion of the bile duct and bile stasis in the biliary system. It occasionally occurs with cancer of the body and tail, in which case

it is caused by compression of the common bile duct by metastases to the lymph nodes. Jaundice is rarely the first symptom of the disease; it is often preceded by pain or weight loss. Jaundice is mechanical in nature and develops gradually, steadily increasing in intensity. Jaundice is accompanied by discoloration of urine and stool. Stool becomes discolored. Urine becomes brown, reminiscent of beer. Sometimes changes in urine and stool occur before jaundice. Itching is caused by irritation of skin receptors by bile acids. With jaundice due to PC, itching occurs in most patients. It typically occurs after the onset of jaundice, most often with high bilirubin levels in the blood, but sometimes patients report itching of the skin even before jaundice. Itching significantly worsens the patient's well-being, disturbs their peace of mind, causes insomnia and increased irritability, and often leads to numerous scratches, the traces of which are visible on the skin. Weight loss is one of the most significant symptoms. It is caused by intoxication due to the developing tumor and impaired intestinal digestion due to obstruction of the bile and pancreatic ducts. Weight loss is observed in most patients and is sometimes the first symptom of the disease, preceding the onset of pain and jaundice. Loss of appetite occurs in more than half of patients. An aversion to fatty or meaty foods often develops. Weight loss and loss of appetite are accompanied by increasing weakness, fatigue, and sometimes nausea and vomiting. A feeling of heaviness after eating and heartburn are sometimes observed. Bowel function is often disrupted, with flatulence, constipation, and, occasionally, diarrhea. Stools are bulky, clay-gray in color, with an unpleasant, foul odor, and contain a large amount of fat.

Physical examination: symptoms of PC are a consequence of three clinical phenomena caused by the growing tumor: obstruction, compression, and intoxication. Compression is characterized by pain due to the growth of or compression of pancreatic nerve trunks by the tumor. Obstruction occurs when the growing tumor obstructs the common bile duct, duodenum, pancreatic duct, or compresses the splenic vein. Obstruction of the common bile duct leads to biliary hypertension, which is associated with mechanical jaundice, pruritus, liver and gallbladder enlargement, discolored stool, and dark urine. Biliary hypertension is a severe pathological condition that determines the patient's prognosis. It leads to dysfunction of the liver, cardiovascular and nervous systems, and metabolism, causing bradycardia, headache, apathy, and increased irritability. Prolonged and intense jaundice can lead to liver and hepatorenal failure, as well as cholemic bleeding. Tumor invasion of the duodenum leads to obstruction, clinically resembling pyloric stenosis. The phenomenon of intoxication is manifested by weight loss, decreased appetite, and general weakness. These symptoms are often observed in PC, as they are caused not only by the influence of the tumor itself, but also by impaired intestinal digestion [1].

Laboratory tests:

1) basic: cytological examination of a biopsy of a pancreatic tumor or liver metastasis (increase in cell size up to giant, changes in the shape and number of intracellular elements, increase in the size of the nucleus and its contours, varying degrees of maturity of the nucleus and other cellular elements, changes in the number and shape of nucleoli); histological examination of a biopsy specimen of a pancreatic tumor or liver metastasis (marked cellular polymorphism, increased cell size, pronounced hypochromia, large nuclei containing one or more nucleoli, glandular structures of cancer cells in the form of rosettes, numerous cells in mitosis);

2) additional: immunohistochemical examination of the biopsy and surgical material for a detailed determination of the tumor subtype; molecular genetic testing: due to the frequency of detection of mutations in the BRCA1 and BRCA2 genes of over 5%, as well as the significant impact of these mutations on the choice of chemotherapy regimen, their determination is advisable in all patients; a biochemical blood test for a tumor localized in the head of the pancreas is characterized by the development of mechanical ("subhepatic") jaundice - laboratory tests reveal hyperbilirubinemia.

Non-specific laboratory tests or in cases when deciding on the appointment of chemotherapy, the following are recommended: complete general (clinical) blood test, erythrocyte sedimentation rate; blood biochemistry: total protein, glucose, bilirubin, creatinine, urea, iron, alanine aminotransferase, aspartate aminotransferase, total bilirubin, alkaline phosphatase, plasma electrolytes (potassium, sodium, chloride), C-reactive protein; general (clinical) urine analysis; coagulology: fibrinogen, prothrombin, international normalized ratio, prothrombin time, prothrombin index, activated partial thromboplastin time, thrombin time; blood test for carcinoembryonic antigen, determination of the level of adenogenic cancer antigen CA 19-9 in order to assess the current clinical situation and, if they increase, for further monitoring of the disease. A baseline assessment should be performed against the background of biliary decompression, normal bilirubin levels, and resolution of inflammation. A blood test for chromogranin A is required for differential diagnosis with neuroendocrine tumors.

Instrumental examinations:

1) basic: abdominal ultrasound – primary diagnosis of pancreatic lesions; multislice computed tomography of the abdominal organs with bolus contrast allows for the diagnosis of PC, assessment of vascular invasion, and identification of metastases (lymph nodes, liver, abdominal cavity); fibrogastroduodenoscopy (to assess tumor spread);

2) additional: endoscopic retrograde cholangiopancreatography – is important in the diagnosis of pancreatic and bile duct obstruction; magnetic resonance imaging with magnetic resonance cholangiopancreatography provides information on the condition of the pancreatic duct and bile ducts; positron emission tomography/computed tomography is one of the most sensitive and informative methods for assessing the extent of tumor spread in the pelvis, abdominal cavity, retroperitoneal space, chest, brain, soft tissues, bones, and for identifying "small" tumors, relapses, and metastases.

In any sequence of instrumental research methods, it is necessary to establish the tumor nature of changes in the pancreas and the extent of the tumor [1].

Hirabayashi K. et al. [2] note in their work that cytology is a useful method for diagnosing pancreatic neoplasms. Although endoscopic ultrasound-guided fine-needle aspiration has recently become the mainstream method for the diagnosis of pancreatic neoplasms, pancreatic juice and pancreatic duct brushing cytology continue to be useful diagnostic methods for the investigation of pancreatic neoplasms. Diagnoses using pancreatic cytology are primarily based on the features related to tumor cells; however, evaluation of the background features provides important information that could further aid the diagnosis. Pancreatic neoplasms show various histological types, each of which is associated with its own characteristic background features. The necrotic background, desmoplastic stroma, and presence of cancer-associated fibroblasts are background features of pancreatic ductal adenocarcinoma, a mucinous background is associated with intraductal papillary mucinous neoplasms and mucinous cystic neoplasms, and hyaline globules are observed in solid pseudopapillary neoplasms. However, some background features are associated with more than one histological type of pancreatic neoplasm, highlighting the importance to base a diagnosis on the results of a comprehensive analysis of not only the background features but also the tumor cells. The authors presented key background cytological features of pancreatic neoplasms that can serve as a guide for improved diagnosis and research.

PC is a malignant neoplasm with an extremely poor prognosis; thus, early diagnosis and treatment are desirable. Although the accuracy of PC diagnosis has improved in recent years due to the development of diagnostic imaging, it is still necessary to carry out biopsy and cytology to differentiate between benign and malignant neoplasms and to determine the histological type. Pancreatic juice cytology and pancreatic duct brushing cytology have long been the major diagnostic methods for pancreatic neoplasms; however, the recent development and application of endoscopic ultrasound-guided fine-needle aspiration (EUS-FNA) has substantially aided and improved the cytological diagnosis of pancreatic neoplasms. Pancreatic juice cytology and pancreatic duct brushing cytology are mainly used for investigating neoplasms involving the large pancreatic ducts, such as pancreatic ductal adenocarcinoma (PDAC) and intraductal papillary mucinous neoplasms (IPMNs), whereas EUS-FNA is now more commonly used for pancreatic neoplasms that have less association with the pancreatic ducts, such as neuroendocrine neoplasms, acinar cell carcinoma, serous cystic neoplasms, mucinous cystic neoplasms, and solid pseudopapillary neoplasms. In cytology, the diagnosis of pancreatic neoplasms is based mainly on morphological evaluation of the tumor cells; however, background features such as the presence of necrosis or mucin also provide important information to assist with the diagnosis. In conclusion, our colleagues point out that there are various histological types of pancreatic neoplasms, and characteristic background features for each type that may be useful for diagnosis have been identified. However, as certain background features also overlap between histological types, it is important to make a comprehensive diagnosis by carefully observing not only the background features but also the characteristics of tumor cells and atypical cells. The diagnostic utility of background features, such as necrotic background or cancer-associated fibroblasts, in pancreatic juice cytology and/or pancreatic duct brushing cytology in early-stage PDAC with pancreatic duct stenosis or dilation is still not well understood. Therefore, further studies on the diagnostic utility of background findings in early-stage PDAC are needed [2].

Selvaggi S.M. in her study compared the use of fine-needle aspiration biopsy and needle biopsy for the diagnosis of pancreatic neoplasms [3]. The author emphasizes that EUS-FNA is highly sensitive and specific in the detection and diagnosis of pancreatic neoplasms. EUS-guided needle core biopsy has been used alone or as an adjunct to maximize diagnostic yield. From January 1, 2018 through December 21, 2020, the Cytopathology Laboratory processed 374 FNAs from solid pancreatic masses of which 332 (89%) had concurrent pancreatic biopsies and form the basis of this study. Of the 332 FNAs, 173 (52%) were positive/suspicious for pancreatic adenocarcinoma, 33 (10%) were positive for a neoplasm, 20 (6%)

were atypical 19 (6%) were negative and 87 (26%) were non-diagnostic. Biopsies were concordant in 248 (75%) cases and discordant in 84 (25%) cases. Of the 84 discordant cases, 29 (35%) had neoplastic cells on FNA of which 14 were atypical, 11 were negative and 4 were nondiagnostic on core biopsy. Of the 18 (21%) FNAs with atypical cells, 8 showed adenocarcinoma on core biopsy. Thirty-seven nondiagnostic FNAs showed adenocarcinoma on 25 (70%) core biopsies. If nondiagnostic FNAs were included, FNA sensitivity was 89% and specificity; 100%, and both were 100%, if the nondiagnostic cases were excluded. The needle core biopsy sensitivity was 91% and specificity; 100%. Summarizing the conducted research, the author says that both FNAs and core biopsies show high sensitivity and specificity in the detection of pancreatic neoplasms. However, utilization of both techniques enhances cellular yields; in particular unsatisfactory FNAs, and often provides sufficient material for ancillary tests in this era of precision medicine [3].

In the scientific work of Lv G. et al. [4], the researchers summarized new modern knowledge on the sequencing of individual cells in pancreatic neoplasms, taking into account the methods used, tumor heterogeneity and treatment methods.

According to the authors, pancreatic neoplasms, including PDAC, IPMN and pancreatic cystic neoplasms, are the most puzzling diseases. Numerous studies have not brought significant improvements in prognosis and diagnosis, especially in PDAC. One important reason is that previous studies only focused on differences between patients and healthy individuals but ignored intratumoral heterogeneity. In recent years, single-cell sequencing techniques, represented by single-cell RNA sequencing (scRNA-seq), have emerged by which researchers can analyse each cell in tumours instead of their average levels. Based on the conducted research, the authors state that pancreatic neoplasms, especially PDAC, remain the most complex and malignant disease due to their high heterogeneity. Single-cell sequencing benefits from its single-cell resolution and has become the most appropriate approach to uncover the underlying mechanisms of PDAC. Several frameworks and algorithms of single-cell sequencing have been applied, such as copy number karyotyping of aneuploid tumors, minimally invasive adenocarcinoma and SPOT-light, among which scRNA-seq combined with the spatial transcriptome has presented more obvious advantages. scRNA-seq enables rapid determination each cellular gene-expression patterns of thousands of individual cells. By using this emerging sequencing technology, scientists have revealed high heterogeneities in cancer cells, the tumour environment, circulating tumour cells, and the progression from precancerous lesions to PDAC. Immune checkpoint inhibitors have shown cooperates in many cancers; however, PDAC is still resistant to them. Recent studies found that a few new targets and inhibitors had an obvious ability to suppress PDAC growth when they were combined with immune checkpoint inhibitors. In conclusion, single-cell sequencing provides us with novel insights into intratumoral heterogeneity, subclusters identification, unique genes mutations, and dynamic evolution in PDAC. However, some shortcomings limit its large-scale use. As a high-throughput protocol, scRNA-seq only captures a fraction of molecules, ranging from 5% to 20% RNA physically present in cells. Meanwhile, enzymes used to obtain single-cell suspensions can degrade RNA, which is more pronounced in PDAC. The batch effect is frequently observed as samples are collected at different periods. These technical noises mentioned above generate bias and make it more difficult to differentiate rare cell types. Meanwhile, there are many algorithms and parameters for single-cell analysis that make novices too difficult to choose a correct combination. Another limitation is the expensive cost of experiments [4].

Vicentini C. et al. [5] note that pancreatic and peri-pancreatic neoplasms encompass a variety of histotypes characterized by a heterogeneous prognostic impact. Researchers point out that MicroRNAs (miRNAs) are considered efficient candidate biomarkers due to their high stability in tissues and body fluids. They applied Nanostring profiling of circulating exosomal miRNAs to distinct pancreatic lesions in order to establish a source for biomarker development. A series of 140 plasma samples obtained from patients affected by pancreatic ductal adenocarcinoma (PDAC, n = 58), pancreatic neuroendocrine tumors (Pancreatic neuroendocrine tumours, n = 42), IPMN, n = 20, and ampulla of Vater carcinomas, n = 20 were analyzed. Comprehensive miRNA profiling was performed on plasma-derived exosomes. Relevant miRNAs were validated by quantitative reverse-transcription polymerase chain reaction (qRT-PCR) and in situ hybridization (ISH). Lesion specific miRNAs were identified through multiple disease comparisons. Selected miRNAs were validated in the plasma by qRT-PCR and at tissue level by ISH. The researchers leveraged the presence of clinical subtypes with each disease cohort to identify miRNAs that are differentially enriched in aggressive phenotypes. The authors emphasize that this study shows that pancreatic lesions are characterized by specific exosomal-miRNA signatures. Our colleagues also provided a bioresource for future explorations aimed to understand the biological and clinical relevance of such signatures.

Faur A.C. et al. [6] in their work they say that PC has a low incidence rate but a high mortality, with patients often in the advanced stage of the disease at the time of the first diagnosis. If detected, early neoplastic lesions are ideal for surgery, offering the best prognosis. Preneoplastic lesions of the pancreas include pancreatic intraepithelial neoplasia and mucinous cystic neoplasms, with intraductal papillary mucinous neoplasms being the most commonly diagnosed. The study focused on predicting PC by identifying early signs using noninvasive techniques and artificial intelligence (AI). A systematic English literature search was conducted on the PubMed electronic database and other sources. Our colleagues obtained a total of 97 studies on the subject of pancreatic neoplasms. The final number of articles included in this study was 44, 34 of which focused on the use of AI algorithms in the early diagnosis and prediction of pancreatic lesions. AI algorithms can facilitate diagnosis by analyzing massive amounts of data in a short period of time. Correlations can be made through AI algorithms by expanding image and electronic medical records databases, which can later be used as part of a screening program for the general population. AI-based screening models should involve a combination of biomarkers and medical and imaging data from different sources. This requires large numbers of resources, collaboration between medical practitioners, and investment in medical infrastructures.

