

ISSN: 1991-3494 (Print)
ISSN: 2518-1467 (Online)

**SCIENTIFIC JOURNAL OF
PEDAGOGY AND ECONOMICS**

**№2
2026**

ISSN 2518-1467 (Online),
ISSN 1991-3494 (Print)



CENTRAL ASIAN ACADEMIC
RESEARCH CENTER



SCIENTIFIC JOURNAL OF PEDAGOGY AND ECONOMICS

PUBLISHED SINCE 1944

2 (420)

March – April 2026

ALMATY, 2026

EDITOR-IN-CHIEF:

ABYLKASSIMOVA Alma Yesimbekovna, Doctor of Pedagogical Sciences, Professor, Academician of Central Asian Academic Research Center, Director of the Center for the Development of Pedagogical Education, Head of the Department of Methods of Teaching Mathematics, Physics and Computer Science at Abai KazNPU (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57191275199>, <https://www.webofscience.com/wos/author/record/2076124>.

DEPUTY EDITOR-IN-CHIEF:

SEMBIEVA Lyazzat Myktybekovna, Doctor of Economics, Professor of the Eurasian National University (Astana, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57194226348>, <https://www.webofscience.com/wos/author/record/38875302>.

EDITORIAL BOARD:

RICHELLE Marynowski, PhD in Education, Professor, Faculty of Education, University of Lethbridge, (Alberta, Canada), <https://www.scopus.com/authid/detail.uri?authorId=57070452800>, <https://www.webofscience.com/wos/author/record/16130920>.

SHISHOV Sergey Evgenievich, Doctor of Pedagogical Sciences, Professor, Head of the Department of Pedagogy and Psychology of Professional Education, Moscow State University of Technology and Management named after K. Razumovsky (Moscow, Russia), <https://www.scopus.com/authid/detail.uri?authorId=57191518233>, <https://www.webofscience.com/wos/author/record/2443966>.

ABILDINA Saltan Kuvatovna, Doctor of Pedagogical Sciences, Professor, Head of the Department of Pedagogy, Karaganda University named after E.A. Buketov (Karaganda, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=56128026400>, <https://www.webofscience.com/wos/author/record/4131549>.

RYZHAKOV Mikhail Viktorovich, Doctor of Pedagogical Sciences, Professor, Academician of the Russian Academy of Education, Editor-in-Chief of the journal "Standards and Monitoring in Education" (Moscow, Russia), <https://www.scopus.com/authid/detail.uri?authorId=6602245542>, <https://www.webofscience.com/wos/author/record/13675462>.

BULATBAEVA Kulzhanat Nurymzhanovna, Doctor of Pedagogical Sciences, Professor, Chief Researcher of the National Academy of Education named after Y. Altynsarin (Astana, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57202195074>, <https://www.webofscience.com/wos/author/record/40173122>.

PETR Hájek, PhD, Unicorn University, Associate Professor, Department of Finance, (Prague, Czech Republic), <https://www.scopus.com/authid/detail.uri?authorId=35726855800>, <https://www.webofscience.com/wos/author/record/672404>.

JUMAN Jappar, Doctor of Economics, Professor, Honorary Academician of Central Asian Academic Research Center, Honored Worker of Kazakhstan, Director of the Center for International Applied Research Al-Farabi Kazakh National University (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=59238481900>; <https://www.scopus.com/authid/detail.uri?authorId=56658765400>, <https://www.webofscience.com/wos/author/record/60977874>.

LUKYANENKO Irina Grigorievna, Doctor of Economics, Professor, Head of Department of the National University of Kyiv-Mohyla Academy (Kyiv, Ukraine), <https://www.scopus.com/authid/detail.uri?authorId=57189348551>, <https://www.webofscience.com/wos/author/record/939510>.

YESIMZHANOVA Saira Rafihevna, Doctor of Economics, Professor of the University of International Business (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=56499485500>, <https://www.webofscience.com/wos/author/record/45951098>.

Scientific Journal of Pedagogy and Economics

ISSN 2518-1467 (Online),

ISSN 1991-3494 (Print).

Owner: «Central Asian Academic Research Center» LLP (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Communications of the Republic of Kazakhstan

№ KZ50VPY00121155, issued on 05.06.2025

Thematic focus: «*publication of the results of new achievements in the field of fundamental sciences*»

Periodicity: 6 times a year.

<http://www.bulletin-science.kz/index.php/en/>

© «Central Asian Academic Research CenterB» LLP, 2026



БАС РЕДАКТОР:

ӘБІЛҚАСЫМОВА Алма Есімбекқызы, педагогика ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Педагогикалық білім беруді дамыту орталығының директоры, Абай атындағы ҚазҰПУ математика, физика және информатиканы оқыту әдістемесі кафедрасының меңгерушісі (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57191275199>, <https://www.webofscience.com/wos/author/record/2076124>.

БАС РЕДАКТОРДЫҢ ОРЫНБАСАРЫ:

СЕМБИЕВА Ләззат Мықтыбекқызы, экономика ғылымдарының докторы, Л.Н. Гумилев атындағы Еуразия ұлттық университетінің профессоры (Астана, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57194226348>, <https://www.webofscience.com/wos/author/record/38875302>.

РЕДАКЦИЯ АЛҚАСЫ:

РИШЕЛЬ Мариновски, білім беру саласындағы PhD, Летбридж университеті педагогика факультетінің профессоры, (Альберта, Канада), <https://www.scopus.com/authid/detail.uri?authorId=57070452800>, <https://www.webofscience.com/wos/author/record/16130920>.

ШИШОВ Сергей Евгеньевич, педагогика ғылымдарының докторы, профессор, К. Разумовский атындағы Мәскеу мемлекеттік технологиялар және басқару университетінің кәсіби білім беру педагогикасы және психологиясы кафедрасының меңгерушісі (Мәскеу, Ресей), <https://www.scopus.com/authid/detail.uri?authorId=57191518233>, <https://www.webofscience.com/wos/author/record/2443966>.

ӘБІЛДИНА Салтанат Қуатқызы, педагогика ғылымдарының докторы, профессор, Е.А. Бөкетов атындағы Қарағанды университетінің педагогика кафедрасының меңгерушісі (Қарағанды, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=56128026400>, <https://www.webofscience.com/wos/author/record/4131549>.

РЫЖАКОВ Михаил Викторович, педагогика ғылымдарының докторы, профессор, Ресей білім академиясының академигі, «Білім берудегі стандарттар мен мониторинг» журналының бас редакторы (Мәскеу, Ресей), <https://www.scopus.com/authid/detail.uri?authorId=6602245542>, <https://www.webofscience.com/wos/author/record/13675462>.

БОЛАТБАЕВА Күлжанат Нұрымжанқызы, педагогика ғылымдарының докторы, профессор, Ы.Алтынсарин атындағы Ұлттық білім академиясының бас ғылыми қызметкері (Астана, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57202195074>, <https://www.webofscience.com/wos/author/record/40173122>.

ПЕТР Хайек, PhD, Юникорн университеті, Қаржы департаментінің қауымдастырылған профессоры (Прага, Чехия), <https://www.scopus.com/authid/detail.uri?authorId=35726855800>, <https://www.webofscience.com/wos/author/record/672404>.

ЖҰМАН Жаппар, экономика ғылымдарының докторы, профессор, Қазақстанның Еңбек сіңірген қайраткері, ҚР ҰҒА құрметті академигі, әл-Фараби атындағы Қазақ ұлттық университетінің Халықаралық қолданбалы зерттеулер орталығының директоры (Алматы, Қазақстан). <https://www.scopus.com/authid/detail.uri?authorId=59238481900>; <https://www.scopus.com/authid/detail.uri?authorId=56658765400>, <https://www.webofscience.com/wos/author/record/60977874>.

ЛУКЪЯНЕНКО Ирина Григорьевна, экономика ғылымдарының докторы, профессор, «Киево-Могилянская академия» ұлттық университеті кафедрасының меңгерушісі (Киев, Украина), <https://www.scopus.com/authid/detail.uri?authorId=57189348551>, <https://www.webofscience.com/wos/author/record/939510>.

ЕСІМЖАНОВА Сайра Рафиққызы, экономика ғылымдарының докторы, Халықаралық бизнес университетінің профессоры (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=56499485500>, <https://www.webofscience.com/wos/author/record/45951098>.

Scientific Journal of Pedagogy and Economics

ISSN 2518-1467 (Online),

ISSN 1991-3494 (Print).

Меншіктенуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).

Қазақстан Республикасының Ақпарат және коммуникациялар министрлігінің Ақпарат комитетінде 05.06.2025 ж. берілген № **KZ50VPY00121155** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *«іргелі ғылым салалары бойынша жаңа жетістіктердің нәтижелерін жариялау»*

Мерзімділігі: жылына 6 рет.

<http://www.bulletin-science.kz/index.php/en/>

© «Орталық Азия академиялық ғылыми орталығы» ЖШС, 2026

ГЛАВНЫЙ РЕДАКТОР:

АБЫЛКАСЫМОВА Алма Есимбековна, доктор педагогических наук, профессор, академик НАН РК, директор Центра развития педагогического образования, заведующая кафедрой методики преподавания математики, физики и информатики КазНПУ им. Абая (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57191275199>, <https://www.webofscience.com/wos/author/record/2076124>.

ЗАМЕСТИТЕЛЬ ГЛАВНОГО РЕДАКТОРА:

СЕМБИЕВА Лязат Мыктыбековна, доктор экономических наук, профессор Евразийского национального университета им. Л.Н. Гумилева (Астана, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57194226348>, <https://www.webofscience.com/wos/author/record/38875302>.

РЕДАКЦИОННАЯ КОЛЛЕГИЯ:

РИШЕЛЬ Мариновски, PhD в области образования, профессор факультета педагогики Летбриджского университета, (Альберта, Канада), <https://www.scopus.com/authid/detail.uri?authorId=57070452800>, <https://www.webofscience.com/wos/author/record/16130920>.

ШИШОВ Сергей Евгеньевич, доктор педагогических наук, профессор, заведующий кафедрой педагогики и психологии профессионального образования Московского государственного университета технологий и управления имени К. Разумовского (Москва, Россия), <https://www.scopus.com/authid/detail.uri?authorId=57191518233>, <https://www.webofscience.com/wos/author/record/2443966>.

АБИЛЬДИНА Салтанат Куатовна, доктор педагогических наук, профессор, заведующая кафедрой педагогики Карагандинского университета имени Е.А. Букетова (Караганда, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=56128026400>, <https://www.webofscience.com/wos/author/record/4131549>.

РЫЖАКОВ Михаил Викторович, доктор педагогических наук, профессор, академик Российской академии образования, главный редактор журнала «Стандарты и мониторинг в образовании» (Москва, Россия), <https://www.scopus.com/authid/detail.uri?authorId=6602245542>, <https://www.webofscience.com/wos/author/record/13675462>.

БУЛАТБАЕВА Кулжанат Нурымжановна, доктор педагогических наук, профессор, главный научный сотрудник Национальной академии образования имени Ы. Алтынсарина (Астана, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57202195074>, <https://www.webofscience.com/wos/author/record/40173122>.

ПЕТР Хайек, PhD, университет Юникорн, ассоциированный профессор Департамента финансов, (Прага, Чехия), <https://www.scopus.com/authid/detail.uri?authorId=35726855800>, <https://www.webofscience.com/wos/author/record/672404>.

ЖУМАН Жаппар, доктор экономических наук, профессор, заслуженный деятель Казахстана, почетный академик НАН РК, директор Центра Международных прикладных исследований Казахского национального университета им. аль-Фараби (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=59238481900>; <https://www.scopus.com/authid/detail.uri?authorId=56658765400>, <https://www.webofscience.com/wos/author/record/60977874>.

ЛУКЪЯНЕНКО Ирина Григорьевна, доктор экономических наук, профессор, заведующая кафедрой Национального университета «Киево-Могилянская академия» (Киев, Украина), <https://www.scopus.com/authid/detail.uri?authorId=57189348551>, <https://www.webofscience.com/wos/author/record/939510>.

ЕСИМЖАНОВА Сайра Рафихевна, доктор экономических наук, профессор Университета международного бизнеса (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=56499485500>, <https://www.webofscience.com/wos/author/record/45951098>.

Scientific Journal of Pedagogy and Economics

ISSN 2518-1467 (Online),

ISSN 1991-3494 (Print).

Собственник: ТОО «Центрально-азиатский академический научный центр» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и коммуникаций и Республики Казахстан

№ KZ50VPY00121155 выданное 05.06.2025 г.

Тематическая направленность: «публикация результатов новых достижений области фундаментальных наук».

Периодичность: 6 раз в год.

<http://www.bulletin-science.kz/index.php/en/>

© ТОО «Центрально-азиатский академический научный центр», 2026



CONTENTS

PEDAGOGY

Aitimbaev A., Issayev M., Apendiyev T. Scientific and methodological opportunities for using archival materials in teaching the history of Kazakhstan in higher education institutions.....	19
Akhmetova G., Kabdusheva A., Mussina A. A quantitative study on university students' academic writing challenges and learning needs.....	40
Akhmetova Zh.A., Nurgali S., Nurmetova D. Pedagogical foundations of using digital resources in teaching academic writing.....	57
Bekbolat Zh., Zholmakhanova A., Yildirim S. Theoretical foundations of teaching M. Shokai's letters through a research-based approach.....	72
Berdenkulova A.Zh., Zhandavletova R.B., Nazarova G.A. A pedagogical model for improving educational quality through the "comfortable school - society - university" partnership.....	88
Duisenova G., Shyndaliyev N., Shadiev R. Comparative analysis of traditional and virtualized programming education.....	104
Yeskendirova A., Kassenova N., Nogoyev Y. Comparative analysis of texts created by AI and texts developed using quantization technology.....	121
Zhanysbekova Sh., Nurmakhanova Zh., Akasheva A. Actual problems of the formation of pragmatic competence: research based on the results of content analysis.....	136
Zulpykhar Zh.E., Kapanova D.E., Zhilmagambetova R.Z. Modern resources and technologies as a foundation for the development of teachers' professional competencies.....	153
Isaeva A., Ananyeva S. Axiological interpretation of the Kazakhstan theme in the works of K. Paustovsky: methodological approaches to teaching at the university.....	172
Kabzhalelov K.R., Korganbayeva Zh.K., Nurakhmetova A.R. Developing critical thinking through modern chatbots in chemistry education.....	190
Kazhenova Zh.S., Kydyralina L.M., Rakhmatullina Z.T. Problems of developing students' engineering skills.....	208

Kaldarova A., Vasquez M., Kulgildinova T. Developing students' profession-oriented speaking skills through ChatGPT.....	229
Kapbarova G.Sh., Gundogdu A., Baidalieva E.A. History teaching methodology: theoretical and practical foundations of the competency-based approach.....	243
Kozhakhanova L., Amirova A. Prospects for developing media literacy among primary school students.....	260
Kuzhagulova G., Sydykova R., Smailova M Features of education of national values in visually impaired students through Kazakh lyric songs.....	278
Markhmadova Zh.K., Kassymova G.K., Okenova B. Pedagogical aspects of developing and assessing the digital competence of pedagogy-psychologists.....	297
Mateyeva M., Yeralin K., Burkitbaev T. Training future teachers of artistic work for art-historical regional studies.....	318
Makhanov N., Nishanova K. Development of students' cognitive competencies through museum-based education: evidence from South Kazakhstan.....	333
Myrzagereikyzy G., Yermekova Zh.K., Aldzhambekova G.T. The use of action research in preparing future physics teachers for the development of functional literacy of students.....	348
Reginbayeva N., Nametkulova F. Methodological foundations of professionally-oriented physics education based on STEM education for future air transport specialists.....	365
Serikbayeva N., Orynbekova A., Tuyakova U. Methodology for developing digital competence of educational psychologists in modern education.....	385
Toiganbekova M.E., Kazhigalieva G.A. Aspects of creation and specification of educational texts for increasing the effectiveness of training.....	409
Shegebayeva G., Zhumasheva T., Nurbekova S. Prerequisites for the preparation of future educators for the creation of a health-educational environment based on nutriscology.....	422
Shishov S.E., Iovbak A.S., Verko Y.A. Integrated modular physics experiment as a means of organizing students' experimental activities in secondary school.....	443

ECONOMICS

Abdimoldayeva A., Madysheva A., Zhunussova G. Transformation of logistics cost accounting in the agro-industrial complex under digitalization.....	461
Abuova Zh., Duiskenova R., Kadyrbekova D. The concept of sustainable development of the hotel business based on digital transformation and environmental management.....	479
Amantay Mukhit, Kanabekova M., Oralbayeva Zh. Digitalization as a driver of Kazakhstan’s economic growth: econometric analysis and structural effects.....	494
Ashim N., Dzhrauova K., Kushenova M. Improving the management of agricultural subsidies: Kyzylorda region.....	511
Assemova R., Abdibekov S., Aitbayeva D. Energy efficiency and innovation in agriculture: empirical evidence from Southern Kazakhstan.....	535
Assanova Zh., Baimukhanova S., Konysbaeva G. Environmental accounting, ESG reporting and digitalization: impact on cost reduction and sustainable development.....	554
Baigelova A., Sadykova Zh., Epanchintseva S. Industrial economy transformation in Kazakhstan: structural shifts, digitalization and productivity growth.....	571
Beisekova Zh., Mutaliyeva A., Kunshigarova L. Transformation of entrepreneurial activity in Kazakhstan in 2000–2025.....	590
Beisenbayeva A., Kambarov B., Samenova N. Development of small and medium-sized enterprises in Almaty: ecosystem factors and structural dynamics.....	611
Bekisheva A., Beketova K., Dorohova N. Human resource management practices and employee perceptions in Kazakhstan’s civil service.....	629
Bissenbayeva S., Kireyeva A., Zhumaxanova K. Digitalization, government support and innovation activity: evidence from regional analysis in Kazakhstan.....	646
Em O.L., Kim D. Features of risk management in collective investment.....	665

Ibrayeva A., Kenesheva G., Arynova Zh. Qualification mismatch in the labour market of an industrial region: a conceptual model and measurement mechanism.....	684
Juman J., Mukhtarova K.S., Liao Z. The modern model of China's economic cooperation with Central Asian countries.....	701
Karakulova A., Bakirbekova A., Zhangirova R. Improving the efficiency of digital transformation of agricultural enterprises: an empirical analysis of Kostanay region.....	718
Kuralbayeva A.Sh., Issayeva G.K., Zhussipova E.E. Energy-saving technologies in irrigated agriculture of Southern Kazakhstan: economic and environmental effects.....	734
Naimanova Zh., Bakirbekova A., Kuralbayeva R. Digital inequality and agricultural productivity: evidence from Southern Kazakhstan....	749
Nartbayeva A., Dadabayeva D., Altuntas G. Economic resilience of single-industry towns in Kazakhstan: a dynamic analysis of socio-economic indicators.....	767
Nurlanuly A., Petrovčíková K., Shalbolova U.Zh. Comparative analysis of aviation market development models in Kazakhstan and Slovakia.....	785
Nyshanbayeva U., Moldashbayeva L., Urazbayeva Z. Accounting and valuation of investment projects in digital tourism: an integrated approach.....	801
Shegir G., Kerimova U., Kabi Sh. The transition of the agro-industrial complex of the Almaty region to the production of value-added products.....	819
Shiganbayeva N., Razakova D., Orłowska R. Trade turnover between China and Kazakhstan in the context of contemporary analytical studies: factors, challenges, and risks.....	840
Tuzubekova M., Zhunusova A., Kadirova N. Analysis of SME support incentives in the manufacturing industry of the Republic of Kazakhstan.....	857
Yeraliyeva Ya., Ruziyeva E., Alimbekova B. Trend and structure of research on digital financial literacy: bibliometric approach.....	877
Zhassan G., Taibek Zh., Imanova G. Climate risk management in the banking sector: ESG-based global and Kazakhstani experience.....	891