As the researchers note to improve the clinical management and prognosis for patients with PC, new diagnostic methods should be developed to identify precursor lesions. AI is a tool that can offer a personalized approach in this regard by analyzing a large quantity of heterogeneous data and can also help in decision-making, increasing the prediction accuracy for an early diagnosis. As for future prospects, the authors conclude that for PC, a cost-effective screening method for early lesions is needed. AI models developed for a diverse group of patients from high-risk PDAC cohorts belonging to broad datasets from different sources can be of great use for improving PDAC treatment outcomes and enhancing diagnostic precision. AI methods represent a needed step to reach a standardized interpretation of patient data and investigations while reducing human bias or error. For this, a wide range of data from different sources is necessary. All of these data have a central role in training AI methods in diagnosing PC and establishing the most accurate algorithm to be used for such a diagnosis. Correlations can be made through AI algorithms by expanding the image and electronic medical record databases, which will significantly improve the diagnostic accuracy and provide an early diagnosis for PC patients, thereby producing a better prognosis and more effective therapy. AI creates a common ground in diagnosing PC that can be standardized and used for the general population. Such an AI model should contain a combination of biomarkers, medical data, and imaging data obtained by alternating computed tomography, endoscopic ultrasound-guided, and magnetic resonance imaging testing so that maximized accuracy and early diagnosis with noninvasive techniques can be achieved. The coronavirus disease 2019 pandemic has produced a model for forming an international infrastructure that can be studied with AI algorithms and even used for predicting and early diagnosing cancers. The collaboration between scientists and academic centers has shown that humans from different countries and continents can work together to share information in a common attempt to save lives while creating a vast database. This will require resources, global solidarity, and support investment in medical infrastructures worldwide. However, the need to develop health infrastructure and multidisciplinary research studies is crucial, as the pandemic situation has already shown [6].

Conducted analysis [6] of the current diagnostic methods for detecting PC noninvasively with an emphasis on early lesions has revealed a series of common features and limitations: published studies about predicting early lesions in PC are lacking. For PC diagnosis, noninvasive tests such as imaging, tumor marker analysis, and population-based studies can be used to train AI algorithms to identify features, patterns, and subtle changes that can help classify pancreatic lesions and build predictive models that can improve the awareness of the risk of pancreatic neoplasia. Published studies typically included only small samples from a limited number of cases. The analysis of these studies focused mostly on just one type of investigation (radiomics features, personal data, biomarkers, or genomic features without making correlations between all the data that a physician analyses for a diagnosis of PC in a specific patient). A high percentage of the studies only performed internal validation, so bias and overfitting can constitute a problem when generalizing their conclusions. Commonly, for machine diagnosis, the mechanism that generates the output is not clearly explained, so assessing how a specific AI algorithm makes its final diagnosis remains controversial. AI algorithms for assessing pancreatic volumes with and without tumors are time- and cost-consuming that are usually run manually and in direct relation with the radiologist's experience. Finding an AI-driven automated volumetric segmentation algorithm is difficult because of the variations in shape, the shallowness of the boundaries, and the small size of the pancreas. Pancreatic tumors smaller than 2 cm frequently have inconspicuous borders with high similarity to the surrounding

tissues on radiomics analysis, making early lesion diagnosis challenging. However, AI methods have the potential to improve accuracy and support clinical decisions for the preoperative diagnosis of pancreatic lesions and to aid in the surgical management and prognosis of PC.

Hsieh M.J. et al. [7] in their study note that PC is a highly lethal malignancy due to the cancer routinely being diagnosed late and having a limited response to chemotherapy. PDAC is the most common form of pancreatic malignant tumor, representing more than 85% of all PCs. In the present study, authors characterized the phenotypes of concomitant P53 and adenomatous polyposis coli (APC) mutations in pancreatic neoplasms driven by the oncogene Kirsten Rat Sarcoma Viral Oncogene Homolog (KRAS) in genetically modified mice (GEMM). In this GEMM setting, APC haploinsufficiency coupled with P53 deletion and KRASG12D activation resulted in an earlier appearance of pancreatic intraepithelial neoplasia lesions and progressed rapidly to highly invasive and metastatic PDAC. Through a microarray analysis of murine PDAC cells derived from our APC-deficient PDAC model, the researchers observed that APC loss leads to upregulated CD34 expression in PDAC. CD34 is a member of a family of single-pass transmembrane proteins and is selectively expressed in hematopoietic progenitor cells, vascular endothelial cells, interstitial precursor cells, and various interstitial tumor cells. However, the functional roles of CD34 in PC remain unclear. Thus, in this study, our colleagues explored the mechanisms regarding how CD34 promotes the deterioration of pancreatic malignancy. These results demonstrated that the increased expression of CD34 induced by APC inactivation promotes the invasion and migration of PDAC cells, which may relate to PDAC metastasis in vivo. Collectively, this study provides first-line evidence to delineate the association between CD34 and the Wingless / Int-1 signaling (APC/Wnt) pathway in PDAC, and reveals the potential roles of CD34 in PDAC progression.

The authors' analysis revealed that CD34 is predominantly expressed on hematopoietic progenitor cells and endothelial progenitors, and has been widely used as a stem and progenitor cell marker. The results of the present study provided important evidences revealing the association between CD34 and the APC/Wnt pathway in PDAC, and authors demonstrated the potential roles for CD34 upregulation induced by APC inactivation in promoting PDAC cell growth, migration and invasion. Moreover, because CD34 is thought to be a biomarker for stem cells to maintain self-renewal and proper stemness, CD34 could be a novel drug candidate for the treatment of PDAC harboring APC mutations [7].

Huang B. et al. [8] devoted their scientific research to the study of IPMN. IPMNs are a commonly identified non-invasive cyst-forming pancreatic neoplasms with the potential to progress into invasive pancreatic adenocarcinoma. There are few in vitro models with which to study the biology of IPMNs and their progression to invasive carcinoma. Therefore, authors generated a living biobank of organoids from 7 normal pancreatic ducts and 10 IPMNs. The researchers characterized 8 IPMN organoid samples using whole genome sequencing and characterized 5 IPMN organoids and 7 normal pancreatic duct organoids using transcriptome sequencing. Our colleagues identified an average of 11,344 somatic mutations in the genomes of organoids derived from IPMNs, with one sample harboring 61,537 somatic mutations enriched for T->C transitions and T->A transversions. Recurrent coding somatic mutations were identified in 15 genes, including KRAS, GNAS, RNF43, PHF3, and RBM10. The most frequently mutated genes were KRAS, GNAS, and RNF43, with somatic mutations identified in 6 (75%), 4 (50%), and 3 (37.5%) IPMN organoid samples respectively. On average, they identified 36 structural variants in IPMN derived organoids, and none had an unstable phenotype (>200 structural variants). Transcriptome sequencing identified 28 genes differentially expressed between normal pancreatic duct organoid and IPMN organoid samples. The most significantly upregulated and downregulated genes were CLDN18 and FOXA1. Immunohistochemical analysis of FOXA1 expression in 112 IPMNs, 113 mucinous cystic neoplasms, and 145 pancreatic ductal adenocarcinomas demonstrated statistically significant loss of expression in low-grade IPMNs ($p < 0.0016$), mucinous cystic neoplasms ($p < 0.0001$), and pancreatic ductal adenocarcinoma of any histologic grade ($p < 0.0001$) compared to normal pancreatic ducts. These data indicate that FOXA1 loss of expression occurs early in pancreatic tumorigenesis. As the authors note, this study highlights the utility of organoid culture to study the genetics and biology normal pancreatic duct and IPMNs.

In this study, our colleagues generate a living biobank of organoids derived from 7 normal human pancreatic ducts and 10 human IPMN samples. They also present the characterization of somatic alterations in these IPMN organoids using whole genome sequencing. Furthermore, the researchers use transcriptomic sequencing to identify genes differentially expressed between normal pancreatic duct and IPMN organoids. The authors emphasize that their study documents a biobank of IPMN and normal pancreatic duct organoids, characterized by genomic and transcriptomic sequencing, a unique resource for the interrogation of these precancerous lesions. Using whole genome sequencing and RNA-Seq they

identified potential drivers of IPMN tumor development. These included 12 genes with recurrent somatic mutations and 28 genes that were differentially expressed when compared to normal pancreatic duct. The obtained results demonstrate that organoid culture is an effective tool for analyzing small precursor lesions at – omics scale to identify critical molecular alterations in precious human tissue samples [8].

Jain M. et al. [9] in their work say that Cell-free DNA (cfDNA) analysis-based liquid biopsy is a rapidly emerging diagnostic and prognostic tool in PDAC. KRAS point mutations are the main biomarkers used for the detection of tumor cfDNA. However, there is another less studied yet frequent genetic alteration in this gene, namely copy number gain (CNG). The aim of this study was to evaluate the diagnostic and prognostic potential of KRAS CNG analysis in plasma and bile of patients with PDAC using droplet digital polymerase chain reaction (ddPCR). This study included healthy volunteers ($n = 69$), patients with PDAC ($n = 94$), and other pancreatic neoplasms (OPN) ($n = 17$). The sensitivity and specificity of KRAS CNG compared to the control group were 16% and 100% (AUC-ROC - 0.580), and compared to the OPN group, 16% and 94% (AUC-ROC - 0.554), respectively. Addition of KRAS point mutations to the analysis increased the sensitivity to 65% (AUC-ROC - 0.824 and 0.801, respectively). Bile exhibited an equal KRAS CNG detection rate compared to plasma (20% vs. 16%). KRAS CNG was not associated with clinical parameters, except prognosis. The probability of survival was worse in patients with KRAS CNG (hazard ratio - 3.54; 95% confidence interval: 1.55-8.12; $p = 0.001$). KRAS CNG in cfDNA might be a promising biomarker for both diagnostic and prognostic purposes in PDAC.

In the course of the study, the authors state that copy number variants are an important yet underexplored aspect of cancer molecular biology. This exploratory study has demonstrated that not only are they detectable in cell-free DNA (cfDNA) of plasma and bile, but also they might be relevant to predicting poor survival in PDAC patients. The prognostic potential of KRAS CNG in plasma cfDNA, especially in combination with point mutations in this gene, might be useful to guide therapeutic decisions, for example, to identify patients requiring neoadjuvant chemotherapy or those who may benefit from additional imaging prior to treatment. However, the clinical implications of this kind of cfDNA analysis require further investigation. The ddPCR assay for KRAS CNG analysis presented in this work might be easily reproduced in any laboratory equipped with a ddPCR instrument, and our colleagues hope that it will be useful for future studies on the topic in PDAC and beyond [9].

An interesting study was conducted by Angerilli V. et al. [10]. They analyzed a cohort of 49 high-grade gastro-entero-pancreatic neoplasms (HG GEP-NENs) by targeted Next-Generation Sequencing (TrueSight Oncology 500), RNA-seq, and immunohistochemistry for p53, Rb1, SSTR-2A, and PD-L1. As the authors note HG GEP-NENs can be stratified according to their morphology and Ki-67 values into three prognostic classes: neuroendocrine tumors grade 3 [(neutrophil extracellular traps (NETs) G3)], neuroendocrine carcinomas with Ki-67 < 55% [(neuroendocrine carcinomas (NECs) <55)] and NECs with Ki-67 $\geq$ 55% (NECs $\geq$ 55). Frequent genomic alterations affected TP53 (26%), APC (20%), KRAS and MEN1 (both 11%) genes. NET G3 were enriched in MEN1 ($p = 0.02$) mutations, while both NECs groups were enriched in TP53 ($p = 0.001$), APC ($p = 0.002$) and KRAS ($p = 0.02$) mutations and tumors with TMB $\geq$ 10 muts/Mb ($p = 0.01$). No differentially expressed (DE) gene was found between NECs <55% and NECs $\geq$ 55%, while 1129 DE genes were identified between NET G3 and NECs. A slight enrichment of CD4+ and CD8+ T cells in NECs and of cancer-associated fibroblasts and macrophages (M2-like) in NET G3. Multivariate analysis identified histologic type and Rb1 loss as independent prognostic factors for overall survival. This study showed that GEP-NET G3 and GEP-NECs exhibit clear genomic and transcriptomic differences, differently from GEP-NECs <55% and GEP-NECs $\geq$ 55%, and provided molecular findings with prognostic and potentially predictive value.

Mazer B.L. et al. [11] in their fundamental study emphasize that most patients with PC present with advanced stage, incurable disease. However, patients with high-grade precancerous lesions and many patients with low-stage disease can be cured with surgery, suggesting that early detection has the potential to improve survival. While serum CA19-9 has been a long-standing biomarker used for PC disease monitoring, its low sensitivity and poor specificity have driven investigators to hunt for better diagnostic markers. In their work, our colleagues examined the latest advances in genetics, proteomics, imaging, and artificial intelligence, which offer opportunities for the early detection of curable pancreatic neoplasms. As an expert on this work notes, from exosomes, to circulating tumor DNA, to subtle changes on imaging, we know much more now about the biology and clinical manifestations of early pancreatic neoplasia than we did just five years ago. The overriding challenge, however, remains the development of a practical approach to screen for a relatively rare, but deadly, disease that is often treated with complex surgery. It is our hope that future advances will bring us closer to an effective and financially sound approach for the early detection of PC and its precursors.

The authors' analysis revealed that at first glance, PC seems to be an ideal target for screening and early detection. It is a highly lethal cancer, and most patients do not develop signs and symptoms until late in the course of their illness. A variety of methods have been developed to screen for early disease. From blood CA19-9 levels to circulating tumor DNA, each method has advantages and disadvantages, and it is likely that the best approach will incorporate multiple complementary modalities. It is also likely that artificial intelligence, whether applied to electronic patient medical records or to image analysis, will play a role in identifying the highest risk individuals. Screening for PC, however, must take into account the rarity of the disease in the general population, the costs of false positive test results, and the real potential for overtreatment of low-risk lesions.

According to an expert on this study if we wait until patients develop symptoms from PC, most will die within months of their diagnosis. There are, however, a number of potential approaches to the earlier diagnosis of PC and its precursors in asymptomatic individuals. The unresolved challenge is that none of the existing approaches have the sensitivity and specificity needed to effectively screen the general population. While combining tests can improve sensitivities, even these combinations fall short. Existing approaches to screening, therefore, have to be focused on populations at greatest risk of the disease. Towards this end, screening efforts to date have targeted individuals with a strong family history of PC or a known pathogenic germline variant that predisposes to PC. Other groups with a heightened cancer risk that have not yet been clinically targeted include cigarette smokers, obese individuals, and adults with new onset diabetes mellitus. Screening programs that target high-risk groups and utilize imaging modalities like magnetic resonance imaging and endoscopic ultrasound have generated promising results. These programs, however, have thus far been relatively expensive and limited in scope [11].