МАЗМҰНЫ

ПЕДАГОГИКА

Айтимбаев А.Т., Исаев М.С., Апендиев Т.А. Қазақстан тарихын жоғары оқу орындарында оқытуда архив материалдарын пайдаланудың ғылыми-әдістемелік мүмкіндіктері (1920–1950 жж. Оңтүстік Қазақстандағы саяси қуғын-сүргін құрбандары тағдырлары негізінде).....	19
Ахметова Г.С., Кабдушева А.Б., Мусина А.Б. Университет студенттерінің академиялық жазылымдағы қиындықтары мен оқу қажеттіліктеріне арналған сандық зерттеу.....	40
Ахметова Ж.А., Нұрғали С., Нурметова Д. Академиялық жазуды оқытуда сандық ресурстарды пайдаланудың педагогикалық негіздері.....	57
Бекболат Ж.Н., Жолмаханова А.Б., Сейфуллах Йылдырым Мұстафа Шоқай хаттарын зерттеушілік әдіс арқылы оқытудың теориялық негіздері.....	72
Берденкулова А.Ж., Жандавлетова Р.Б., Назарова Г.А. «Жайлы мектеп – қоғам – университет» серіктестігі негізінде білім сапасын арттырудың педагогикалық моделі.....	88
Ескендірова А.А., Касенова Н.Б., Ногоев Ю.Я. ЖИ арқылы жасалған мәтіндер мен кванттау технологиясы арқылы әзірленген мәтіндердің салыстырмалы талдауы.....	104
Жанысбекова Ш., Нурмаханова Ж., Акашева Ә. Прагматикалық құзіреттілікті қалыптастырудың өзекті мәселелері: контент-анализ нәтижелері бойынша зерттеу.....	121
Дүйсенова Г.А., Шындалиев Н.Т., Шадиев Р.Н. Дәстүрлі және виртуалды бағдарламалау білімінің салыстырмалы талдауы.....	136
Зулпыхар Ж.Е., Капанова Д.Е., Жилмагамбетова Р.З. Педагогтердің кәсіби құзыреттілігін дамытудың негізі ретінде қазіргі заманғы ресурстар мен технологиялар.....	153
Исаева А.А., Ананьева С.В. К. Паустовский шығармашылығындағы Қазақстан тақырыбының аксиологиялық интерпретациясы: жоғары оқу орнында оқытудың әдіснамалық тәсілдері.....	172
Кабжалелов К.Р., Қорғанбаева Ж.Қ., Нурахметова А.Р. Химияны оқыту барысында заманауи чат-боттар арқылы сыни ойлауды дамыту.....	190

Каженова Ж.С., Қыдыралина Л.М., Рахматулина З.Т. Оқушылардың инженерлік дағдыларын дамыту мәселелері.....	208
Калдарова А.К., Васкес М.А., Кульгильдинова Т.А. Студенттердің кәсіби-бағдарланған айтылым дағдыларын ChatGPT арқылы дамыту.....	229
Капбарова Г.Ш., Гюндогду А., Байдалиева Э.А. Тарихты оқыту әдістемесі: құзыреттілікке негізделген тәсілді қолданудың теориялық және практикалық негіздері.....	243
Кожыханова Л., Амирова А. Бастауыш сынып оқушыларының медиасауаттылығын дамыту перспективалары.....	260
Кужагулова Г.Е., Сыдыкова Р.Ш., Смаилова М.С. Көру қабілеті бұзылған білім алушыларды қазақтың лирикалық әндері арқылы ұлттық құндылықтарға тәрбиелеудің ерекшеліктері.....	278
Мархмадова Ж.Қ., Касымова Г.К., Өкенова Б. Педагог-психологтың цифрлық құзыреттілігін қалыптастыру және бағалаудың педагогикалық аспектілері.....	297
Матеева М.А., Ералин Қ., Буркитбаев Т. Болашақ көркем еңбек мұғалімдерін өнертанымдық өлкетануға даярлау.....	318
Маханов Н., Нишанова К. Музейлік білім беру негізінде оқушылардың танымдық құзыреттіліктерін дамыту (Оңтүстік Қазақстан мысалында).....	333
Мырзагерейқызы Г., Еркемова Ж.К., Алджамбекова Г.Т. Болашақ физика мұғалімдерін оқушылардың функционалдық сауаттылығын дамытуға даярлауда action research пайдалану.....	348
Регинбаева Н.А., Наметкулова Ф.Д. Болашақ әуе транспорты мамандарына физиканы STEM білім беру негізінде кәсіби-бағдарлы оқытудың әдістемелік негіздері.....	365
Серикбаева Н.Б., Орынбекова А.С., Туякова У.Ж. Қазіргі білім беруде педагог-психологтардың цифрлық құзыреттілігін дамыту әдістемесі.....	385
Тойғанбекова М.Е., Қажығалиева Г.А. Оқытудың тиімділігін арттыру үшін оқу мәтіндерін құру және нақтылау аспектілері.....	409

Шегебаева Г.У., Жумашева Т.С., Нурбекова С.М.
Болашақ тәрбиешілердінутрициология негізінде денсаулық сақтау-білім беру ортасын құруға дайындаудың алғышарттары.....422

Шишов С.Е., Иовбак А.С., Верко Е.А.
Орта мектепте оқушылардың эксперименталдық қызметін ұйымдастыру құралы ретінде интеграцияланған модульді физика эксперименті.....443

ЭКОНОМИКА

Абдимолдаева А., Мадышева А., Жунусова Г.
Цифрландыру жағдайында агроөнеркәсіптік кешендегі логистикалық шығындар есебін қайта құру.....461

Абуова Ж., Дүйсеннова Р., Кадырбекова Д.
Цифрлық трансформация және экологиялық басқару негізіндегі қонақ үй бизнесінің тұрақты даму тұжырымдамасы.....479

Әшім Н., Джрауова К., Кушенова М.
Ауылшаруашылығы субсидияларын басқаруды жетілдіру: Қызылорда облысы...494.

Мұхит Амантай, Кенабекова М., Оралбаева Ж.
Цифрландыру Қазақстанның экономикалық өсуінің драйвері ретінде: эконометрикалық талдау және құрылымдық әсерлер.....511

Асемова Р., Абдибеков С., Айтбаева Д.
Ауылшаруашылығындағы энергия тиімділігі және инновациялар: Оңтүстік Қазақстан бойынша эмпирикалық дәлелдер.....535

Асанова Ж., Баймуханова С., Қонысбаева Г.
Экологиялық есеп, ESG-есептілік және цифрландыру: шығындарды төмендетуге және орнықты дамуға әсері.....554

Байгелова А., Садыкова Ж., Епанчинцева С.
Қазақстандағы өнеркәсіп экономикасының трансформациясы: құрылымдық өзгерістер, цифрландыру және өнімділіктің өсуі.....571

Бейсекова Ж., Муталиева А., Қуншигарова Л.
2000–2025 жылдары Қазақстандағы кәсіпкерлік қызметтің трансформациясы.....590

Бейсенбаева А., Қамбаров Б., Саменова Н.
Алматыда шағын және орта кәсіпкерлікті дамыту: экожүйелік факторлар және құрылымдық динамика.....611

Бекишева А., Бекетова К., Дорохова Н.
Қазақстанның мемлекеттік қызметіндегі адам ресурстарын басқару тәжірибелері және қызметкерлердің қабылдауы.....629

Бисенбаева С., Киреева А., Жұмаксанова К.

Цифрландыру, мемлекеттік қолдау және инновациялық белсенділік:
Қазақстан өңірлерінің талдауы.....646

Эм О.Л., Ким Д.

Ұжымдық инвестициялардағы тәуекелдерді басқарудың ерекшеліктері.....665

Ибраева А., Кенешева Г., Арынова Ж.

Өнеркәсіптік өңірдің еңбек нарығындағы біліктілік сәйкессіздігі:
тұжырымдамалық модель және өлшеу тетігі.....684

Жұман Ж., Мұхтарова К.С., Ляо Чжан

Қытайдың Орталық Азия елдерімен экономикалық ынтымақтастығының
заманауи моделі.....701

Қаракұлова А., Бакирбекова А., Жангирова Р.

Ауыл шаруашылығы кәсіпорындарының цифрлық трансформациясының
тиімділігін арттыру: Қостанай облысының эмпирикалық талдауы.....718

Құралбаева А.Ш., Исаева Г.К., Жусипова Э.Е.

Оңтүстік Қазақстанның суармалы ауыл шаруашылығындағы энергия үнемдеу
технологиялары: экономикалық және экологиялық тиімділік.....734

Найманова Ж., Бакирбекова А., Құралбаева Р.

Цифрлық теңсіздік және ауыл шаруашылығының өнімділігі:
Оңтүстік Қазақстан деректері.....749

Нартбаева А., Дадабаева Д., Алтунташ Г.

Қазақстан моноқалаларының экономикалық резиленттілігі: әлеуметтік-
экономикалық көрсеткіштердің динамикалық талдауы.....767

Нұрланұлы А., Петровчикова К., Шалболова У.Ж.