AI has the potential to be a significant advance. AI-based algorithms can be applied to medical records and to imaging. AI-based algorithms can be trained to scour electronic patient medical records and imaging scans for subtle patterns, which may not be recognizable to the human eye, yet that indicate an increased risk of PC. Clinicians could then be alerted and even guided on the best ways to evaluate their patients further. AI-based algorithms have already been built that can evaluate computed tomography and other scans for subtle changes caused by low-stage, curable, pancreatic neoplasms. These algorithms could quietly run in the background, evaluate the millions of computed tomography and other scans that are already being performed for other indications, and have the potential to identify changes in the pancreas that radiologists could easily miss in their day to day practice. Again, the program could alert the radiologist to look more closely at the images of the pancreas, and even suggest the best next steps to evaluate the subtle AI-detected changes. This approach has the advantage of not requiring additional testing until an abnormality is discovered. But enthusiasm about AI technologies must be tempered by the yet unproven real-world benefit and privacy concerns of these tools.

The growing emphasis on early detection of PC and its precursors should be balanced with a consideration of the costs and harms of screening. Costs are incurred during acquisition of the screening cohort, initial testing, confirmatory imaging and biopsies, surgery and other treatments, and post-treatment follow up and care. Screening can also cause serious patient harm. This harm includes the psychological stresses that individuals will feel when they are told that they are at increased risk, the worries from an initial result, and the medical complications that can occur from unnecessary biopsies and surgeries. The pancreas lies deep in the abdomen, and surgical resection of the head of the gland (the pancreatoduodenectomy) is associated with a 1-2% operative mortality rate and significant incidence. If this surgery is done for a false positive screening test or low-risk precursor lesion, we have done significant harm to the individual.

As the researchers look forward to the next five to ten years, authors hope that new technical advances will improve the sensitivity and specificity of screening for PC. Our colleagues also anticipate a better understanding of who is at risk, and of which groups will benefit most from screening. The development of new AI-based tools might improve screening approaches and help refine the identification of at-risk populations. The challenge, then, will be to fulfill these goals in a cost-effective manner that minimizes patient harm and to prove, prospectively and rigorously, the real-world value of these interventions before widespread implementation [11].

Now, regarding this pathology in our country at the national level. The incidence of PC in the Republic of Kazakhstan in 2023 was 6.5 per 100,000 population (6.0 in 2022), with a growth rate of 7.6% compared to the previous year. It ranked 8th among all nosological forms of malignant neoplasms, accounting for 1,290 cases in absolute numbers (1,175 cases in the previous year). The proportion of cases diagnosed for the first time, recorded by oncology organizations, was 3.5% (3.3% in 2022), moving up one place from 12th place to 11th place. In this case, 631 men fell ill (the proportion is 3.9%), women –

659 (the proportion is 3.2%) [12].

The rate of PCa above the national average was established in 10 regions of the country: Kostanay – 11.3 (the maximum rate); North Kazakhstan – 10.7; Pavlodar – 10.6; East Kazakhstan and Abay – 10.0; West Kazakhstan – 9.1; Karaganda – 8.4; Akmola – 8.1; Zhetysu – 7.9 regions and the city of Almaty – 7.3. This indicator is below the national average in the remaining 10 regions: Turkestan – 3.1 (the lowest rate); Mangistau – 3.3; Kyzylorda and Almaty – 3.8; Zhambyl – 4.2; Atyrau – 5.0; the city of Shymkent – 5.2; Ulytau – 5.9; Aktope – 6.1 regions and the city of Astana – 6.3 per 100,000 population.

The mortality rate from this pathology was 4.1 per 100,000 population with a growth rate of 5.7% compared to the previous year (3.8 in 2022).

The regions where the mortality rate from PC is above the national average (4.1 per 100,000 population) include: East Kazakhstan – 7.3 (the highest level); Abay and Akmola – 6.6; Pavlodar and Kostanay – 6.4; West Kazakhstan – 5.6; the city of Almaty – 4.9; Karaganda – 4.6; the city of Astana – 4.5. The North Kazakhstan region is on par with the national average. The lowest rates are recorded in the Atyrau and Turkestan regions – 2.3, followed by: Aktope, Kyzylorda and Mangistau – 2.6; the city of Shymkent – 2.8; Zhambyl – 2.9; Almaty – 3.0; Ulytau – 3.2; Zhetysu – 3.9 regions per 100,000 population [12].

The one-year lethality rate was 52.1% (51.0% in 2022), which is the highest percentage among all nosological forms of malignant tumors; every second patient dies in the first year after the diagnosis of this formidable disease. Moreover, the ratio between the one-year lethality and advanced stage (stage IV) was 1.5 (in 2022 – 1.4). At the same time, we recall that the value furthest from “1” is the worst ratio between the one-year lethality and neglect rates.

Now, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were actively identified than in 2022. This is 25,193 patients compared to 23,623 patients identified in 2022, i.e., +6.6%. This is due to the continued easing of the epidemiological situation due to the coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during preventive examinations increased from 62.0% to 62.4% of the total number of patients identified for the year.

Of course, early diagnosis rates are very important when analyzing the epidemiological situation. Overall, of all cancer cases detected in all locations, the proportion of forms detected in the early stages (stages 0, I-II) increased in 2023 from 66.3% to 67.9%.

Regarding PC, the early detection rate of this pathology during preventive examinations increased from 27.9% to 34.0%. The absolute number of patients with PC identified during preventive examinations was 574 (577 in the previous year). Of these, 195 were in the early stages (compared to 161 in 2022).

The regions where the proportion of patients with early stage I of the pathology in question is above the national average (4.5% and 4th place among the worst indicators only after liver cancer (3.8%), nasopharynx (3.7%) and laryngopharynx (2.7% - the worst indicator) include the following regions: North Kazakhstan – 16.1%; (the best indicator); Kyzylorda – 12.5%; Zhambyl – 11.8%; Zhetysu – 9.4; Atyrau – 8.8; Abay – 8.3%; Turkestan – 6.2%; the city of Astana – 5.9%; West Kazakhstan – 5.3%.

The lowest indicators of early diagnosis were recorded in: Almaty, Mangistau, Ulytau regions and the city of Shymkent – not a single patient (0.0% is the worst indicator). They are followed by the following regions: Kostanay – 1.1%; Karaganda – 1.2%; East Kazakhstan – 1.6%; Aktope – 1.8%; Akmola – 3.3%; Pavlodar and the city of Almaty – 2.5% [12].

The regions where the proportion of patients with PC detected at stages I-II is above the national average (26.6%) include the following regions. North Kazakhstan region stands out separately, where every second patient was detected in the early stages of the disease – 55.4%. Then come: Atyrau – 38.2%; Zhambyl – 35.3%; Zhetysu – 32.1%; Kyzylorda – 31.3%; Kostanay and Abay – 30.0%; Aktope – 26.8% of the regions. Low rates of early diagnosis were recorded in Ulytau – 7.7% (the worst result in the country); Mangistau – 11.5%; Almaty – 18.2%; the city of Shymkent – 18.3%; Turkestan – 18.5%; West Kazakhstan – 21.1%; East Kazakhstan – 22.6%; Pavlodar – 24.1%; the city of Astana – 24.7%; Akmola – 25.0%; the city of Almaty – 25.3%; Karaganda – 25.6% regions [12].

As the data above clearly demonstrates, there is a significant range in early diagnosis rates across the country, from very good to alarming. While migration and other factors influencing early diagnosis rates must be taken into account, the results obtained provide a reason for oncologists, endocrinologists, radiologist, ultrasound technician, and general practitioners to continue to improve. Improving early diagnosis rates for malignant tumors remains a fundamental tenet and a key objective of medicine as a whole, and remains a pressing issue today.

The proportion of stage IV PC among all malignant neoplasms was 36.5%, ranking first among all malignant neoplasms in the country. Overall, in 2023, the proportion of stage IV malignant neoplasms across the republic, across all nosologies, decreased from 12.58 to 11.7% (from 4,790 to 4,735 patients). Naturally, this was due to other tumor localizations.

As for the average national indicator of the proportion of stage IV (36.5%), the North Kazakhstan region stands out against this background - 14.3%; followed by the following regions: the city of Almaty (25.9%); Zhetysu (26.4%); Atyrau (26.5%); Almaty (27.3%); Aktobe (30.4%); Pavlodar (32.9%); the city of Shymkent, West Kazakhstan and Zhambyl regions (33.3%); Mangistau (34.6%); East Kazakhstan (35.5%); Kyzylorda (40.6%); the city of Astana (41.2%); Akmola (45.0%); Kostanay (46.7%); Karaganda (48.8%). The most deplorable situation with neglect is in three regions of our country: Turkestan (52.3%); Abay (55.0%); and Ulytau (69.2%).

The total number of patients with malignant neoplasms registered with specialized oncology organizations of the republic continued to increase and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the previous year (2022 – 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1,055.3 to 1,096.4 per 100,000 population. This increase is due to both increased incidence and detection of the disease, as well as increased cancer patient survival.

Furthermore, statistical data on patients diagnosed with malignant neoplasms who have been under observation for 5 years or more and who continue to be monitored in 2023 showed that the number of patients under observation by oncology organizations in Kazakhstan for over five years continued to grow, reaching 117,616 at the end of the reporting year, an increase of 6.2% (2022: 110,790, an increase of 6.6%) (Form No. 7).

Another important clinical aspect worth noting is the coverage of patients diagnosed with PC in the Republic of Kazakhstan with specialized treatment.

In 2023, the number of hospitalizations for all types of malignant tumors in the country's oncology organizations amounted to 108,252 cases (2022: 101,095), representing a 7.1% increase compared to the previous year. This is due to the steady growth of the cancer patient population, improved standardization of oncology care, and the development of palliative and restorative services.

At the end of 2023, the absolute number of PC patients who completed specialized treatment was 338, with 384 patients continuing treatment. The following results were obtained in percentages by treatment methods and types. The overwhelming majority of patients received comprehensive treatment (57.1%), drug treatment alone (19.8%), surgery alone (19.2%), radiation therapy alone (0.6%), and chemoradiation (0.3%).

Next, regarding five-year patient survival. As for PC, at the end of 2023, 1,270 people were registered for follow-up care, or 6.4 per 100,000 population (at the end of 2022, 1,156 patients, or 5.9 per 100,000 population, respectively).

Moreover, in terms of mortality, PC has held the lead for many years. The mortality rate among observed cohorts in 2023 was 63.6%.

The five-year survival rate for patients with PC was 30.2% in 2023, which is lower than the previous year; in 2022 - 31.7% [12].

In summary, despite the increasing effectiveness of preventive screenings and improved early detection rates, PC continues to experience a relatively high incidence of new cases each year, with a five-year survival rate of only 30.2%, meaning only one in three survives the five-year mark. The paucity, variability, and subtlety of symptoms, along with their similarity to various non-core conditions, contribute to the neglect and progression of the disease, even during regular follow-up. This requires oncologists, primary care providers, and, of course, endocrinologists, radiologists, and ultrasound specialists to increase cancer awareness, inform the public about early symptoms that may indicate this pathology or the onset of proliferative changes, and implement high-tech diagnostic procedures, including for the purpose of differential diagnosis and, consequently, timely treatment. People at risk are advised to visit specialized specialists annually and, if necessary, undergo screening.

An epidemiological assessment of the PC situation in our country shows that there are sometimes significant regional differences not only in incidence rates but also in early diagnosis and mortality rates. Therefore, this pathology continues to be a serious problem in modern clinical oncology.

References

1 Klinicheskij protokol diagnostiki i lechenija «Rak podzheludochnoj zhelezy» - Odobren Ob#edinennoj komissiej po kachestvu medicinskih uslug Ministerstva zdavoohranenija Respubliki Kazahstan ot 14 dekabnja 2023 goda Protokol №198 – 26 s (In Russ.).

2 Hirabayashi K, Saika T, Nakamura N. Background features in the cytology of pancreatic neoplasms. *DEN Open*. 2022 Mar 23;2(1):e105. doi: 10.1002/deo2.105.

3 Selvaggi SM. The value of concurrent endoscopic ultrasound-guided fine needle aspirates and needle core biopsies in the diagnosis of pancreatic neoplasms. *Diagn Cytopathol*. 2022 Oct;50(10):459-462. doi: 10.1002/dc.25016.

4 Lv G, Zhang L, Gao L, Cui J, Liu Z, Sun B, Wang G, Tang Q. The application of single-cell sequencing in pancreatic neoplasm: analysis, diagnosis and treatment. *Br J Cancer*. 2023 Jan;128(2):206-218. doi: 10.1038/s41416-022-02023-x.

5 Vicentini C, Calore F, Nigita G, Fadda P, Simbolo M, Sperandio N, Luchini C, Lawlor RT, Croce CM, Corbo V, Fassan M, Scarpa A. Exosomal miRNA signatures of pancreatic lesions. *BMC Gastroenterol*. 2020 May 6;20(1):137. doi: 10.1186/s12876-020-01287-y.

6 Faur AC, Lazar DC, Ghenciu LA. Artificial intelligence as a noninvasive tool for pancreatic cancer prediction and diagnosis. *World J Gastroenterol*. 2023 Mar 28;29(12):1811-1823. doi: 10.3748/wjg.v29.i12.1811.

7 Hsieh MJ, Chiu TJ, Lin YC, Weng CC, Weng YT, Hsiao CC, Cheng KH. Inactivation of APC Induces CD34 Upregulation to Promote Epithelial-Mesenchymal Transition and Cancer Stem Cell Traits in Pancreatic Cancer. *Int J Mol Sci*. 2020 Jun 23;21(12):4473. doi: 10.3390/ijms21124473.

8 Huang B, Trujillo MA, Fujikura K, Qiu M, Chen F, Felsenstein M, Zhou C, Skaro M, Gauthier C, Macgregor-Das A, Hutchings D, Hong SM, Hruban RH, Eshleman JR, Thompson ED, Klein AP, Goggins M, Wood LD, Roberts NJ. Molecular characterization of organoids derived from pancreatic intraductal papillary mucinous neoplasms. *J Pathol*. 2020 Nov;252(3):252-262. doi: 10.1002/path.5515.

9 Jain M, Atayan D, Rakhmatullin T, Dakhtler T, Inokenteva V, Popov P, Farmanov A, Viborniy M, Gontareva I, Samokhodskaya L, Egorov V. KRAS Copy Number Gain in Cell-Free DNA Analysis-Based Liquid Biopsy of Plasma and Bile in Patients with Various Pancreatic Neoplasms. *Int J Mol Sci*. 2025 Sep 9;26(18):8763. doi: 10.3390/ijms26188763.

10 Angerilli V, Sabella G, Simbolo M, Lagano V, Centonze G, Gentili M, Mangogna A, Coppa J, Munari G, Businello G, Borgia C, Schiavi F, Pusceddu S, Leporati R, Oldani S, Fassan M, Milione M. Comprehensive genomic and transcriptomic characterization of high-grade gastro-entero-pancreatic neoplasms. *Br J Cancer*. 2024 Jul;131(1):159-170. doi: 10.1038/s41416-024-02705-8.