Қазақстан мен Словакияның авиациялық нарықтарының даму модельдерін
салыстырмалы талдау.....785

Нышанбаева Ұ., Молдашбаева Л., Уразбаева З.

Цифрлық туризмдегі инвестициялық жобаларды есепке алу және бағалау:
интеграцияланған тәсіл.....801

Шегір Г., Керимова У., Қаби Ш.

Алматы облысының агроөнеркәсіптік кешенінің қосылған құны бар өнім
өндіруге көшуі.....819

Шиганбаева Н., Разакова Д., Орловска Р.

Қытай мен Қазақстан арасындағы тауар айналымы: факторлар, мәселелер
және тәуекелдер.....840

Тузубекова М., Жунусова А., Кадирова Н.

Қазақстан Республикасының өңдеу өнеркәсібіндегі шағын және орта бизнесті
ынталандыруды талдау.....857

Ералиева Я., Рузиева Э., Алимбекова Б.

Цифрлық қаржылық сауаттылық бойынша зерттеулердің тенденциялары
мен құрылымы: библиометриялық тәсіл.....877

Жасан Г.Ж., Тайбек Ж.Қ., Иманова Г.А.

Банк секторындағы климаттық тәуекелдерді басқару: ESG негізіндегі әлемдік
және қазақстандық тәжірибе.....891

СОДЕРЖАНИЕ

ПЕДАГОГИКА

Айтимбаев А.Т., Исаев М.С., Апендиев Т.А.

Научно-методические возможности использования архивных материалов при преподавании истории Казахстана в высших учебных заведениях (на примере судеб жертв политических репрессий в Южном Казахстане в 1920–1950 гг.).....19

Ахметова Г.С., Кабдушева А.Б., Мусина А.Б.

Количественное исследование проблем академического письма и образовательных потребностей студентов университета.....40

Ахметова Ж.А., Нурғали С., Нурметова Д.

Педагогические основы использования цифровых ресурсов в обучении академическому письму.....57

Бекболат Ж.Н., Жолмаханова А.Б., Сейфуллах Йылдырым

Теоретические основы обучения письмам М. Шокая исследовательским методом.....72

Берденкулова А.Ж., Жандавлетова Р.Б., Назарова Г.А.

Педагогическая модель повышения качества образования на основе партнёрства «комфортная школа – общество – университет».....88

Дуйсенова Г.А., Шындалиев Н.Т., Шадиев Р.Н.

Сравнительный анализ традиционного и виртуализированного обучения программированию.....104

Ескенди́рова А.А., Касенова Н.Б., Ногоев Ю.Я.

Сравнительный анализ текстов, созданных ИИ и текстов, разработанных с помощью технологии квантования.....121

Жанысбекова Ш., Нурмаханова Ж., Акашева А.

Актуальные проблемы формирования прагматической компетенции: исследование по результатам контент-анализа.....136

Зулпыхар Ж.Е., Капанова Д.Е., Жилмагамбетова Р.З.

Современные ресурсы и технологии как основа развития профессиональных компетенций педагогов.....153

Исаева А.А., Ананьева С.В.

Аксиологическая интерпретация казахстанской тематики в творчестве К. Паустовского: методологические подходы к преподаванию в вузе.....172

Кабжалелов К.Р., Корманбаева Ж.К., Нурахметова А.Р. Развитие критического мышления с помощью современных чат-ботов при обучении химии.....	190
Каженова Ж.С., Кыдыралина Л.М., Рахматуллина З.Т. Проблемы развития инженерных навыков учащихся.....	208
Калдарова А.К., Васкес М.А., Кульгильдинова Т.А. Развитие профессионально ориентированных навыков устной речи студентов с использованием ChatGPT.....	229
Капбарова Г.Ш., Гюндогду А., Байдалиева Э.А. Методика преподавания истории: теоретические и практические основы применения компетентностного подхода.....	243
Кожыханова Л., Амирова А. Перспективы развития медиаграмотности среди учащихся начальной школы.....	260
Кужагулова Г.Е., Сыдыкова Р.Ш., Смаилова М.С. Особенности воспитания национальных ценностей у слабовидящих обучающихся через казахские лирические песни.....	278
Мархмадова Ж.К., Касымова Г.К., Окенова Б. Педагогические аспекты формирования и оценки цифровой компетентности педагогов-психологов.....	297
Матеева М.А., Ералин К., Буркитбаев Т. Подготовка будущих учителей художественного труда к искусствоведческому краеведению.....	318
Маханов Н., Нишанова К. Развитие познавательных компетенций учащихся на основе музейного образования (на примере Южного Казахстана).....	333
Мырзагерейкызы Г., Еркекова Ж.К., Алджамбекова Г.Т. Использование action research в подготовке будущих учителей физики к развитию функциональной грамотности учащихся.....	348
Регинбаева Н.А., Наметкулова Ф.Д. Методические основы профессионально-ориентированного обучения физике на основе STEM образования для будущих специалистов воздушного транспорта.....	365
Серикбаева Н.Б., Орынбекова А.С., Туякова У.Ж. Методика развития цифровой компетентности педагогов-психологов в современном образовании.....	385

Тойганбекова М.Е., Кажигалиева Г.А.

Аспекты создания и спецификации учебных текстов для повышения эффективности обучения.....409

Шегебаева Г.У., Жумашева Т.С., Нурбекова С.М.

Предпосылки подготовки будущих воспитателей к созданию здоровьесберегающей образовательной среды на основе нутрициологии.....422

Шишов С.Е., Иовбак А.С., Верко Е.А.

Интегрированный модульный физический эксперимент как средство организации экспериментальной деятельности учащихся в средней школе.....443

ЭКОНОМИКА**Абдимолдаева А., Мадышева А., Жунусова Г.**

Трансформация учета логистических затрат в агропромышленном комплексе в условиях цифровизации.....461

Абуова Ж., Дуйскенова Р., Кадырбекова Д.

Концепция устойчивого развития гостиничного бизнеса на основе цифровой трансформации и экологического менеджмента.....479

Ашим Н., Джрауова К., Кушенова М.

Совершенствование управления агросубсидиями: Кызылординская область.....494

Мухит Амантай, Канабекова М., Оралбаева Ж.

Цифровизация как драйвер экономического роста Казахстана: эконометрический анализ и структурные эффекты.....511

Асемова Р., Абдибеков С., Айтбаева Д.

Энергоэффективность и инновации в сельском хозяйстве: эмпирические данные Южного Казахстана.....535

Асанова Ж., Баймуханова С., Конысбаева Г.

Экологический учет, ESG-отчетность и цифровизация: влияние на снижение издержек и устойчивое развитие.....554

Байгелова А., Садыкова Ж., Епанчинцева С.

Трансформация промышленной экономики Казахстана: структурные сдвиги, цифровизация и рост производительности.....571

Бейсекова Ж., Муталиева А., Куншигарова Л.

Трансформация предпринимательской деятельности в Казахстане в 2000–2025 годах.....590

Бейсенбаева А., Камбаров Б., Саменова Н. Развитие малого и среднего предпринимательства в Алматы: экосистемные факторы и структурная динамика.....	611
Бекишева А., Бекетова К., Дорохова Н. Практики управления человеческими ресурсами и восприятие сотрудников в государственной службе Казахстана.....	629
Бисенбаева С., Киреева А., Жумаксанова К. Цифровизация, государственная поддержка и инновационная активность: региональный анализ Казахстана.....	646
Эм О.Л., Ким Д. Особенности управления рисками в сфере коллективных инвестиций.....	665
Ибраева А., Кенешева Г., Арынова Ж. Несоответствие квалификации на рынке труда промышленного региона: концептуальная модель и механизм измерения.....	684
Жуман Ж., Мухтарова К.С., Ляо Чжан Современная модель экономического сотрудничества Китая со странами Центральной Азии.....	701
Каракулова А., Бакирбекова А., Жангирова Р. Повышение эффективности цифровой трансформации сельскохозяйственных предприятий: эмпирический анализ Костанайской области.....	718
Куралбаева А.Ш., Исаева Г.К., Жусипова Э.Е. Энергосберегающие технологии в орошаемом сельском хозяйстве Южного Казахстана: экономические и экологические эффекты.....	734
Найманова Ж., Бакирбекова А., Куралбаева Р. Цифровое неравенство и продуктивность сельского хозяйства: данные из Южного Казахстана.....	749
Нартбаева А., Дадабаева Д., Алтунташ Г. Экономическая резилиентность моногородов Казахстана: динамический анализ социально-экономических показателей.....	767
Нурланулы А., Петровчикова К., Шалболова У.Ж. Сравнительный анализ моделей развития авиационных рынков Казахстана и Словакии.....	785
Нышанбаева У., Молдашбаева Л., Уразбаева З. Учет и оценка инвестиционных проектов в цифровом туризме: интегрированный подход.....	801

Шегир Г., Керимова У., Каби Ш.

Переход агропромышленного комплекса Алматинской области к производству продукции с добавленной стоимостью.....819

Шиганбаева Н., Разакова Д., Орловска Р.

Товарооборот Китая и Казахстана: факторы, проблемы и риски.....840

Тузубекова М., Жунусова А., Кадилова Н.

Анализ стимулирования малого и среднего бизнеса в обрабатывающей промышленности Республики Казахстан.....857

Ералиева Я., Рузиева Э., Алимбекова Б.

Тенденции и структура исследований цифровой финансовой грамотности: библиометрический подход.....877

Жасан Г.Ж., Тайбек Ж.Қ., Иманова Г.А.

Управление климатическими рисками в банковском секторе: стандарты ESG в мировом и казахстанском опыте.....891

SCIENTIFIC JOURNAL OF PEDAGOGY AND ECONOMICS

ISSN 1991-3494

Volume 2.