11 Mazer BL, Lee JW, Roberts NJ, Chu LC, Lennon AM, Klein AP, Eshleman JR, Fishman EK, Canto MI, Goggins MG, Hruban RH. Screening for pancreatic cancer has the potential to save lives, but is it practical? *Expert Rev Gastroenterol Hepatol*. 2023 Jan-Jun;17(6):555-574. doi: 10.1080/17474124.2023.2217354.

12 Kaidarova D.R., Shatkovskaya O.V., Ongarbayev B.T., Zhylkaidarova A.Zh., Seisenbayeva G.T., Lavrentyeva I.K., Sagi M.S. Indicators of the oncology service of the Republic of Kazakhstan, 2023: statistical and analytical materials – Almaty: KIOR JSC, 2024. – 410 p.

Pedagogical sciences

UDC 21102

ARTIFICIAL INTELLIGENCE AND GAME METHODS IN TEACHING ENGLISH TO PRESCHOOLERS

Beisembayeva A.B

English Language Teacher,

College of Humanities of the city of Ush-tobe

Otizbayeva ZH. K.

Lecturer of the specialty "Preschool Education"

College of Humanities of the city of Ush-tobe

Abstract

The purpose of this study was to identify the effectiveness of the integration of artificial intelligence (AI) technologies and game methods in the process of preparing future preschool teachers to teach English to preschool children. In the course of the study conducted at the College of Humanities in Ush-tobe, practical training of students was organized, within the framework of which they mastered and developed game tasks using free online platforms (LearningApps, Quizizz, Wordwall, Blooket, Mentimeter) equipped with AI tools. To assess the effectiveness, a pedagogical experiment was conducted, which included questionnaires, testing and observation of the work of students at various stages of the development of game lessons. The results of statistical analysis showed that the use of AI tools and game methods helps to increase the motivation of students to create innovative educational materials for preschoolers, improves their skills in using digital tools, and also contributes to the formation of a creative approach to teaching English. In addition, it was found that game tasks based on the principles of cooperation and interactivity increase the interest of preschoolers in learning a foreign language and allow them to develop speech and communication skills in a more accessible and exciting form. The results obtained can be widely used in the training of teachers, as well as in the practical teaching of English to preschoolers in the context of the digital transformation of the education system of Kazakhstan.

Keywords: artificial intelligence, game methodology, teaching English, preschoolers, teacher training.

Introduction

The relevance of the use of artificial intelligence and game technologies in teaching English to preschoolers in Kazakhstan is due to the current trend towards the digital transformation of education [1]. The State Program for the Development of Education in the Republic of Kazakhstan for 2020-2025 focuses on the need to develop future teachers' skills in using the latest digital tools to improve the quality of the educational process [2].

The purpose of this study is to develop and test a practice-oriented model for preparing future preschool teachers for teaching English based on the integration of AI technologies and game methods.

The objectives of the study include:

- Study of the theoretical foundations of the use of AI and game methods in preschool teaching of English.
- Development and implementation of an experimental student training course in the educational process based on the use of free online platforms with AI elements.
- Analysis of the effectiveness of the implementation of this methodology (through questionnaires, testing, observations and statistical data processing).

The theoretical significance of the work lies in the expansion of scientific ideas about the possibility of using AI technologies and game forms of training in the professional training of teachers. The practical significance lies in the development and description of specific tasks and methodological materials that can be used in the training of future teachers of preschool and primary education.

The problem of the research is to search for optimal forms and methods of mastering innovative technologies by future teachers that allow them to effectively teach English to preschool children. **Hypothesis:** the integration of AI and game methods into the system of training students contributes to increasing their readiness to develop and implement modern English lessons for preschoolers.

2. Materials and methods

2.1. Materials, equipment and software

In the course of the study, a set of digital services and applications was used:

- **LearningApps (learningapps.org):** An online platform for creating interactive exercises.
 - **Quizizz (quizizz.com):** A service for creating and conducting quizzes and surveys in real time.
 - **Wordwall (wordwall.net):** an online service for the formation of various types of game tasks.
 - **Blooket (blooket.com):** A platform for creating engaging educational games with elements of competition and teamwork. Some game modes use AI algorithms to adapt difficulty.
 - **Mentimeter (mentimeter.com):** A service for creating interactive presentations with polls, quizzes, and word clouds, allowing you to quickly get feedback and engage students.
 - Microsoft Office applications (Word, PowerPoint, Excel) and free analogues of Google Docs, Google Forms for processing the results of questionnaires and testing.
 - If necessary, SPSS and Microsoft Excel were used for the initial statistical processing of the data.
- All of these platforms are provided on a shareware model or completely free, which makes them especially relevant for implementation in the educational process with limited resources. Some platforms, such as Blooket, use AI elements to dynamically adapt the difficulty of assignments based on student progress, which can be demonstrated to future educators as an example of personalizing learning.*

2.2. Research methods

The pedagogical experiment was carried out in two stages:

- **The ascertaining stage** is the collection of initial data on the skills and readiness of students to use AI and game techniques (questionnaires, entrance testing).
- **The formative stage** is the organization and conduct of trainings, seminars and practical classes on the development of game tasks with AI elements, their subsequent approbation in simulated classes with preschoolers.

The survey was conducted at the beginning and at the end of the experiment in order to identify the dynamics of students' attitudes to the use of AI and game techniques.

Testing included testing knowledge of the theory and methodology of teaching English to preschoolers, as well as practical tasks on creating game resources.

Observation was carried out in the process of developing tasks by students, as well as during their approbation in the conditions of classes.

2.3. Study participants

The study involved 20 2nd year students of the specialty "Preschool Education" of the Humanitarian College of Ushtobe. The age of students ranged from 17 to 22 years, all of them take a course in the methodology of teaching English to preschool children as part of their training.

2.4. Research materials

In quantitative terms, during the experiment period, the following was developed:

- 15 game tasks on the LearningApps platform on the topics of "Colors", "Numbers", "Animals", "Family", etc.
- 10 quizzes in the Quizizz service for prompt testing of lexical and grammatical skills in preschoolers.
- 8 game templates on Wordwall (drag and drop words, create puzzles, wheel of fortune, etc.).
- 7 interactive tasks with gamification elements on the Blooket platform (for example, "Blooket", "Gold Rush" modes).
- 5 interactive polls and word clouds created in Mentimeter to collect feedback.

The study involved 20 students, all of whom filled out questionnaires before and after training.

Example of descriptors for evaluating developed tasks:

- **The content part:** compliance with the age characteristics of preschoolers; the relevance of lexical and grammatical material.
- **Game component:** the presence of interactive elements, a variety of forms of tasks, the level of children's involvement.
- **Technical implementation:** correct operation of links, platform settings, availability of elements of automatic response verification (AI module, if applicable).

Fragment of questionnaire questions (10 questions, 5-point scale):

1. How comfortable are you working with online platforms (LearningApps, Quizizz, Wordwall, Blooket, Mentimeter)?
2. Do you find it effective to use AI to automate answer checking?
3. How confident are you in your ability to develop game tasks with AI elements for preschoolers?

4. How do you assess the possibilities of using the assignment generation feature (if available on the platform) to create training materials?

Statistical analysis was carried out in Microsoft Excel using descriptive statistics (means, mode, median) and verification of the significance of differences (Student's t-test) in the SPSS program.

3. Main part

3.1. Course of scientific research

The study was carried out in several consecutive stages:

- **Diagnostic:** questionnaires and testing aimed at identifying the initial level of students' competencies in the use of AI and game techniques.
- **Design:** organization of training cycles, during which students got acquainted with free platforms, their functionality and opportunities for integration into pedagogical practice. Particular attention was paid to the Blooket and Mentimeter platforms as new and interesting tools, as well as the possibilities of using AI to generate questions in Quizizz and adaptive functions in Blooket.
- **Practical:** students independently develop game tasks, discuss and adjust them under the guidance of a teacher. Students experimented with different types of tasks, including quizzes with automatic checking, interactive matching and classification exercises, as well as games with elements of competition.
- **Approbation:** the use of the developed tasks in simulated conditions (children's groups) and the collection of feedback from the preschoolers themselves and teachers-mentors.
- **Analytical:** processing of the data obtained, formulation of conclusions about the effectiveness of the technique.

3.2. Critical analysis of scientific works on the topic

In recent years, there have been more and more studies on the use of AI and game methods in teaching foreign languages [3, 4]. Most of the works emphasize the positive role of game resources in the formation and development of communication skills of preschoolers [5]. At the same time, there is a growing interest in using the capabilities of AI to automate the creation of educational materials and personalize learning [6]. However, empirical data on the use of free online platforms with AI elements in the Kazakh context of training future preschool teachers are still insufficient [7]. The present study contributes to the study of this issue, focusing on the practical application of modern and affordable tools.

3.3. Developed game tasks

Examples of game tasks created by students:

- **LearningApps:** "Color Matching Game" – preschoolers are asked to match colors with their names in English, and the platform automatically detects errors and gives hints.
- **Quizizz:** "Animals around Us" is a quiz where the child must choose the correct answer options with the possibility of instant automatic feedback (the AI module marks the correctness or incorrectness of the answer). Some features of Quizizz allow you to generate questions based on the entered topic, which was demonstrated to students.
- **Wordwall:** "My Family" is an interactive puzzle in which the child collects words (mother, father, sister, etc.) in the correct order. After completing the puzzle, the system generates a short motivational phrase in English.
- **Blooket:** "Animal Kingdom Race" is a multiplayer game in which children compete by answering questions on the topic of "Animals". The platform uses AI algorithms to adapt the difficulty of the questions and provide dynamic gameplay.
- **Mentimeter:** "What is your favorite toy?" is an interactive survey where preschoolers (in a simulated situation) choose their favorite toy from the proposed options in English. The results are displayed in the form of a diagram, which allows you to visualize the preferences of children.

The purpose of such tasks is to stimulate speech activity and interest of preschoolers. The method of use involves short game sessions, alternating with explanation and consolidation of the material. Future teachers learned to integrate these tasks into various stages of the lesson, using them to introduce new vocabulary, practice pronunciation and consolidate the studied material.

Hypothesis testing. The hypothesis that the combination of AI technologies and game methods will contribute to improving the level of training of future teachers was generally confirmed. The results of the final testing on the methodology of teaching English to preschoolers showed statistically significant improvements in indicators ($p < 0.05$), and the analysis of questionnaires showed an increase in positive feedback on the use of AI platforms and their capabilities for generating tasks and adaptive learning.

4. Results and discussions

The results are grouped into three main groups:

Questionnaire. At the end of the experiment, 88% of students noted an "increase in motivation" to design interactive activities (compared to 45% at the beginning), and 82% "feel more confident" in using AI resources. There has been a significant increase in the use of platforms such as Blooket and Mentimeter due to their interactivity and ability to engage learners. (**Table 1** - Comparison of the data of the questionnaire of students before and after the experiment)

Table 1 - Comparison of the data of the questionnaire of students before and after the experiment

Indicator	Before experiment (average)	Post-experiment (average)	Statistical significance (p-value)
Confidence in knowledge of the use of AI	2.9	4.3	<0.05
Interest in the use of game techniques	4.1	4.8	> 0.05
Willingness to use AI in future work	3.3	4.7	<0.05
Evaluation of the usefulness of new platforms (Blooket, Mentimeter)	-	4.5	-
Evaluate AI capabilities to generate and adapt jobs	-	4.2	-

Practical tasks

About 80% of the game tasks developed by students received a positive assessment from college teachers and teachers-mentors. It was noted that students have become more active in using the capabilities of AI platforms, including the functions of automatic verification, adaptation of complexity and content generation.

Overall, the results suggest that expanding the range of free platforms used, especially those with AI features such as responsiveness and assignment generation, significantly improves the effectiveness of preparing students to work with preschoolers. The discussion of the data confirms that game forms with AI elements make learning more personalized and exciting for both future teachers and their future students [4, 6].

Conclusion

The study confirmed the hypothesis that the integration of AI technologies and game methods using a variety of free online platforms contributes to a more effective development of the necessary competencies for teaching English by future preschool teachers. The main results include:

- A significant increase in the level of students' motivation and their readiness to use interactive technologies, including new platforms with AI elements.
- Increasing the average academic performance of students in the methodology of teaching English to preschoolers.
- Development of students' skills in designing, analyzing and reflecting on the play activity of preschoolers using modern digital tools.
- Students are aware of the opportunities to use the assignment generation and adaptive learning features provided by some AI platforms.

The practical significance of the work lies in the fact that the described game tasks and methodological recommendations can be used in the educational process of educational institutions of Kazakhstan. The results indicate the promise of further exploring and implementing the capabilities of artificial intelligence in combination with game-based techniques to improve the process of teaching English at an early stage.

References

1. Badakova, L.S. Digital Transformation of Education in Kazakhstan: Trends and Prospects // Scientific Journal "Education and Science". – 2021. – № 4. – S. 112–119.
2. Ministry of Education and Science of the Republic of Kazakhstan. State Program for the Development of Education in the Republic of Kazakhstan for 2020-2025. – Nur-Sultan, 2019. – 89 p.
3. Werbach, K., & Hunter, D. For the Win: How Game Thinking Can Revolutionize Your Business. – Philadelphia: Wharton Digital Press, 2012. – 148 p.
4. Hornung, C. & Bandlow, G. Game-based Learning for Early Childhood: A Systematic Literature Review // International Journal of Early Years Education. – 2018. – 26(3). – P. 302–317.
5. Council of Europe. Common European Framework of Reference for Languages: Learning, Teaching, Assessment. – Council of Europe, 2020. – 278 p.
6. Hwang, G. J., Xie, H. C., Zeng, W. D., & Huang, Y. M. (2021). Application of artificial intelligence in education: Bibliometric analysis and research trends. *Sustainability*, 13(17), 9243.

7. Yusupova, G.M. *Ispol'zovanie igrovye tekhnologii v obuchenii doshkol'nikov angliyskomu yazyku v usloviyakh tsifrovizatsii* [The use of game technologies in teaching preschoolers English in the context of digitalization]. – 2022. – № 2. – P. 51–57.