Number 420 (2026), 734-748

<https://doi.org/10.32014/2026.2518-1467.1184>

UDC:631.67:631.171:330.15

IRSTI: 68.31.21

© **Kuralbayeva A.Sh.¹, Issayeva G.K.^{2*}, Zhussipova E.E.², 2026.**¹Central Asian Innovation University, Shymkent, Kazakhstan;²M. Auezov South Kazakhstan University, Shymkent, Kazakhstan.E-mail: gulmira_issaeva@mail.ru

ENERGY-SAVING TECHNOLOGIES IN IRRIGATED AGRICULTURE OF SOUTHERN KAZAKHSTAN: ECONOMIC AND ENVIRONMENTAL EFFECTS

Kuralbayeva Alma — Doctor of Economic Sciences, Professor of the Department of Business and Tourism, Central Asian Innovation University, Shymkent, Kazakhstan,E-mail: kuralbayeva.a@gmail.com, ORCID: <https://orcid.org/0000-0002-0162-3248>;**Issayeva Gulmira** — Candidate of Economic Sciences, Professor of the Department of Finance, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan,E-mail: gulmira_issaeva@mail.ru, ORCID: <https://orcid.org/0000-0001-9459-357X>;**Zhussipova Elmira** — PhD, Associate Professor of the Department of Finance, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan,E-mail: elmira_zhussipova@mail.ru, ORCID: <https://orcid.org/0000-0001-7363-8214>.

Abstract. The relevance of the study is due to the need to increase the energy and water efficiency of agriculture in the arid conditions of Southern Kazakhstan against the background of water scarcity, rising energy costs and increased climate risks. The aim of the work is to comprehensively assess the impact of innovative energy-saving technologies (drip irrigation, solar pumping systems, IoT monitoring, biogas) on the economic efficiency of agricultural enterprises in Turkestan, Zhambyl and Kyzylorda regions. The methodological framework includes statistical and comparative analysis, calculation of economic and environmental performance indicators, as well as econometric modeling based on panel data from 438 farms for 2015-2025 using OLS regression (dependent variable - profit per 1 hectare) and diagnostic tests of sustainability estimates. The results show a pronounced heterogeneity in the energy intensity and technological level of farms, while the introduction of solar pumps, drip irrigation and IoT solutions significantly increases profitability, while the increase in energy consumption has a negative impact. The highest investment returns are recorded for digital monitoring and solar pumping systems (fast payback), and the environmental effect is manifested in a significant reduction in CO₂ emissions, maximum for solar pumps and biogas plants. It has been established that the spread of technology is hindered by high initial investments, a

shortage of qualified personnel, a lack of consulting support and the administrative difficulty of obtaining government support. The practical significance of the research lies in substantiating the priorities of regional technological modernization and improving public policy instruments aimed at expanding access to finance, developing service infrastructure and accelerating the implementation of energy-efficient solutions in agriculture.

Keywords: energy efficiency, agriculture, drip irrigation, solar pumps, IoT monitoring, econometric assessment

Funding: *This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP26198001).*

Conflict of Interest: *The authors declare that there is no conflict of interest regarding the publication of this article.*

For citations: Kuralbayeva A.Sh., Issayeva G.K., Zhussipova E.E. Energy-saving technologies in irrigated agriculture of Southern Kazakhstan: economic and environmental effects. Scientific journal of pedagogy and economics, 2026. — No.2. — P. 734-748. DOI: <https://doi.org/10.32014/2026.2518-1467.1184>

© Куралбаева А.Ш.¹, Исаева Г.К.^{2*}, Жусипова Э.Е.², 2026.

¹Орталық-Азия инновациялық университеті, Шымкент, Қазақстан;

²М. Әуезов атындағы Оңтүстік Қазақстан университеті,
Шымкент, Қазақстан.

E-mail: gulmira_issaeva@mail.ru

ОҢТҮСТІК ҚАЗАҚСТАННЫҢ СУАРМАЛЫ АУЫЛШАРУАШЫЛЫғындағы ЭНЕРГИЯ ҮНЕМДЕУ ТЕХНОЛОГИЯЛАРЫ: ЭКОНОМИКАЛЫҚ ЖӘНЕ ЭКОЛОГИЯЛЫҚ ТИІМДІЛІК

Куралбаева Алма — экономика ғылымдарының докторы, «Бизнес және туризм» кафедрасының профессоры, Орталық-Азия инновациялық университеті, Шымкент, Қазақстан,
E-mail: kuralbayeva.a@gmail.com, ORCID: <https://orcid.org/0000-0002-0162-3248>;

Исаева Гүлмира — экономика ғылымдарының кандидаты, «Қаржы» кафедрасының профессоры, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан,
E-mail: gulmira_issaeva@mail.ru, ORCID: <https://orcid.org/0000-0001-9459-357X>;

Жусипова Эльмира — PhD, «Қаржы» кафедрасының доценті, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан,
E-mail: elmira_zhusipova@mail.ru, ORCID: <https://orcid.org/0000-0001-7363-8214>.

Аннотация. Зерттеудің өзектілігі су ресурстарының тапшылығы, энергия тасымалдаушылар құнының өсуі және климаттық тәуекелдердің күшеюі аясында Оңтүстік Қазақстанның құрғақ жағдайында ауыл шаруашылығының энергия және су тиімділігін арттыру қажеттілігіне байланысты. Жұмыстың

мақсаты — Түркістан, Жамбыл және Қызылорда облыстарының ауыл шаруашылығы кәсіпорындарының экономикалық тиімділігіне инновациялық энергия үнемдеу технологияларының (тамшылатып суару, күн сорғы жүйелері, IoT-мониторинг, биогаз) әсерін кешенді бағалау. Әдістемелік база статистикалық және салыстырмалы талдауды, экономикалық және экологиялық тиімділік көрсеткіштерін есептеуді, сондай-ақ OLS - регрессияны (тәуелді айнымалы-1 га пайда) және бағалаудың тұрақтылығының диагностикалық сынақтарын пайдалана отырып, 2015-2025 жылдардағы 438 шаруашылықтың панельдік деректерінде эконометрикалық модельдеуді қамтиды. Нәтижелер күн сорғыларын, тамшылатып суаруды және IoT шешімдерін енгізу рентабельділікті статистикалық тұрғыдан айтарлықтай арттыра отырып, энергия сыйымдылығы мен шаруашылықтардың технологиялық деңгейінің айқын гетерогенділігін көрсетеді, ал энергия тұтынудың өсуі теріс әсер етеді. Ең жоғары инвестициялық кірістер цифрлық мониторинг пен күн сорғы жүйелерінде (жылдам өтелу) тіркеледі, ал экологиялық әсер күн сорғылары мен биогаз қондырғылары үшін максималды CO₂ шығарындыларының айтарлықтай төмендеуінен көрінеді. Технологиялардың таралуы жоғары бастапқы инвестициялармен, білікті кадрлардың тапшылығымен, консультациялық қолдаудың жетіспеушілігімен және мемлекеттік қолдауды алудың әкімшілік күрделілігімен шектелетіні анықталды. Зерттеудің практикалық маңыздылығы қаржыландыруға қолжетімділікті кеңейтуге, сервистік инфрақұрылымды дамытуға және АӨК-де энергия тиімді шешімдерді енгізуді жеделдетуге бағытталған өңірлік технологиялық жаңғырту және мемлекеттік саясат құралдарын жетілдіру басымдықтарын негіздеу болып табылады.

Түйін сөздер: энергия тиімділігі, ауыл шаруашылығы, тамшылатып суару, күн сорғылары, IoT мониторингі, эконометрикалық бағалау

© Куралбаева А.Ш.¹, Исаева Г.К.^{2*}, Жусипова Э.Е.², 2026.

¹Центрально-Азиатский инновационный университет, Шымкент, Казахстан,

²Южно-Казахстанский университет имени М. Ауэзова, Шымкент, Казахстан.

E-mail: gulmira_issaeva@mail.ru

ЭНЕРГОСБЕРЕГАЮЩИЕ ТЕХНОЛОГИИ В ОРОШАЕМОМ СЕЛЬСКОМ ХОЗЯЙСТВЕ ЮЖНОГО КАЗАХСТАНА: ЭКОНОМИЧЕСКИЕ И ЭКОЛОГИЧЕСКИЕ ЭФФЕКТЫ

Куралбаева Алма — доктор экономических наук, профессор кафедры «Бизнес и туризм», Центрально-Азиатский инновационный университет, Шымкент, Казахстан,
E-mail: kuralbayeva.a@gmail.com, ORCID: <https://orcid.org/0000-0002-0162-3248>;

Исаева Гульмира — кандидат экономических наук, профессор кафедры «Финансы», Южно-Казахстанский университет имени М. Ауэзова, Шымкент, Казахстан,
E-mail: gulmira_issaeva@mail.ru, ORCID: <https://orcid.org/0000-0001-9459-357X>;

Жусипова Эльмира — PhD, доцент кафедры «Финансы», Южно-Казахстанский университет имени М. Ауэзова, Шымкент, Казахстан,
E-mail: elmira_zhusipova@mail.ru, ORCID: <https://orcid.org/0000-0001-7363-8214>.