8. LearningApps.org. (Дата обращения: 17 марта 2025). <https://learningapps.org/>

9. Quizizz.com. (Дата обращения: 16 марта 2025). <https://quizizz.com/>

10. Wordwall.net. (Дата обращения: 18 марта 2025). <https://wordwall.net/>

11. Blooket.com. (Дата обращения: 18 марта 2025). <https://blooket.com/>

12. Mentimeter.com. (Дата обращения: 16 марта 2025). <https://www.mentimeter.com/>

Technical sciences

OPTIMIZATION OF ELECTRONIC-OPTICAL SURVEILLANCE USING UNMANNED AERIAL VEHICLES AND ITS APPLICATION CAPABILITIES

Bekirova Lale

*Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Professor.*

Hasanzade Kamil

*Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Master's Student.*

PİLOTSUZ UÇUŞ APARATLARI İLƏ ELEKTRON-OPTİK MÜŞAHİDƏNİN APARILMASI VƏ TƏTBİQ İMKANLARININ OPTİMALLAŞDIRILMASI

Bəkirova Lalə

*Azərbaycan Dövlət Neft və Sənaye Universiteti,
Cihaz Mühəndisliyi Bölümü, Prof.*

Həsənzadə Kamil

*Azərbaycan Dövlət Neft və Sənaye Universiteti,
Alət mühəndisliyi fakültəsi, magistratura tələbəsi.*

ОПТИМИЗАЦИЯ ПРОВЕДЕНИЯ ЭЛЕКТРОННО-ОПТИЧЕСКОГО НАБЛЮДЕНИЯ И ВОЗМОЖНОСТЕЙ ЕГО ПРИМЕНЕНИЯ С ИСПОЛЬЗОВАНИЕМ БЕСПИЛОТНЫХ ЛЕТАТЕЛЬНЫХ АППАРАТОВ

Бекирова Лале

*Азербайджанский государственный нефтегазовый университет,
Кафедра приборостроения, профессор.*

Хасанзаде Камиль

*Азербайджанский государственный нефтегазовый университет,
Кафедра приборостроения, магистрант.*

Abstract

In the article, an analysis is conducted of the conditions for the use of unmanned aerial vehicles (UAVs) and the evaluation of data obtained as a result of their application in the successful implementation of tasks related to search and rescue operations, as well as the surveillance of strategic facilities. The importance of applying advanced technologies for rapid response in emergency situations, effective personnel operations, and the determination of deployment positions is substantiated, and the necessity of UAV utilization is particularly emphasized. Based on current operational tasks, the study examines how UAVs operate in complex and challenging environments through the application of technological innovations.

It is noted that currently available multirotor-, fixed-wing-, and VTOL-based UAVs classified as nano, micro, mini, small, medium, and large according to their weight and size are used as primary and auxiliary elements for the digitalization of the integrated deployment of forces and assets during numerous international and local search and rescue operations, as well as other special missions. Furthermore, their integration into artificial intelligence-based solutions for process optimization is highlighted.

During UAV-based search and rescue operations, the optimization of electronic-optical surveillance and its application capabilities, achieved through proper planning of UAV flight routes and observation algorithms, is investigated using approaches such as "survivability," "mass," "swarm," and similar methodologies. The criteria that must be considered to optimize UAV-based surveillance during operational planning are identified and justified.

In addition, the article determines that UAVs are widely employed in a broad range of applications, including aerial reconnaissance and search and rescue missions, the delivery of medical supplies and essential equipment to designated locations within flight restrictions for emergency medical assistance, and area monitoring during emergency situations.

Xülasə

Məqalədə pilotsuz uçuş aparatlarının (PUA) istifadəsi üçün şərtlər və onların tətbiqi nəticəsində əldə edilən məlumatların axtarış-xilasetmə əməliyyatları ilə bağlı tapşırıqların uğurla yerinə yetirilməsi, eləcə də strateji obyektlərin müşahidəsi baxımından qiymətləndirilməsi təhlil edilir. Təcili vəziyyətlərdə sürətli reaksiya üçün qabaqcıl texnologiyaların tətbiqinin, personal əməliyyatlarının effektivliyinin və yerləşdirmə mövqelərinin müəyyən edilməsinin əhəmiyyəti əsaslandırılır və PUA-ların istifadəsinin zəruriliyi xüsusilə vurğulanır. Cari əməliyyat tapşırıqlarına əsaslanaraq, tədqiqat texnoloji yeniliklərin tətbiqi vasitəsilə PUA-ların mürəkkəb və çətin mühitlərdə necə fəaliyyət göstərdiyini araşdırır.

Qeyd olunur ki, hazırda mövcud olan çoxrotorlu, sabit qanadlı və VTOL əsaslı PUA-lar, çəki və ölçülərinə görə nano, mikro, mini, kiçik, orta və iri kateqoriyalarına ayrılaraq, əsas və əlavə elementlər kimi bir çox beynəlxalq və yerli axtarış-xilasetmə əməliyyatlarında və digər xüsusi missiyalarda qüvvələrin və vasitələrin integrasiya olunmuş yerləşdirilməsinin rəqəmsallaşdırılması üçün istifadə olunur. Bundan əlavə, onların proseslərin optimallaşdırılması üçün süni intellekt əsaslı həllərə integrasiyası vurğulanır.

PUA-lar vasitəsilə həyata keçirilən axtarış-xilasetmə əməliyyatlarında, PUA uçuş marşrutlarının və müşahidə alqoritmlərinin düzgün planlaşdırılması sayəsində əldə edilən elektron-optik müşahidənin optimallaşdırılması və tətbiq imkanları "sağ qalma," "kütlə," "sürü" və oxşar metodologiyalar kimi yanaşmalar əsasında araşdırılır. Əməliyyat planlaması zamanı PUA əsaslı müşahidənin optimallaşdırılması üçün nəzərə alınmalı olan kriteriyalar müəyyən edilir və əsaslandırılır.

Əlavə olaraq, məqalədə PUA-ların geniş istifadə sahələri müəyyən edilir. Bunlara hava kəşfiyyatı və axtarış-xilasetmə missiyaları, təcili tibbi yardım üçün uçuş məhdudiyyətləri çərçivəsində təyin olunmuş ərazilərə tibbi ləvazimat və zəruri avadanlığın çatdırılması, eləcə də fəvqəladə vəziyyətlər zamanı ərazi nəzarəti daxildir.

Аннотация

В статье анализируются условия использования беспилотных летательных аппаратов (БПЛА) и оценка данных, полученных в результате их применения, с точки зрения успешного выполнения задач, связанных с поисково-спасательными операциями, а также наблюдения за стратегическими объектами. Обосновывается значимость применения передовых технологий для быстрой реакции в чрезвычайных ситуациях, эффективности действий персонала и определения позиций развертывания, при этом особое внимание уделяется необходимости использования БПЛА. Исследование рассматривает, как БПЛА функционируют в сложных и труднодоступных условиях с применением технологических инноваций.

Отмечается, что в настоящее время применяются много роторные, самолетные с фиксированным крылом и БПЛА с вертикальным взлетом и посадкой (VTOL), которые классифицируются по весу и размерам как нано-, микро-, мини-, малые, средние и большие, и используются в качестве основных и вспомогательных элементов для цифровизации интегрированного развертывания сил и средств во множестве международных и местных поисково-спасательных операций, а также других специальных миссий. Дополнительно подчеркивается их интеграция в решения на основе искусственного интеллекта для оптимизации процессов.

В рамках поисково-спасательных операций с использованием БПЛА исследуется оптимизация электронно-оптического наблюдения и возможности его применения, достигаемые за счет правильного планирования маршрутов полета и алгоритмов наблюдения, с использованием подходов, таких как «выживаемость», «массовость», «рой» и аналогичных методологий. Определяются и обосновываются критерии, которые необходимо учитывать для оптимизации наблюдения на основе БПЛА при планировании операций.

Кроме того, в статье определяется широкий спектр применения БПЛА, включая воздушную разведку и поисково-спасательные миссии, доставку медицинских средств и необходимого оборудования в указанные зоны в рамках ограничений полета для оказания экстренной медицинской помощи, а также мониторинг территорий в чрезвычайных ситуациях.

Keywords: VTOL, unmanned aerial vehicle, onboard control and measurement system, inertial measurement unit, accelerometer, gyroscope, RPM

Açar sözlər: VTOL, pilotsuz uçuş aparatı, bort nəzarət-ölçü sistemi, ətalətli ölçü modulu, akselerometr, giroskop, RPM.

Ключевые слова: VTOL, беспилотный летательный аппарат, бортовая система контроля и измерений, инерциальный измерительный модуль, акселерометр, гироскоп, RPM.

Introduction

In cases where human observation is impossible or difficult, monitoring an area by means of an electronically controlled electro-optical payload (PL) mounted on a remotely operated UAV, along with the capability to transmit this video imagery over long distances, has provided significant advantages to this type of aerial platform [1–3].

The development of information acquisition, processing, and transmission, as well as digital and artificial intelligence technologies, has led to a significant improvement in image quality, transmission speed, and data volume, enabling their transmission over longer distances.

Nevertheless, digital technologies also have certain limitations, which affect the efficiency of their application in reconnaissance and surveillance systems.

Electronic-optical systems installed on UAVs are mainly used for the following purposes:

- conducting airborne electronic-optical reconnaissance (surveillance) to monitor the operational situation in an area of interest and transmitting live imagery to the control center;
- obtaining detailed video imagery of objects or areas within the area of interest, as well as areas, zones, and objects subject to patrol and surveillance flights;
- acquiring photographic and/or video images of objects located in the area that cannot be visually observed by the human eye, measuring the distance to the target, and providing laser designation (illumination).

From a technical perspective, electronic-optical PL are mounted either directly onto the UAV airframe as an integrated system through their structural design or via a gyroscopically stabilized adjustable platform. This gyrostabilized system ensures that the electronic-optical PL can be rotated and controlled in any direction at a specified speed. A stable, rigid, and stabilized connection between the UAV structure and the PL along the Y-axis, together with the capability of 360° rotation, creates the conditions for acquiring stable, high-quality, high-resolution photo and video imagery [4–6].

Cameras and electronic-optical devices are primarily used to obtain images of the front or surrounding areas of the UAV during remote flight operations. For this purpose, during flight planning, in addition to meteorological constraints, factors such as flight altitude, air humidity, viewing angle, and azimuth must be taken into account. Furthermore, depending on the season, the angle of solar incidence during imaging and the rotation of the PL relative to the UAV landing gear direction must be strictly controlled [7, 8].

The application of optical devices enables the solution of many tasks. It is known that, depending on the distance to the target and the quality (high resolution) of the acquired imagery of the observed area, the weight and cost of such devices increase. To obtain high-quality results, strict technical requirements must be met to stabilize the UAV during aerial imaging. Non-stabilized optical systems provide limited support for target tracking and observation in the “lock-on” mode, and attempts to apply this mode result in numerous limitations and difficulties. Optical devices mounted on gyrostabilized platforms are more advantageous, and substantial practical experience in their application has been accumulated by specialists [9, 10].

Gyrostabilized platform-based optical devices ensure the tracking of selected stationary and moving targets during flight. The integration of daylight (TV), thermal, and infrared (IR) cameras into a single platform enables the acquisition of high-information-content imagery. This allows the obtained video and photographic images to be processed and converted into analog or digital signal formats. In addition, the laser rangefinder technology integrated into the gyrostabilized platform enables precise determination of target coordinates. If the electronic-optical PL is further integrated with a laser designator for guiding laser-guided missiles and bombs, using an additional laser generator (energy source), its weight, cost, and operational effectiveness are increased [11].

Resolution capabilities of electro-optical systems

The resolution capability of a digital electro-optical system refers to the system’s ability, through its lens, to form images of objects located at a given distance with a certain level of detail. The primary factor determining the resolution of electro-optical systems is the CCD (charge-coupled device) matrix, which projects the image obtained through the lens [12, 13].

The source of image data can be the terrain or the airspace. The field of view angle of the lens determines the amount of information captured. Images captured from the ground or air significantly affect the device’s resolving power. It should be noted that the displayed image depends on the physical

composition and color of the observed area, as well as the difference between the actual linear dimensions of objects on the ground and their representation on the screen.

Figure 1 shows the field of view formed by the lens of the electro-optical system. The dimensions of the field of view depend on the UAV's flight altitude, the lens's viewing angle, and the deflection angle of the lens optical axis [14].

As seen in Figure 1, the shape of the observed area is physically close to a trapezoidal geometric form. In calculations, the probability of reduced correlation can be used as an initial approach.

$$\delta = \frac{l}{R_{\text{terrain}}} \gg 0.0003 \quad (1)$$

Here, l corresponds to the length equal to the largest linear dimension of the observed area, and R_{terrain} is the average radius of the terrain. Due to the slope of the terrain, the curves present in the area (mountains, valleys) are assumed to be flat during calculations. The fact that the real appearance of the terrain is not a perfectly flat plane significantly affects the effectiveness of the electro-optical system application.

The electro-optical PL installed on a UAV is designated to perform specific functions. Therefore, the evaluation of electro-optical PL is based on factors such as the detection and tracking of typical objects during UAV operations, as well as the resolution capability of the acquired imagery and other relevant parameters [15, 16].

Depending on the capabilities of the electro-optical system installed on the UAV, one of the key parameters that allows the determination of the required flight altitude is the fill factor (Figure 2).

$$K = \frac{F_{\text{target}}}{F} \quad (2)$$

F_{target} – the area of the visible target, F – the area of the field of view (observed area).

The fill factor is the quantity that indicates how many times the required field of view must be enlarged for the selected object (target) to be visible and tracked on the observation monitor.

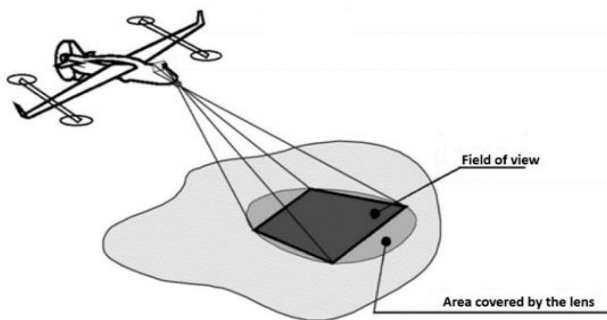


Figure 1. Field of view formed by the lens of the electro-optical system

The size of the CCD matrix significantly affects the resolution of the image obtained by the electro-optical device. Specifically, the size of the CCD matrix determines the level of detail captured from the image provided by the optical lens. The larger the matrix, the higher the level of detail and resolution of the image displayed on the system screen. To achieve a resolution close to the optical resolving power of the lens in a digital

electro-optical system, it is necessary either to have a CCD matrix of very large size or to reduce the field of view angle. The resolution capability of a digital electro-optical system (lens – CCD matrix – display) is determined based on a set of parameters that depend on the magnification of the image on the display.

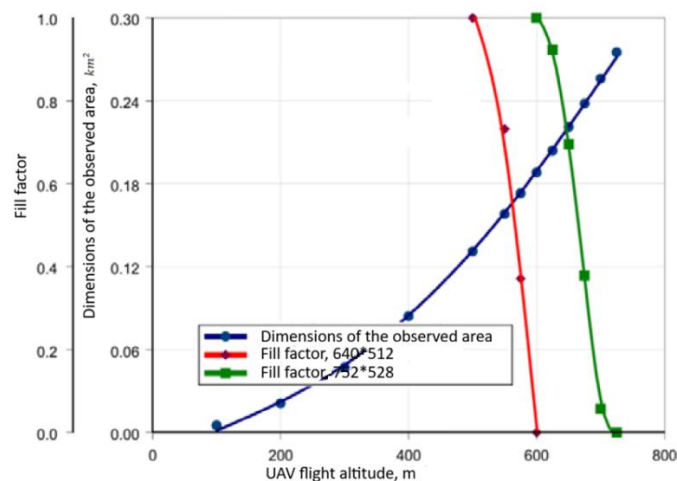


Figure 2. Graph of the fill factor dependence on flight altitude

$$R^- = f(L, \beta, \gamma, \phi, M) \quad (3)$$

Here, L terrain is the slant (inclined) distance to a point on the terrain, (β, γ, ϕ) represent the angular deviations of the observed point relative to the optical axis in right-left and up-down directions, as well as the optical axis tilt in a normal coordinate system, and M is the size of the CCD matrix.