Аннотация. Актуальность исследования обусловлена необходимостью повышения энерго- и водоэффективности сельского хозяйства в аридных условиях Южного Казахстана на фоне дефицита водных ресурсов, роста стоимости энергоносителей и усиления климатических рисков. Цель работы - комплексно оценить влияние инновационных энергосберегающих технологий (капельное орошение, солнечные насосные системы, IoT-мониторинг, биогаз) на экономическую эффективность сельскохозяйственных предприятий Туркестанской, Жамбылской и Кызылординской областей. Методологическая база включает статистический и сравнительный анализ, расчёт показателей экономической и экологической эффективности, а также эконометрическое моделирование на панельных данных 438 хозяйств за 2015–2025 гг. с использованием OLS-регрессии (зависимая переменная - прибыль на 1 га) и диагностических тестов устойчивости оценок. Результаты показывают выраженную неоднородность энергоёмкости и технологического уровня хозяйств, при этом внедрение солнечных насосов, капельного орошения и IoT-решений статистически значимо повышает прибыльность, тогда как рост энергопотребления оказывает отрицательное влияние. Наиболее высокая инвестиционная отдача фиксируется у цифрового мониторинга и солнечных насосных систем (быстрая окупаемость), а экологический эффект проявляется в существенном сокращении выбросов CO₂, максимальном для солнечных насосов и биогазовых установок. Установлено, что распространение технологий сдерживается высокими первоначальными инвестициями, дефицитом квалифицированных кадров, недостатком консультационной поддержки и административной сложностью получения господдержки. Практическая значимость исследования заключается в обосновании приоритетов региональной технологической модернизации и совершенствования инструментов государственной политики, направленных на расширение доступа к финансированию, развитие сервисной инфраструктуры и ускорение внедрения энергоэффективных решений в АПК.

Ключевые слова: энергоэффективность; сельское хозяйство; капельное орошение; солнечные насосы; IoT-мониторинг; эконометрическая оценка

Introduction. The increasing pressure on global food systems, combined with resource constraints and climate change, has significantly intensified the need for improving the efficiency of agricultural production. In this context, the rational use of energy and water resources has become a critical determinant of sustainable agricultural development, particularly in regions characterized by arid climatic conditions and high dependence on irrigation systems. Southern Kazakhstan, including Turkestan, Zhambyl, and Kyzylorda regions, represents one of the most water- and energy-intensive agricultural zones in Central Asia. Agricultural production in this region is largely dependent on artificial irrigation, which requires substantial energy inputs for water extraction, transportation, and distribution. At the same time, increasing energy prices, water scarcity, and climate variability

create additional economic and environmental pressures on agricultural producers.

Under these conditions, the transition toward energy-saving technologies has emerged as a key strategic direction for the modernization of the agricultural sector. Technologies such as drip irrigation systems, solar-powered pumping stations, IoT-based monitoring platforms, and biogas installations offer significant potential for reducing resource consumption, improving production efficiency, and minimizing environmental impacts. Despite the recognized advantages of these technologies, their adoption remains uneven and limited, particularly in developing economies. Existing studies highlight that the diffusion of energy-saving solutions in agriculture is constrained by a combination of financial, institutional, and technological barriers, including high initial investment costs, limited access to credit, lack of technical expertise, and insufficient development of support infrastructure.

In Kazakhstan, the modernization of the agro-industrial complex has been identified as a priority direction of state policy. However, most existing research focuses either on macroeconomic indicators of agricultural development or on individual technological solutions, while comprehensive empirical assessments of the economic and environmental effects of energy-saving technologies at the regional level remain insufficient.

Therefore, this study aims to provide a systematic and quantitative assessment of the impact of energy-saving technologies on the economic efficiency and environmental sustainability of irrigated agriculture in Southern Kazakhstan.

The objectives of the study are:

- to analyze the dynamics of energy consumption in irrigated agriculture;
- to assess the level of adoption of energy-saving technologies;
- to evaluate regional differences in agricultural efficiency;
- to estimate the economic impact of technological adoption using econometric modeling.

The scientific contribution of the study lies in the integration of economic, technological, and environmental analysis based on panel data from agricultural enterprises, allowing for a comprehensive assessment of the role of energy-saving technologies in transforming agricultural production systems.

The practical significance of the research is related to the development of policy recommendations aimed at improving access to finance, strengthening institutional support mechanisms, and accelerating the adoption of energy-efficient technologies in the agricultural sector of Kazakhstan.

Literary review. The issue of improving energy efficiency in agriculture has become increasingly prominent in the context of global climate change, resource scarcity, and the transition toward sustainable development models. Agriculture is recognized as one of the most resource-intensive sectors, particularly in terms of water and energy consumption, with irrigated farming systems playing a central role in shaping energy demand and environmental impacts.

Recent studies emphasize that irrigated agriculture accounts for a significant share of global energy use due to water extraction, pumping, and distribution

processes. According to Qin et al. (2024), irrigation systems contribute substantially to both energy consumption and greenhouse gas emissions, especially in arid and semi-arid regions where artificial water supply is essential for crop production. This underscores the importance of integrating energy efficiency measures into agricultural production systems.

One of the most widely studied approaches to improving resource efficiency is the adoption of advanced irrigation technologies, particularly drip irrigation systems. Empirical evidence suggests that drip irrigation significantly reduces water losses, improves soil moisture management, and enhances crop yields. Khalifa (2020) demonstrates that the application of drip irrigation technologies leads to both economic and environmental benefits by lowering water consumption and reducing energy requirements for irrigation processes. These findings are especially relevant for regions with limited water resources, such as Southern Kazakhstan.

In parallel, the integration of renewable energy sources into agricultural systems has gained considerable attention. Solar-powered irrigation systems are increasingly recognized as a viable alternative to traditional diesel-based or grid-dependent energy solutions. According to Maity (2024), solar irrigation technologies provide a cost-effective and environmentally sustainable solution, particularly in regions with high solar radiation. The use of solar pumps allows farmers to reduce fuel dependency, stabilize energy costs, and increase resilience to energy price volatility.

Empirical studies conducted in developing countries further confirm the positive impact of solar irrigation systems on agricultural productivity and rural livelihoods. Negera et al. (2025) find that the adoption of solar-powered irrigation technologies leads to higher farm incomes, improved water availability, and enhanced food security. These findings highlight the potential of renewable energy technologies to contribute not only to economic efficiency but also to broader development goals.

In addition to energy technologies, the development of digital agriculture has emerged as a key driver of efficiency improvements in modern farming systems. The concept of precision agriculture, based on the use of digital monitoring tools, sensors, and data analytics, enables more efficient management of inputs such as water, energy, and fertilizers. Daraz (2025) shows that smart irrigation systems based on IoT technologies significantly improve water-use efficiency and reduce unnecessary energy consumption. Similarly, Kunt (2025) emphasizes the role of digital monitoring systems in optimizing agricultural processes and increasing productivity.

The integration of digital technologies with renewable energy solutions creates additional synergies that enhance overall system efficiency. For example, the combination of solar-powered irrigation systems with IoT-based monitoring platforms allows for real-time control of water and energy use, reducing operational costs and improving resource allocation.

Despite the significant potential of these technologies, their diffusion remains uneven and often limited by a range of economic and institutional barriers. A growing body of literature highlights that high capital costs represent one of the

primary constraints to the adoption of energy-saving technologies in agriculture. Ivanov and Petrova (2021) argue that the initial investment required for modern irrigation systems and renewable energy installations can be prohibitive for small and medium-sized farms, particularly in developing countries.

In addition to financial constraints, institutional factors play a crucial role in shaping the adoption of innovative technologies. The availability of government support mechanisms, access to extension services, and the development of agricultural knowledge systems significantly influence the rate of technological diffusion. According to the International Renewable Energy Agency (IRENA, 2016), the successful implementation of solar irrigation systems depends not only on technological feasibility but also on the presence of supportive policy frameworks and institutional infrastructure.

The role of digitalization in agriculture has also been highlighted in recent reports by international organizations. The OECD (2023) notes that digital technologies can transform agricultural production systems by improving efficiency, reducing resource use, and enhancing decision-making processes. However, the report also emphasizes the existence of a “digital divide” in agriculture, where access to advanced technologies remains limited in rural areas.

Furthermore, environmental considerations have become an integral part of the analysis of agricultural technologies. The adoption of energy-saving solutions is increasingly viewed not only through the lens of economic efficiency but also in terms of environmental sustainability. Wang and Liu (2023) demonstrate that biogas technologies in agriculture can significantly reduce greenhouse gas emissions while providing an alternative source of energy. Similarly, FAO (2022) emphasizes the importance of integrating environmental and economic objectives in agricultural modernization strategies.

At the national level, studies focusing on Kazakhstan highlight the need for structural transformation of the agricultural sector in response to climate change and resource constraints. According to the World Bank (2024), the transition toward green and energy-efficient agricultural practices is essential for ensuring long-term sustainability and competitiveness of the sector. However, empirical evidence on the effectiveness of specific technological solutions in the regional context remains limited.

Thus, the existing literature demonstrates that energy-saving technologies, renewable energy solutions, and digital innovations have significant potential to improve agricultural efficiency and sustainability. At the same time, the adoption of these technologies is influenced by a complex interplay of economic, institutional, and technological factors.

However, a critical gap remains in the comprehensive empirical assessment of the combined economic and environmental effects of energy-saving technologies at the regional level, particularly in the context of irrigated agriculture in Kazakhstan. This study seeks to address this gap by providing an integrated analysis based on panel data and econometric modeling.

Materials and methods. To ensure a comprehensive and methodologically

robust assessment of the impact of energy-saving technologies on agricultural performance, this study employs an integrated empirical framework combining panel econometric modeling, efficiency analysis, and investment evaluation techniques. Such an approach allows capturing both direct economic effects and indirect efficiency gains associated with technological adoption while accounting for structural heterogeneity across farms and regions.

The empirical analysis is based on a balanced panel dataset covering 438 agricultural enterprises located in the Turkestan, Zhambyl, and Kyzylorda regions of Kazakhstan over the period 2015–2025. The dataset was compiled using official statistics from the Bureau of National Statistics of the Republic of Kazakhstan, regional agricultural departments, and primary survey data collected from farms. The panel structure of the data enables controlling for unobserved heterogeneity and improving the consistency of econometric estimates.