To assess the resolution capability of a digital electro-optical system, images of characteristic objects for UAV-based search operations can be used.

The demonstration of the electro-optical system's resolution capability can be illustrated using the example of a "Human" target. The projection of the human figure is aligned with the matrix projection and represented as a corresponding surface. Depending on the size of the projection, the number of elements (pixels) in the CCD matrix can correspond to millimeter, centimeter, or meter dimensions. Therefore, when the "Human" target is maximally magnified in the image, it can be resolved according to the number of pixels corresponding to the system's resolution [14].

Observation with UAVs in security operations. During natural disasters, emergencies, and search-and-rescue tasks, the time factor plays a critical role. The use of UAVs in rescue operations increases the efficiency of search (surveillance), enhances safety, and reduces the overall duration of rescue activities.

In search and rescue operations, the main approach is the proper planning of the UAV route and observation algorithm. In practice, principles such as survival, mass, flocking, and similar strategies can sometimes be applied for these purposes.

In a crowd scenario, objects can be classified into only two types: drones and students. In this case, the drones direct the crowd to the destination using activities such as shouting, signaling, traffic lights, and similar actions. A supervisory drone monitors the crowd's behavior throughout the process and ensures movement along the planned route. For autonomous guidance, UAVs gradually replace the supervisory moderators [12].

To prevent students from being harmed in extreme routes or dangerous situations, UAVs are employed within the framework of route planning and potential rescue operations. To address these challenges, it is proposed to use UAVs for directional guidance and behavioral control by performing "forward-backward" or "left-right" movements, as well as using a "hover" mode in mid-air to execute repeated "stop" commands (Figure 3) [17–20].

Thus, for extreme scenarios, by modeling similar movement using the example of students, the

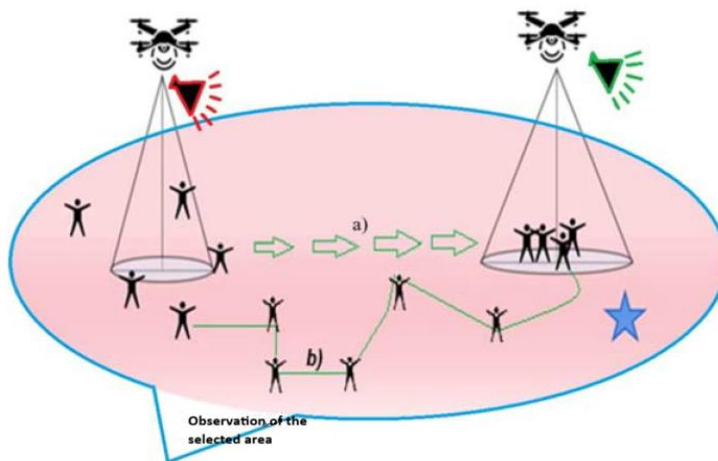


Figure 3. Rescue scenarios using drones

evacuation point or safe zone can be considered as an open area, allowing the two problems to be unified. When planning the route to the safe zone, the observation and monitoring of the targets to be rescued is transformed into a problem that balances evacuation and rescue by monitoring the target dynamics (Figure 3a shows the route).

By using an artificial intelligence program model, it is possible to describe the equations of human crowd dynamics based on Reynolds' rules. This approach can be applied for modeling disaster victims in emergency scenarios.

The unit vectors

$N_d^-, N_L^-, N_r^-, N_i^-, N_e^-$ characterize the influence forces directing students toward the assembly point using an auditory drone. Specifically, in this case, the influence force r_a represents the tendency of other students in the area to move toward the center, the inertial movement force corresponds to the remaining students relative to others, and the noise component represents random elements in the students' movement. Subsequently, the movement direction vector of the students, N^- is determined as follows:

$$N^- = \mu_d N_d^- + \mu_L N_L^- + \mu_r N_r^- + \mu_i N_i^- + \mu_e N_e^- \quad (4)$$

Here, $\mu_d, \mu_L, \mu_r, \mu_i, \mu_e$ are weight coefficients.

In emergency situations, crowd group behavior is based on four main principles:

- Avoiding collisions;
- Aligning speed with nearby members;

- Attraction toward the center by nearby members;
- Evasion from danger.

The UAV determines its position to minimize the distance between itself, the students, and the assembly point in the shortest possible time. Optimal positions for one or multiple UAVs are selected to direct the target students along the boundaries of the expanded area toward designated points near the center of this area. These points are referred to as guidance points, where students can efficiently gather and be monitored by the UAVs.

In the second stage, UAVs equipped with an acoustic broadcast system issue vocal commands, as well as movement commands from the UAV itself, to guide students under observation to designated areas. For this purpose, a route planning algorithm based on multi-objective optimization for search and rescue tasks can be implemented (Figure 3b).

The planning of the research task is divided into several levels: locating the target and establishing the communication path to reach it in minimal time in order to achieve the optimal route. Here, an optimal communication path to the target is created using the UAV, and the aerial vehicle is directed to the operational area to assist the ground team in the rescue. Algorithms can be innovatively proposed to adjust the coverage area of observation or the supported communication range during search and rescue tasks, enhancing operational efficiency. This research demonstrates the feasibility of the proposed algorithm [12, 21–24].

During emergencies at sea or in coastal waters, monitoring and search-and-rescue operations are conducted according to the above operational model. In such cases, to significantly reduce UAV resource consumption while performing wide-area searches and detecting changes, it is necessary to determine the precise perimeters of the area. Optimization of the research allows for meaningful results, which are crucial for UAV-based search and rescue observation tasks.

When performing search-and-rescue and monitoring-observation operations near the shore, it is recommended that UAVs be controlled by an operator from a land-based station. Using UAVs on vessels in open waters is less effective due to factors such as the vessel's motion affecting take-off coordinates, lack of an emergency landing area, sudden wind gusts, and high humidity in open sea conditions.

Because rapid and efficient search-and-rescue operations are critical at sea, VTOL-type UAVs deployed on vessels have demonstrated high effectiveness. VTOL UAVs, which do not require a take-off/landing strip and possess hybrid power systems, have been shown to be suitable for tasks such as monitoring oil and gas platforms, pipeline surveillance, border security, detecting and preventing smuggling, and other related operations [25].

Furthermore, UAVs are widely used in high-priority coordinated operations for real-time data transmission and visual observation via electro-optical devices to support agile decision-making. Law enforcement agencies rely on UAVs for monitoring special tasks, observing operations requiring resolution, tracking suspicious individuals and movements, maintaining public order, and providing emergency assistance, thereby demonstrating the essential role of UAVs in these activities.

During the execution of law enforcement tasks, conducting live observation that provides a wide monitoring coverage is required to ensure rapid and agile response, supported by real-time data from the operational area. Depending on the observation and reconnaissance capabilities of the deployed UAV, it is proposed to develop a sectorization scheme of the monitored area to optimize dynamic observation within the operational zone or observation sector.

To conduct comprehensive search and monitoring along the route of interest, UAVs are deployed in the required number across different areas. In urban operations, in addition to the observation and monitoring capabilities provided by UAVs, they are extensively used for patrolling incidents occurring on major roads. The ability to provide aerial support, relay information, and review UAV-captured footage over time for accident analysis further increases the need for UAV deployment [12, 26].

The operational use of drones is directly proportional to their flight duration, speed, and the functional capabilities of the electro-optical camera. Various approaches exist for monitoring moving targets using UAVs. In this context, micro and larger-class fixed-wing and VTOL UAVs are employed, allowing for the observation of larger areas from higher altitudes. Utilizing electro-optical payloads with target-tracking, laser range-finding, day/night and thermal cameras, as well as laser designators, enables effective monitoring. Additionally, conducting observations from high altitudes reduces the likelihood of visual and acoustic detection (enhancing stealth).

For the execution of special tasks requiring secrecy and confidentiality, UAV usage plays a crucial role in ensuring the successful completion of the mission. It is recommended to apply a covert observation algorithm by frequently and sharply varying the observation angle and distance between the UAV and

the target. In this approach, the UAV is controlled at a safe distance such that the target cannot detect it even if actively looking. Furthermore, maintaining the UAV over the target or performing an "orbiting" flight mode at an optimal altitude allows for high-quality dynamic observation using a continuous tracking approach [27–29].

Key improvements in organizing observation activities conducted with UAVs

Most of the time, the execution of special tasks, observation of strategic objects, search-and-rescue operations, and monitoring activities using UAVs are carried out under simple meteorological conditions and favorable observation environments. In urban areas, at sea, in complex terrains (e.g., mountainous regions), and other operational conditions, the use of UAVs with more robust technical specifications and enhanced flight safety becomes necessary.

In complex environments, additional infrastructure is required to ensure autonomy, navigation, and reliable communication links. During operation planning or in crisis situations (considering UAV energy resource limitations, navigation and communication deficiencies in both enclosed and open environments, radio-electronic warfare conditions, limited visual observation range, and laser designation for target tracking), the execution of tasks using UAVs demands extensive analytical calculations.

To address these challenges, it is recommended to use UAVs or drones with higher tactical-technical and flight-technical capabilities, equipped with advanced flight control systems and management algorithms. Energy limitations of UAVs, primarily determined by the capacity and flight duration of onboard battery accumulators, remain a key constraint [8–10].

Overall, for search-and-rescue, monitoring, and the observation of strategic objects, it is necessary to consider the scope of tasks assigned to UAVs, the continuous execution of operations, and the advantages provided by system deployment during emergencies. Attention should also be given to the durability and robustness of UAV systems, as well as their potential for future development and expansion.

Conclusion:

Criteria to Consider for Optimizing UAV-Based Observation During Operation Planning:

- Energy resource limitations;
- Surface reflectivity coefficient;
- Color;
- Emitted sound effects;
- Degree of stealth;
- Consideration of navigation and communication deficiencies in radio-electronic warfare environments;
- Visual observation range;
- Obtaining the maximum possible resolution quality from the electro-optical camera during observation, taking into account technical capabilities, season of the year, operational time of day, humidity, and other meteorological factors;
- Operations over targets with known coordinates or for unspecified activities.

References

1. R.N. Nabiyev, G.I. Garayev and A.A. Abdullayev. Conceptual functional design of hybrid energy source of unmanned convertiplane. -*Proceedings of the IOP Conference Series: Conference Scopus. Materials Science and Engineering*. -862, 022043, -2020, <https://doi.org/10.1088/1757-899X/862/2/022043>
2. R.N. Nabiyev, A.A. Abdullayev and G.I. Garayev. Structural drafting of convertiplane-type unmanned aerial vehicle. -*Norwegian Journal of development of the International Science*, -№94, -2022, p. 45-51, <https://doi.org/10.5281/zenodo.7198424>
3. R.N. Nabiyev, A.A. Abdullayev and G.I. Garayev. (2024) On-board control-measurement system for micro convertiplane-type unmanned aerial vehicles. *Eurasian Physical Technical Journal*. -21, 2(48), -61-69. <https://doi.org/10.31489/2024No2/61-69>
4. A.A. Abdullayev. VTOL mikro PUA-nın uçuşunun müxtəlif uçuş rejimlərində bort nəzarət ölçü sistemi ilə tədqiqi. *International Conference on Artificial intelligence: from theory (AICON-2024)*, -17-18 september, 2024, Nakhchvan, Azerbaijan. -s.271-277. <https://doi.org/10.5281/zenodo.14031849>
5. Nabiyev R.N., Abdullayev A.A., Garayev G.I. *International Scientific Conference Energy Management of Municipal Facilities and Environmental Technologies (EMMFT-2024) -E3S Web of Conf.* -Volume 592, -06024 (2024), DOI: 10.1051/e3sconf/202459206024

6. Набиев Р.Н., Абдуллаев А.А., Гараев Г.И., Аббасов В.А. Определение центра тяжести беспилотного летательного аппарата конвертопланового типа // Известия ЮФУ-Технические науки, № 5 (229), -2022, с.258-268, DOI: 10.18522/2311-3103-2022-5-258-268.
7. Набиев Р.Н., Гараев Г.И., Абдуллаев А.А., Аббасов В.А. Требования к беспилотным летательным аппаратам на мультироторационной основе. -Авиакосмическое приборостроение, Москва, 2018 г. № 9, с. 3-11, DOI: 10.25791/aviakosmos.09.2018. 166.
8. Набиев Р.Н., Абдуллаев А.А., Гараев Г.И. Сравнительный анализ особенностей аккумуляторных батарей на основе лития. Авиакосмическое приборостроение, -Москва, «№ 9, -2019, с. 42-55. DOI: 10.25791/aviakosmos.09.2019.867.
9. Набиев Р.Н., Абдуллаев А.А., Гараев Г.И. Анализ особенностей водорода в качестве источника энергии. Авиакосмическое приборостроение, Москва, 2021 г. № 3. -с. 41-58. DOI: 10.25791/aviakosmos.3.2021.1211.
10. Набиев Р.Н., Абдуллаев А.А., Гараев Г.И. Разработка концептуальной функциональной схемы беспилотного конвертоплана с гибридным источником энергии. Авиакосмическое приборостроение, Москва, №5. -2021, с. 03-18 DOI: 10.25791/aviakosmos. 5.2021.1217.
11. Набиев Р.Н., Абдуллаев А.А. Исследование основных аэродинамических параметров планера беспилотного летательного аппарата конвертопланового типа //-Авиакосмическое приборостроение, Москва, 2022г. № 4. -с.17-33. DOI:10.25791/aviakosmos. 4.2022.1274.
12. Fang, Z., Savkin, A.V. Strategies for Optimized UAV Surveillance in Various Tasks and Scenarios: A Review. Drones-2024, -8, 193. <https://doi.org/10.3390/drones8050193>
13. Maddern W., Pascoe G. et.al. Real-time Kinematic Ground Truth for the Oxford RobotCar Dataset.
14. Ростопчин В.В., Дмитриев М.Л. Применение цифровых оптических систем для беспилотных аппаратов. -http://uav.ru/articles/opteq_uav.pdf
15. Ростопчин В.В. «Элементарные основы оценки эффективности применения беспилотных авиационных систем для воздушной разведки».-http://www.uav.ru/articles/basic_uav_efficiency.pdf
16. Е. Евгений. Беспилотные летательные аппараты и защита границ. -<http://uav.ru/articles/granitsa.pdf>.
17. D. Magdalena and T. Piotr et.al. Hybrid Fuel Cell - Battery System as a Main Power Unit for Small Unmanned Aerial Vehicles (UAV). -Int. J. Electrochem. Sci., -8 -(2013)-8442-8463.
18. Gailler, L., Labazuy, P. et.al. Validation of a New UAV Magnetic Prospecting Tool for Volcano Monitoring and Geohazard Assessment. Remote Sens. 2021, 13, 894. <https://doi.org/10.3390/rs13050894>
19. Evans, L., Jones, T.H., Pang, K. et.al. Use of drone technology as a tool for behavioral research: A case study of crocodilian nesting. -Herpetol. -Conserv. -Biol. -2015, -10, 90-98.
20. M. Hassanalian, D., Rice, A. Abdelkefi. Evolution of space drones for planetary exploration: A review. -Progress in Aerospace Sciences -97 (-2018), -61-105 p.
21. Linchant, J., Lisein, J. et al. Are unmanned aircraft systems (UAS s) the future of wildlife monitoring? A review of accomplishments and challenges.-Mammal Rev. -2015, -45. 239-252.
22. Groves, P.A., Alcorn, B. Wiest et.al. Testing unmanned aircraft systems for salmon spawning surveys. Facets -2016, -1, 187-204. <https://doi.org/10.1139/facets-2016-0019>
23. Chio, S.H., Lin, C.H. Preliminary Study of UAS Equipped with Thermal Camera for -2017, Volcanic Geothermal Monitoring in Taiwan. 1649. <https://doi.org/10.3390/s17071649> -Sensors -17,
24. Wakeford, Z.E., Chmielewska, M. et.al. Combining thermal imaging with photogrammetry of an active volcano using UAV: An example from Stromboli, Italy. Photogramm. Rec. -2019, 34, 445-466. <https://doi.org/10.1111/phor.12301>
25. Hodgson, J.C., Koh, L.P. Best practice for minimising unmanned aerial vehicle disturbance to wildlife in biological field research. -Curr. Biol. -2016, -26, -R404-R405.
26. Huang, H. Savkin, A.V. Huang, C. Autonomous Navigation and Deployment of UAVs for Communication, Surveillance and Delivery; John Wiley & Sons: Hoboken, NJ, USA, 2022.
27. S. Joachim. Lehrstuhl für Luftfahrtsysteme. "Hybrid-Electric Propulsion Systems for Small Unmanned Aircraft". -Die Dissertation wurde am 12.12.2013 bei der Technischen Universität München eingereicht und durch die Fakultät für Maschinenwesen am 11.07.2014 angenommen. -2013, -188 p.
28. Pashayev, A., Nabiyev, R., Abdullayev, A. et. al. Research of a vertical takeoff and landing micro UAV in the plane mode with the onboard control measurement system. Tuijin Jishu/-Journal of Propulsion Technology. Vol. 46(1), -2025, pp.870-878, ISSN 1001-4055.