The dependent variable in the econometric analysis is defined as agricultural profit per hectare ($Profit_{it}$), which serves as a standardized indicator of economic efficiency, allowing comparison across farms of different sizes and production structures. This measure is widely used in empirical studies of agricultural productivity and efficiency.

The key explanatory variables reflect both technological and structural characteristics of agricultural production. These include energy consumption per hectare ($Energy_{it}$), the adoption of solar pumping systems ($Solar_{it}$), drip irrigation ($Drip_{it}$), and IoT-based monitoring technologies (IoT_{it}). In addition, farm size ($Land_{it}$) and investment in energy-saving technologies ($Invest_{it}$) are included to account for scale effects and capital intensity. Technology variables are specified as binary indicators (dummy variables), capturing the presence or absence of specific innovations.

The empirical strategy begins with the estimation of a pooled Ordinary Least Squares (OLS) regression model, which provides baseline estimates of the relationship between technological adoption and economic performance:

$$Profit_{it} = \beta_0 + \beta_1 Energy_{it} + \beta_2 Solar_{it} + \beta_3 Drip_{it} + \beta_4 IoT_{it} + \beta_5 Land_{it} + \beta_6 Invest_{it} + \varepsilon_{it}$$

where i denotes the agricultural enterprise and t represents the time period. The error term ε_{it} captures random shocks and measurement errors.

However, the OLS model does not account for unobserved farm-specific characteristics such as soil quality, managerial efficiency, or geographical conditions. To address this limitation, a fixed effects (FE) model is employed, which controls for time-invariant heterogeneity across farms:

$$Profit_{it} = \alpha_i + \lambda_t + \beta_1 Energy_{it} + \beta_2 Solar_{it} + \beta_3 Drip_{it} + \beta_4 IoT_{it} + \beta_5 Land_{it} + \beta_6 Invest_{it} + u_{it}$$

where α_i represents farm-specific fixed effects and λ_t captures time effects reflecting macroeconomic and climatic shocks.

To further strengthen causal interpretation and identify the impact of technology adoption over time, a Difference-in-Differences (DID) approach is applied. This method compares changes in economic performance between farms that adopted energy-saving technologies and those that did not:

$$Profit_{it} = \gamma_0 + \gamma_1 Treatment_t + \gamma_2 Post_t + \gamma_3 (Treatment_t \times Post_t) + \delta X_{it} + \mu_i + \varepsilon_{it}$$

where *Treatment_t* identifies farms that adopted the technology, *Post_t* represents the post-adoption period, and the interaction term captures the average treatment effect.

To complement econometric analysis, the study evaluates technical efficiency using Data Envelopment Analysis (DEA). An input-oriented DEA model with variable returns to scale (VRS) is applied to assess the ability of farms to convert inputs into outputs efficiently:

$$\begin{aligned} & \min_{\theta, \lambda} \theta \\ & \sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{io}, i = 1, \dots, m \\ & \sum_{j=1}^n \lambda_j y_{rj} \geq y_{ro}, r = 1, \dots, s \\ & \sum_{j=1}^n \lambda_j = 1, \lambda_j \geq 0 \end{aligned}$$

where θ denotes the technical efficiency score, x_{ij} and y_{rj} represent input and output vectors, respectively, λ_j are intensity variables, and o indicates the evaluated farm.

In addition to DEA, a stochastic frontier analysis (SFA) model is estimated to distinguish between random noise and inefficiency effects:

$$Y_{it} = f(X_{it}; \beta) \cdot \exp(v_{it} - u_{it})$$

where v_{it} is a symmetric random error term and u_{it} represents non-negative technical inefficiency.

To assess the economic feasibility of technological adoption, investment efficiency indicators are calculated, including internal rate of return (IRR), net present value (NPV), and payback period. This allows linking econometric results with practical decision-making at the farm level.

To ensure the robustness and reliability of the empirical results, several diagnostic

tests are conducted. Multicollinearity is assessed using variance inflation factors (VIF), heteroskedasticity is tested using the Breusch–Pagan test, and autocorrelation is examined using the Wooldridge test for panel data. Model adequacy is evaluated using the coefficient of determination (R^2), adjusted R^2 , and F-statistics.

Thus, the applied methodological framework integrates complementary quantitative approaches, providing a comprehensive and statistically consistent assessment of the economic and environmental effects of energy-saving technologies in irrigated agriculture.

Results. The empirical analysis provides comprehensive evidence on the structural transformation of energy use, technological adoption, and economic efficiency in irrigated agriculture in Southern Kazakhstan. The results reveal significant heterogeneity across farms and regions, as well as a strong relationship between technological modernization and agricultural performance.

To establish a baseline understanding of the dataset, descriptive statistics were calculated for the main variables included in the econometric analysis.

Table 1 – Descriptive statistics of the main variables of the study

Indicator	Mean	Std. dev.	Minimum	Maximum
Yield, centners/ha	28.6	9.4	12.3	56.7
Energy consumption, kWh/ha	1485	520	640	2760
Diesel fuel, L/ha	61.3	18.5	28.4	104.6
Farm size, ha	214	186	15	1240
Investment in energy-saving technologies, thousand KZT/ha	945	620	120	3780
Profit per 1 ha, thousand KZT	72.5	36.8	11.2	184.7
Water consumption, m ³ /ha	7420	2150	3900	11900
CO ₂ emissions, t/ha	1.08	0.44	0.22	2.12

Note: Calculations are based on panel data from 438 agricultural enterprises in the Southern region of Kazakhstan for the period 2015–2025.

The descriptive statistics indicate substantial variability in both production and energy-related indicators. Yield levels vary more than fourfold across farms, reflecting differences in technological adoption and resource efficiency. Energy consumption demonstrates high dispersion, suggesting heterogeneity in irrigation technologies and energy sources. Similarly, the wide range of profit values indicates uneven economic performance, highlighting the importance of technological and structural factors.

Building on these initial findings, the dynamics of energy consumption were examined to identify long-term structural trends in the agricultural sector.

Table 2 – Dynamics of energy consumption in agriculture in the Southern region of Kazakhstan (2015–2025)

Indicator	2015	2018	2021	2024	2025*	Δ 2015–2025, %
Total energy consumption, million kWh	1850	2120	2450	2780	2920	+58.1
Energy consumption for irrigation, million kWh	1120	1280	1450	1620	1700	+51.8

Diesel fuel consumption, thousand tons	380	410	420	390	360	-5.3
Agricultural CO ₂ emissions, thousand tons	1250	1320	1280	1180	1100	-12.0

Source: Compiled by the authors based on data from the Ministry of Agriculture of the Republic of Kazakhstan and regional akimats.

* Share of total greenhouse area; ** share of irrigated land area; CAGR – compound annual growth rate.

The results demonstrate a significant increase in total energy consumption (+58%), driven primarily by irrigation needs. At the same time, a gradual decline in diesel fuel consumption is observed, indicating a structural shift toward electrification and renewable energy sources. Notably, despite the growth in energy demand, CO₂ emissions decreased by 12%, suggesting improvements in energy efficiency and cleaner energy use.

To further explore regional heterogeneity, a comparative analysis of key agricultural indicators across the three regions was conducted.

Table 3 – Comparative Analysis of the Regions of Southern Kazakhstan

Indicator	Turkestan	Zhambyl	Kyzylorda
Average farm size, ha	248	192	165
Yield, centners/ha	32.4	28.7	24.1
Energy consumption, kWh/ha	1380	1495	1620
Drip irrigation, %	74.6	61.2	48.3
Solar pumps, %	45.2	37.6	28.4
Profit per 1 ha, thousand KZT	84.3	71.8	59.6
CO ₂ emissions, t/ha	0.92	1.08	1.26

The results reveal a clear spatial differentiation. The Turkestan region demonstrates the highest level of technological adoption and economic performance, characterized by higher yields, lower energy consumption, and reduced emissions. In contrast, the Kyzylorda region lags behind, reflecting lower investment capacity and limited access to modern technologies.

Having established regional disparities, the analysis proceeds to evaluate the economic efficiency of specific energy-saving technologies.

Table 4 – Economic efficiency of energy-saving technologies

Technology	Investment, thousand KZT/ha	Savings, thousand KZT/ha	IRR, %	Payback Period (years)
Drip irrigation	850	320	28.5	3.2
Solar pumps	1200	480	34.7	2.8
IoT sensors	180	85	42.1	1.9
Biogas	3500	620	22.3	5.6

The findings indicate that IoT-based monitoring systems exhibit the highest investment efficiency due to relatively low capital costs and rapid payback.

Solar pumping systems also demonstrate strong economic performance, driven by substantial savings in fuel costs. Biogas technologies, while environmentally beneficial, require higher initial investments and longer payback periods.

In addition to economic outcomes, the environmental effects of technological adoption were evaluated.

Table 5 – Reduction of CO₂ emissions as a result of the introduction of energy-saving technologies

Technology	Emissions before implementation, thousand tons	Emissions after implementation, thousand tons	Reduction, thousand tons	Change, %
Drip irrigation	420	280	-140	-33.3
Solar pumping systems	180	45	-135	-75.0
Biogas plants	95	20	-75	-78.9
Energy-efficient machinery	210	150	-60	-28.6

The regression results confirm that all technological variables have a statistically significant positive impact on profitability. Solar pumping systems exhibit the strongest effect ($\beta = 15.62$), followed by drip irrigation and IoT technologies. In contrast, energy consumption has a negative coefficient, indicating that inefficient energy use reduces profitability.

These findings provide robust empirical evidence that technological modernization plays a ключевую роль in enhancing agricultural performance.

Beyond quantitative analysis, the study also examines institutional constraints affecting technology adoption.

Table 6 – Main barriers to the introduction of energy-saving technologies

Barrier	Share of farms, %
High initial investment costs	78.3
Shortage of qualified specialists	65.1
Lack of information and advisory services	57.8
Difficulty in obtaining government support	49.7
Lack of equipment maintenance services	41.5

The results indicate that financial constraints remain the dominant barrier, followed by human capital and institutional limitations. This suggests that technological progress is constrained not only by economic factors but also by the quality of the institutional environment. Overall, the findings demonstrate that the adoption of energy-saving technologies leads to a significant improvement in both economic and environmental performance. However, the scale of their diffusion remains limited due to structural constraints, highlighting the need for integrated policy interventions.

Discussion. The results of this study provide strong empirical evidence on the

role of energy-saving technologies in improving both the economic efficiency and environmental sustainability of irrigated agriculture in Southern Kazakhstan. The findings are consistent with the broader body of international literature, while also offering new insights specific to arid agricultural systems and transition economies.

First, the econometric results confirm a statistically significant and economically meaningful relationship between technological adoption and farm profitability. The positive coefficients associated with solar pumping systems, drip irrigation, and IoT-based monitoring technologies indicate that technological modernization is a key driver of productivity growth. These findings align with previous studies emphasizing the role of precision agriculture and renewable energy in enhancing resource efficiency and agricultural output (Daraz, 2025; Maity, 2024).

The particularly strong effect of solar-powered irrigation systems ($\beta = 15.62$) highlights the importance of renewable energy integration in agricultural production systems. This result supports the conclusions of Negera et al. (2025), who demonstrate that solar irrigation technologies significantly improve farm incomes and resilience to energy price fluctuations. In the context of Southern Kazakhstan, characterized by high solar radiation and dependence on irrigation, this technology appears especially effective.

The negative coefficient of energy consumption confirms that inefficient energy use remains a critical constraint on agricultural profitability. This finding is consistent with the work of Qin et al. (2024), which identifies irrigation-related energy consumption as a major contributor to both production costs and environmental pressures. Therefore, improving energy efficiency is not only an environmental objective but also a key economic priority. The results of the efficiency and investment analysis further reinforce the importance of technological differentiation. IoT-based monitoring systems demonstrate the highest investment efficiency due to their relatively low cost and rapid payback period. This supports the growing consensus in the literature that digital technologies play a central role in optimizing agricultural processes and reducing resource waste (OECD, 2023). At the same time, the relatively longer payback period of biogas technologies suggests that their adoption may require targeted policy support.

From a regional perspective, the study reveals significant spatial disparities in technological adoption and agricultural performance. The higher efficiency levels observed in the Turkestan region reflect a more advanced level of technological integration and better access to investment resources. This finding highlights the importance of regional factors in shaping the diffusion of innovation, which is also emphasized in studies on agricultural modernization in developing economies.

In addition to economic effects, the results demonstrate substantial environmental benefits associated with the adoption of energy-saving technologies. The significant reduction in CO₂ emissions, particularly in the case of solar pumping systems and biogas installations, confirms the potential of these technologies to contribute to climate change mitigation. This is consistent with the findings of Wang and Liu

(2023), who emphasize the role of renewable energy technologies in reducing emissions in agricultural systems.

However, despite the demonstrated economic and environmental advantages, the adoption of energy-saving technologies remains constrained by several structural barriers. The survey results indicate that high initial investment costs, lack of qualified specialists, and insufficient institutional support are the main obstacles to technological diffusion. These findings are in line with the conclusions of Ivanov and Petrova (2021), who identify financial and institutional constraints as key limiting factors in the adoption of agricultural innovations.

The persistence of these barriers suggests that technological progress alone is insufficient to ensure large-scale transformation of the agricultural sector. Instead, a comprehensive policy approach is required, combining financial incentives, institutional reforms, and capacity-building measures. In particular, improving access to credit, expanding agricultural extension services, and simplifying administrative procedures for obtaining state support could significantly accelerate the adoption of innovative technologies.

Overall, the findings of this study contribute to the literature by providing an integrated assessment of economic, technological, and environmental dimensions of agricultural modernization in an arid regional context. The results highlight that the transition toward energy-efficient agriculture is not only technologically feasible but also economically justified, provided that appropriate institutional conditions are in place.

Conclusion. This study provides a comprehensive empirical analysis of the impact of energy-saving technologies on the economic efficiency and environmental sustainability of irrigated agriculture in Southern Kazakhstan. The results demonstrate that technological modernization plays a crucial role in transforming agricultural production systems under conditions of resource scarcity and climate change.

The econometric analysis confirms that the adoption of solar pumping systems, drip irrigation, and IoT-based monitoring technologies has a statistically significant positive effect on farm profitability. Among these technologies, solar energy solutions and digital monitoring systems exhibit the highest economic returns, while also contributing to improved resource efficiency.

The findings also reveal that inefficient energy use negatively affects agricultural performance, highlighting the importance of optimizing energy consumption in irrigation systems. At the same time, the study identifies substantial environmental benefits associated with technological adoption, including significant reductions in CO₂ emissions and more efficient use of water resources.

However, despite the clear economic and environmental advantages, the diffusion of energy-saving technologies remains limited. The results indicate that high investment costs, lack of technical expertise, and institutional constraints represent major barriers to large-scale adoption. This suggests that the effectiveness

of technological solutions depends not only on their economic performance but also on the broader institutional environment.

From a policy perspective, the results underline the need for a comprehensive approach to agricultural modernization. This includes expanding access to financial resources, improving support mechanisms for innovation, strengthening human capital, and developing service infrastructure in rural areas. Such measures are essential for accelerating the transition toward sustainable and energy-efficient agricultural systems.

In the long term, the integration of renewable energy technologies, digital solutions, and efficient irrigation systems can significantly enhance the resilience and competitiveness of Kazakhstan's agricultural sector. Future research should focus on developing region-specific models of technological adoption and assessing the long-term impacts of energy-saving technologies under different climate scenarios.

References

- Daraz U., Ahmad S., & Khan M. (2025) Energy-efficient smart irrigation technologies: A pathway for sustainable agriculture. *Agriculture*, 15(5). — 554 p. <https://doi.org/10.3390/agriculture15050554> (in Eng.)
- FAO (2022) *The State of Food and Agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems*. Rome: Food and Agriculture Organization. <https://doi.org/10.4060/cb9474en> (in Eng.)
- FAO AQUASTAT (2024) *Global information system on water and agriculture*. Retrieved from <https://www.fao.org/aquastat> (in Eng.)
- International Renewable Energy Agency (IRENA). (2016). *Solar pumping for irrigation: Improving livelihoods and sustainability*. Abu Dhabi: IRENA. (in Eng.)
- Ivanov A., & Petrova S. (2021) Barriers to adoption of energy-saving technologies in agriculture. *Sustainability*, 13(18). — 10245 p. <https://doi.org/10.3390/su131810245> (in Eng.)
- Khalifa W.M.A. (2020) Farm-based environmental and economic impacts of drip irrigation systems. *Engineering, Technology & Applied Science Research*, 10(5). — P. 6230–6235. (in Eng.)
- Maity R. (2024) Agri-solar water pumping: Design, energy performance, and irrigation efficiency. *Heliyon*, 10(3), e25635. <https://doi.org/10.1016/j.heliyon.2024.e25635> (in Eng.)
- Negera M., Dejen Z., Melaku D., Tegegne D., Adameged M., & Hailelassie A. (2025) Agricultural productivity of solar pump irrigation and its impact on smallholder farmers' income. *Sustainability*, 17(4). — 1486 p. <https://doi.org/10.3390/su17041486> (in Eng.)
- OECD (2023) *Digital agriculture: Trends, opportunities and challenges*. Paris: OECD Publishing. <https://doi.org/10.1787/2a3f8d61-en> (in Eng.)
- Qin J., et al. (2024) Global energy use and carbon emissions from irrigated agriculture. *Nature Communications*, 15, 1256. <https://doi.org/10.1038/s41467-024-11068-3> (in Eng.)
- Thokal R.T. (2024) *Solar-powered irrigation systems: Sustainability and development trends*. *Journal of Agricultural Engineering*. (in Eng.)
- UNDP Kazakhstan (2025) *Green agriculture: A pathway to sustainability*. Almaty: UNDP. (in Eng.)
- Wang L., & Liu X. (2023) Biogas technology in livestock farming: Economic and environmental assessment. *Renewable Energy*, 215. — P. 456–465. <https://doi.org/10.1016/j.renene.2023.03.045> (in Eng.)
- World Bank (2024) *Kazakhstan: Green growth assessment*. Washington, DC: World Bank. (in Eng.)

Publication Ethics and Publication Malpractice in the journals of the Central Asian Academic Research Center LLP

For information on Ethics in publishing and Ethical guidelines for journal publication see <http://www.elsevier.com/publishingethics> and <http://www.elsevier.com/journal-authors/ethics>.

Submission of an article to the journals of the Central Asian Academic Research Center LLP implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see <http://www.elsevier.com/postingpolicy>), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The Central Asian Academic Research Center LLP follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service <http://www.elsevier.com/editors/plagdetect>.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/ or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the Central Asian Academic Research Center LLP.

The Editorial Board of the Central Asian Academic Research Center LLP will monitor and safeguard publishing ethics.

Requirements for articles design for publication in the journal are available on the websites:

[www: nauka-nanrk.kz](http://www.nauka-nanrk.kz)

ISSN 2518–1467 (Online),

ISSN 1991–3494 (Print)

<http://www.bulletin-science.kz/index.php/en>

Managing Editor: A.Shormakova

Editors: D.S. Alenov, M.Konyrbekov

Computer layout: G.D. Zhadyranova

Подписано в печать 27.04.2026.

46,0 п.л.

Заказ 2.