29. Р.Н. Набиев, А.А. Абдуллаев Оптимизация наблюдательных возможностей беспилотных летательных аппаратов // Естественные и технические науки. Москва, 2025. -№2 (201), - с.258-268, DOI: 10.25633/ETN.2025.02.19

CERTIFICATION TESTING TO ENHANCE THE LONGEVITY OF AUTOMOBILE TIRES

Hikmat Asgarov

*Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Doctor of Philosophy in Engineering.*

Selvi İsmayilova

*Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Master's Student.*

AVTOMOBİL ŞİNLƏRİNİN UZUNÖMÜRLÜLÜYÜNÜN ARTIRILMASINDA SERTİFİKATLAŞDIRMA SINAQLARI

Hikmət Əsgərov

*Azərbaycan Dövlət Neft və Sənaye Universiteti,
Cihaz mühəndisliyi kafedrası, mühəndislik üzrə fəlsəfə doktoru.*

Selvi İsmayilova

*Azərbaycan Dövlət Neft və Sənaye Universiteti,
Alət mühəndisliyi fakültəsi, magistratura tələbəsi.*

СЕРТИФИКАЦИОННЫЕ ИСПЫТАНИЯ ДЛЯ УВЕЛИЧЕНИЯ СРОКА СЛУЖБЫ АВТОМОБИЛЬНЫХ ШИН

Хикмет Асгаров

*Азербайджанский государственный нефтегазовый университет,
Кафедра приборостроения, кандидат технических наук.*

Сельви Исмаилова

*Азербайджанский государственный нефтегазовый университет,
Факультет приборостроения, магистрантка.*

Abstract

Automobile tires are a critical component of vehicle safety, performance, and environmental sustainability. Their design, material composition, and durability directly influence road safety, fuel efficiency, and driving comfort, while also impacting operational costs and ecological effects. In modern automotive engineering, advanced technologies and materials are employed to enhance tire performance, yet systematic testing and certification are essential to validate their effectiveness. Certification procedures assess mechanical strength, wear resistance, and stability under varying thermal and climatic conditions, ensuring product reliability and manufacturing quality. Additionally, test results provide a foundation for technological improvements and optimizations throughout the production process.

This study investigates the application and significance of tire testing and certification methodologies, with a focus on improving durability and performance. The research examines mechanical evaluations such as tensile, compression, abrasion, slip, and temperature resistance tests, while emphasizing the importance of compliance with international standards, including ISO and ECE protocols. Key factors in testing rubber compounds, such as tensile behavior under extreme thermal gradients and the integration of metallic reinforcing cords, are highlighted. Advanced measurement systems, including the Instron AVE 2 non-contacting video extensometer and pneumatic side-action grips, facilitate precise and reproducible data acquisition under both ambient and environmental chamber conditions. These methodologies ensure that tires meet the stringent operational and safety requirements expected by consumers.

Within the scope of the study, a comparative analysis of tire models from leading manufacturers—Michelin (France), Bridgestone (Japan), Continental (Germany), and Goodyear (USA)—was conducted. Performance criteria included fuel efficiency, braking distance, noise level, wear resistance, handling characteristics, and relative price. Results indicate that Michelin (Model A) provides balanced performance with high fuel efficiency, low noise, and superior handling. Bridgestone (Model B) excels in durability and service life, demonstrating long-term reliability. Continental (Model C) achieves outstanding braking and handling stability, emphasizing safety, while Goodyear (Model D) offers a favorable balance of handling performance and cost efficiency, making it an economically advantageous option.

Overall, this research underscores the pivotal role of standardized testing and certification in ensuring tire safety, performance, and environmental sustainability. By systematically evaluating tire

characteristics and benchmarking models across international standards, manufacturers can optimize design, enhance material selection, and deliver products that meet both consumer expectations and regulatory requirements. The findings provide practical guidance for tire producers and highlight effective strategies for improving durability, safety, and operational efficiency across diverse driving conditions.

Xülasə

Avtomobil şinləri nəqliyyat vasitələrinin təhlükəsizliyi, performansı və ekoloji davamlılığı baxımından kritik komponentdir. Onların dizaynı, material tərkibi və dayanıqlılığı yol təhlükəsizliyi, yanacaq səmərəliliyi və sürücülük rahatlığına birbaşa təsir göstərir, eyni zamanda istismar xərcləri və ekoloji təsirləri də müəyyən edir. Müasir avtomobil mühəndisliyində şin performansını artırmaq üçün qabaqcıl texnologiyalar və materiallar tətbiq edilir, lakin onların effektivliyini təsdiqləmək üçün sistemli sınaq və sertifikatlaşdırma zəruridir. Sertifikatlaşdırma prosedurları şinlərin mexaniki möhkəmliyini, yeyilməyə qarşı dayanıqlılığını və müxtəlif istilik və iqlim şəraitində sabitliyini qiymətləndirir, məhsulun etibarlılığını və istehsal keyfiyyətini təmin edir. Həmçinin, sınaq nəticələri istehsal prosesində texnoloji təkmilləşdirmələr və optimallaşdırmalar üçün əsas baza təşkil edir.

Bu tədqiqat şinlərin dayanıqlılığını və performansını artırmağa yönəlmiş sınaq və sertifikatlaşdırma metodologiyalarının tətbiqini və əhəmiyyətini araşdırır. Araşdırmada gərilmə, sıxılma, sürtünmə, sürüşmə və temperatur müqaviməti kimi mexaniki testlər təhlil olunur və ISO və ECE beynəlxalq standartlarına uyğunluq vurğulanır. Rezindən hazırlanmış nümunələrdə gərilmə davranışı, ekstremal istilik şəraitində testlərin aparılması və şin strukturunda metal gücləndirici telin integrasiyası kimi kritik faktorlar qeyd olunur. Preciz və təkrarolunan məlumatların toplanması üçün Instron AVE 2 əlaqəsiz videoya əsaslanan uzanma ölçən cihaz və pnevmatik yan hərəkət tutacaqları kimi qabaqcıl ölçü sistemləri tətbiq olunur. Bu metodologiyalar şinlərin istehlakçıların gözlədiyi təhlükəsizlik və əməliyyat tələblərinə cavab verməsini təmin edir.

Tədqiqat çərçivəsində dünyanın aparıcı istehsalçıları – Michelin (Fransa), Bridgestone (Yaponiya), Continental (Almaniya) və Goodyear (ABŞ) – tərəfindən istehsal olunan şin modellərinin müqayisəli analizi aparılmışdır. Qiymətləndirmə meyarları yanacaq səmərəliliyi, əyləc məsafəsi, səssizlik, yeyilməyə qarşı dayanıqlılıq, idarəetmə qabiliyyəti və nisbi qiymət olmuşdur. Nəticələr göstərir ki, Michelin (Model A) yüksək yanacaq səmərəliliyi, səssiz işləmə və yaxşı idarəetmə xüsusiyyətləri ilə balanslaşdırılmış performans təqdim edir. Bridgestone (Model B) uzunömürlülük və dayanıqlılıq üzrə üstün göstəricilər nümayiş etdirir. Continental (Model C) əyləc məsafəsi və idarəetmə sabitliyi baxımından yüksək nəticələr göstərir, təhlükəsizliyi vurğulayır, Goodyear (Model D) isə idarəetmə performansını və qiymət baxımından ən münasib nisbəti təmin edərək iqtisadi cəhətdən əlverişli seçimdir.

Ümumiyyətlə, bu tədqiqat standartlaşdırılmış test və sertifikatlaşdırmanın şin təhlükəsizliyi, performansını və ekoloji davamlılıq üçün əhəmiyyətini vurğulayır. Şin xüsusiyyətlərinin sistemli qiymətləndirilməsi və beynəlxalq standartlar üzrə modellərin müqayisəsi istehsalçılara dizaynın optimallaşdırılması, material seçiminin təkmilləşdirilməsi və istehlakçı tələblərinə cavab verən məhsullar təqdim etməyə imkan yaradır. Nəticələr həm istehsalçılar, həm də son istifadəçilər üçün praktiki tövsiyələr təqdim edir, müxtəlif yol şəraitində dayanıqlılığı, təhlükəsizliyi və əməliyyat səmərəliliyini artırmaq üçün effektiv strategiyaları göstərir.

Аннотация

Автомобильные шины являются критически важным компонентом безопасности транспортного средства, его эксплуатационных характеристик и экологической устойчивости. Их конструкция, состав материалов и долговечность напрямую влияют на безопасность на дороге, топливную эффективность и комфорт вождения, а также определяют эксплуатационные расходы и экологическое воздействие. В современной автомобильной инженерии применяются передовые технологии и материалы для повышения эффективности шин, однако систематическое тестирование и сертификация необходимы для подтверждения их надежности. Процедуры сертификации оценивают механическую прочность, износостойкость и стабильность шин в различных температурных и климатических условиях, обеспечивая качество продукции и надежность производства. Результаты испытаний также служат основой для технологических улучшений и оптимизации производственного процесса.

Данное исследование изучает применение и значение методик тестирования и сертификации шин с целью повышения их долговечности и эксплуатационных характеристик. Рассматриваются механические испытания, такие как растяжение, сжатие, абразивный износ, скольжение и температурная устойчивость, при этом подчеркивается необходимость соответствия международным стандартам ISO и ECE. Выделены ключевые факторы

тестирования резиновых компаундов, включая поведение при растяжении в экстремальных температурных условиях и интеграцию металлических армирующих кордов в конструкцию шины. Для точного и воспроизводимого измерения применяются передовые системы, включая оптический бесконтактный экстензометр Instron AVE 2 и пневматические захваты с боковым действием. Эти методики гарантируют, что шины соответствуют строгим требованиям безопасности и эксплуатационным характеристикам.

В рамках исследования был проведен сравнительный анализ моделей шин ведущих производителей — Michelin (Франция), Bridgestone (Япония), Continental (Германия) и Goodyear (США). Критерии оценки включали топливную эффективность, тормозной путь, уровень шума, износостойкость, управляемость и относительную цену. Результаты показали, что Michelin (Модель А) демонстрирует сбалансированные характеристики с высокой топливной эффективностью, низким уровнем шума и хорошей управляемостью. Bridgestone (Модель В) обладает выдающейся долговечностью и надежностью. Continental (Модель С) показывает превосходные результаты по тормозному пути и стабильности управляемости, подчеркивая безопасность. Goodyear (Модель D) обеспечивает оптимальное соотношение управляемости и цены, делая его экономически выгодным выбором.

В целом, исследование подчеркивает важность стандартизированных испытаний и сертификации для обеспечения безопасности, производительности и экологической устойчивости шин. Системная оценка характеристик и сравнение моделей по международным стандартам позволяет производителям оптимизировать дизайн, улучшать подбор материалов и выпускать продукцию, соответствующую требованиям потребителей. Полученные результаты предоставляют практические рекомендации для производителей и пользователей, демонстрируя эффективные стратегии повышения долговечности, безопасности и эксплуатационной эффективности шин в различных дорожных условиях.

Keywords: Tire performance, road safety, durability, certification testing, wear resistance, standards, rubber tensile tests

Ключевые слова: Производительность шин, дорожная безопасность, долговечность, сертификационные испытания, износостойкость, стандарты, испытания резины на растяжение

Açar sözlər: Şin performansı, yol təhlükəsizliyi, dayanıqlılıq, sertifikatlaşdırma testləri, Yeyilməyə davamlılıq, standartlar, rezində gərilmə testləri

Introduction

Automobile tires play a fundamental role in terms of road safety, fuel efficiency, and driving comfort. The longevity and reliability of tires not only ensure driver safety but are also directly correlated with vehicle operating costs and environmental impact. In the contemporary automotive industry, various technologies and materials are implemented to enhance tire performance; however, a systematic testing and certification process is essential to evaluate their effectiveness. Certification trials assess the mechanical strength, wear resistance, and stability of tires against thermal and climatic fluctuations, thereby validating manufacturing quality. Concurrently, the results of these tests establish a fundamental basis for technological refinements and optimizations within the production process.

This article analyzes the application methods and methodologies of certification tests aimed at increasing the durability of automotive tires, as well as the utilization of test results in the manufacturing and certification stages. The certification process not only verifies product quality but also provides a primary foundation for the improvement of production technology and the integration of novel materials. The objective is to identify effective testing strategies that enhance tire performance and ensure road safety. Simultaneously, as environmental requirements and consumption standards in the automotive industry escalate, tire design and material composition must be further optimized, and resistance to wear and friction must be increased. In this context, certification tests serve as a critical instrument for ensuring both the safety and ecological sustainability parameters of tires.

1. Research Objective and Significance

The primary objective of this study is to investigate the significance of certification testing protocols in enhancing the longevity of automotive tires. Within the scope of this research, material quality, structural stability, and operational behavior under diverse road conditions will be evaluated. The impact of certification assessments on tire performance and safety parameters will be determined. Furthermore, the effectiveness of testing methodologies aligned with international standards and their influence on

the service life of tires will be examined. Consequently, practical recommendations will be formulated for both tire manufacturers and end-users. A tire is not merely a pneumatic rubber component; it is a sophisticated engineering product manufactured in various configurations and designed to withstand multifaceted operational challenges. In this context, the study will review various tire types available in the market and the specific technical advantages they provide to vehicles.

2. Problem Statement and Related Work

Comparative analyses of tire models from various manufacturers demonstrate that certain designs exhibit significant deficiencies in terms of operational longevity and performance metrics. The lack of consistent alignment between testing methodologies and international standards frequently results in non-uniform product quality. Empirical mechanical evaluations indicate that specific tire configurations possess a higher susceptibility to structural deformation and stress cracking when subjected to high load cycles and diverse terrain conditions. Furthermore, climatic endurance assessments reveal a degradation in the performance parameters of particular models under conditions of extreme thermal stress and high humidity. Certification protocols frequently identify models that fail to meet established safety and durability thresholds, necessitating targeted technological refinements in the manufacturing sector.

Conventionally, tire evaluation is equated primarily with abrasive wear analysis; however, the manufacturing cycle encompasses a comprehensive suite of multidimensional diagnostic procedures. To characterize the fundamental properties of raw materials, tensile strength, rheology, and tear resistance analyses are strictly executed. Following the raw material phase, adhesion testing is utilized to validate the interlaminar bonding integrity between the tire's diverse structural layers. Dynamic impact assessments are conducted to simulate real-world operational scenarios, such as adverse road topography or high-velocity encounters with foreign objects. Ultimately, fatigue and wear-rate evaluations ensure that the final product adheres to the long-term durability and reliability standards required by consumers. Testing procedures are integrated throughout the entire production lifecycle—from raw material procurement to the finished product. The scope of these assessments depends primarily on the functional classification of the laboratory. For instance, in-plant facilities primarily focus on periodic quality control (QC) assessments to ensure process stability and adherence to specifications; this paradigm differs from the operational environments of other industrial sectors where Instron equipment is utilized. Nevertheless, the most extensive and rigorous experimental procedures are typically concentrated within Research and Development (R&D) laboratories.

3. Key considerations during tensile tests of rubber

One of the most dynamic variables in tire evaluation is the extensive variability of the climates in which the products operate. Consumers frequently transition from high-temperature, saline coastal environments to mountainous regions characterized by sub-zero temperatures and unpaved terrains. Consequently, contemporary tire designs must be engineered to withstand diverse environmental extremes while simultaneously maintaining optimal ride quality. To ensure material integrity, tensile characterization of rubber compounds must be conducted across these specific thermal gradients. Environmental chambers are utilized to simulate these conditions, necessitating specialized solutions for specimen gripping and strain measurement within the enclosed chamber. Measuring deformation poses a significant challenge, particularly in high-elongation elastomers that can exhibit strain levels exceeding 1000% of their initial gauge length.

Another critical factor is the integration of metallic reinforcing cords within the tire architecture. These components possess high tensile strength, making the secure gripping of such cables during tensile testing particularly complex. Most reinforcing materials, whether textile-based or metallic, are twisted with auxiliary fibers to enhance structural resilience.

Instron provides a diverse range of testing systems and solutions, including automated platforms designed for high-volume throughput. The Instron Advanced Video Extensometer 2 (AVE 2) represents an optical, non-contact strain measurement solution that demonstrates high efficacy for elastomers under both ambient and environmental chamber conditions (Figure 1). Furthermore, pneumatic side-action grips offer an ideal solution for testing across varying conditions, providing versatile gripping capabilities with high operational productivity. The acquisition of precise empirical data is paramount in tire testing, as field failures can result in catastrophic financial and safety consequences. Thus, the synergy of high throughput and extreme precision constitutes a significant challenge for tire research and development laboratories [1].

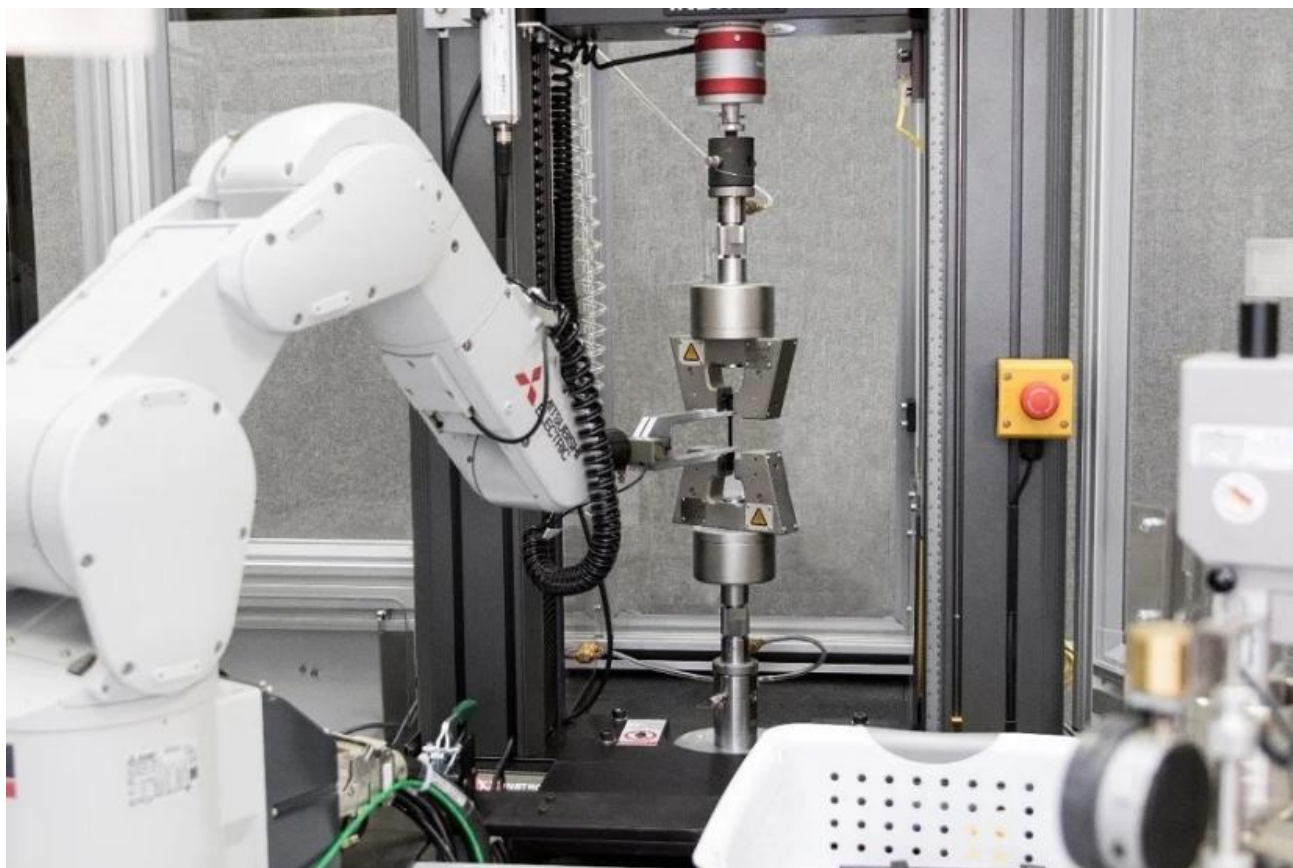


Figure 1. Instron AVE 2 testing machine

The process of verifying the compliance of automotive tire testing methodologies with international standards (ISO, ECE) is executed as follows:

ISO (International Organization for Standardization) and ECE (Economic Commission for Europe) provide various standards for tires. ISO standards typically cover mechanical properties of the material, tensile, fatigue, abrasion, and elasticity tests. ECE standards, on the other hand, define requirements for road traffic safety, load and speed capacity, noise, and environmental impacts. Regarding the comparison of testing methodologies, currently utilized test procedures are compared with the test conditions, instrument precision, specimen preparation, and measurement methods specified in the standards. Tests such as tensile, compression, abrasion, slip, and temperature resistance are verified for compliance with ISO or ECE requirements [2].

4. Comparative Analysis of Tires Within Research

A comparative analysis of tire models from different manufacturers was conducted within the framework of the study. As a result of the conducted comparative analysis, the performance indicators of models from the world's leading tire manufacturers - Michelin (France), Bridgestone (Japan), Continental (Germany), and Goodyear (USA) were evaluated. The analysis was based on criteria such as fuel efficiency, braking distance, noise level, wear resistance, handling performance, and relative price (Figure 2).

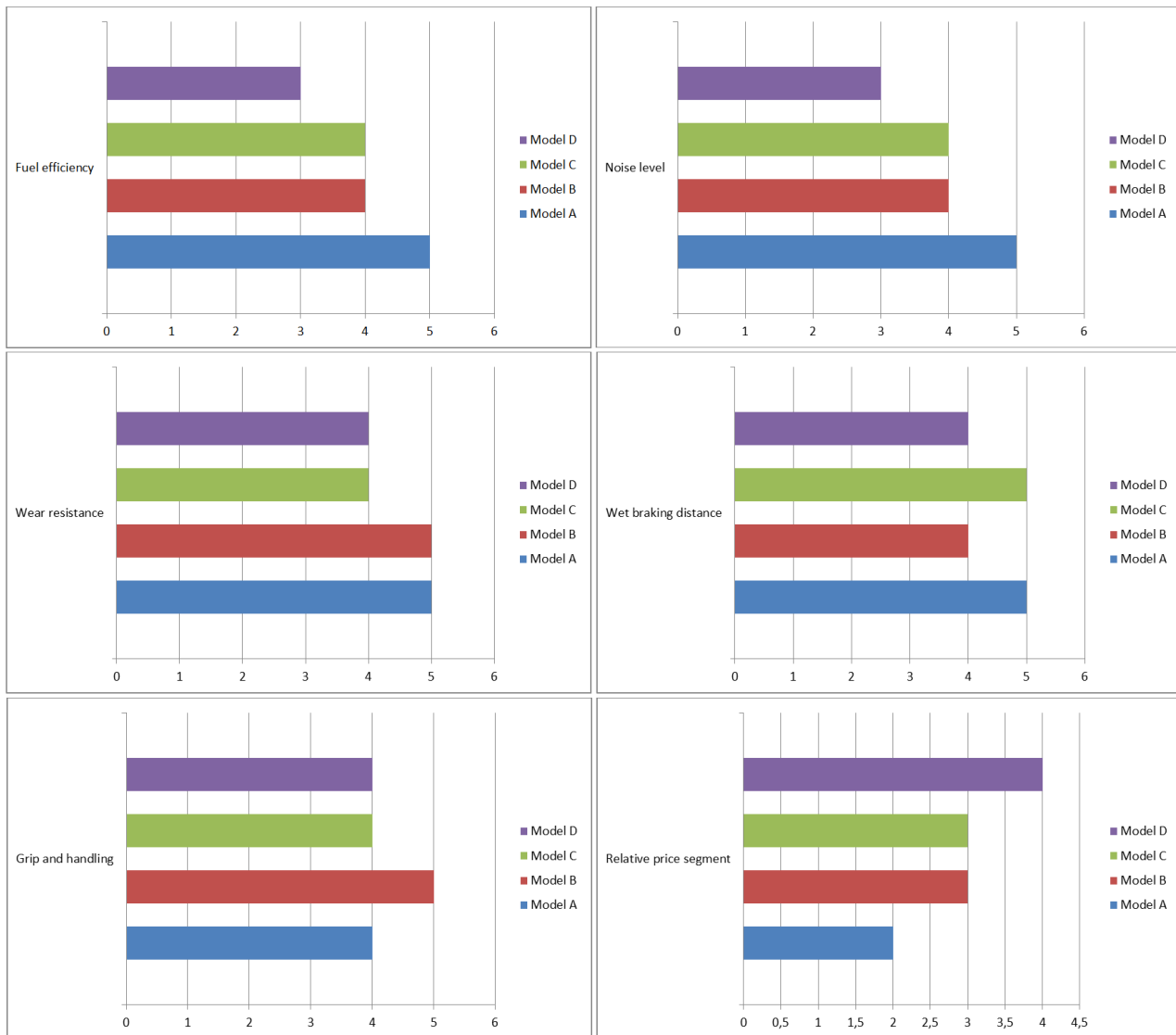


Figure 2. Comparative diagrams of tire models from different manufacturers based on key attributes

Based on the results, Michelin (Model A) was evaluated as a model with balanced performance, standing out for its high fuel efficiency, quiet operation, and handling characteristics. Bridgestone (Model B) demonstrated the highest indicators in terms of longevity and durability, holding a leading position in service life. Continental (Model C) achieved superior results in terms of braking distance and handling stability, highlighting its safety performance. Goodyear (Model D), on the other hand, offered the most favorable ratio of handling and price, making it an economically advantageous choice.

Conclusion

Automobile tires are a crucial factor in ensuring road safety, vehicle performance, and environmental sustainability. The study demonstrates that systematic certification testing is essential for validating tire durability, mechanical properties, and operational reliability. Comparative analysis of models from leading manufacturers revealed significant differences in fuel efficiency, wear resistance, braking distance, noise level, and handling characteristics. Michelin (Model A) provided balanced performance, Bridgestone (Model B) excelled in longevity, Continental (Model C) demonstrated superior safety, and Goodyear (Model D) offered the most cost-effective combination of handling and price. Compliance with international standards such as ISO and ECE ensures uniform quality and informs technological improvements in tire manufacturing. Advanced testing methodologies, including tensile and abrasion tests using instruments like the Instron AVE 2, play a pivotal role in achieving precise and reproducible results. Overall, integrating systematic testing and certification into tire design and production supports both consumer safety and industry sustainability goals.

References

1. Instron. (2024). AVE 2 Non-Contacting Video Extensometer. Instron Inc.

2. *Tire Industry Association, Tire Testing and Performance Evaluation: An Overview of Industry Standards, Tires.org, 2022.*
3. *Newton, Richard (2007). Wheel and Tire Performance Handbook*
4. *Esmailzadeh, E., Design Synthesis of a Vehicle Suspension System Using Multi-Parameter Optimization, Vehicle System Dynamics, 2007, P 83-96.*
5. *Yang, Derong. Vehicle Dynamics Control after Impacts in Multiple-Event Accidents. Göteborg : Chalmers University of Technology, 2013. PhD thesis. ISBN 978-91-7385-887-8.*
6. *ISO 19365:2016 Passenger cars-Validation of vehicle dynamic simulation - Sine with dwell stability control testing.*
7. *Reza N. Jazar /Vehicle Dynamics: Theory and Application/-2008 P. 250*



<https://sconferences.com>
info@sconferences.com

ISBN



9 789165 424593