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Human capital development and technology adaptation for sustainable organic agriculture in Kazakhstan: education, research and knowledge transfer

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Abstract

Background and Aim. Sustainable organic agriculture in Kazakhstan requires qualified human capital, applied research, regionally adapted technologies, and effective knowledge transfer. Despite an established regulatory framework and considerable agricultural resources, linkages among education, research, qualification systems, advisory services, and farm-level implementation remain insufficiently developed. This study assessed the contribution of agrarian research and educational institutions to human capital development and technology adaptation and identified measures for strengthening the organic sector.

Materials and Methods. A qualitative document-based institutional analysis was conducted using analytical, comparative, logical, systems-based, and content-analysis approaches. The evidence included Kazakhstan's regulatory and institutional documents, university educational programmes, scientific and technical programmes implemented during 2012–2026, the draft Professional Standard "Organic Agriculture", international reports, and peer-reviewed research.

Results. Three interrelated institutional gaps were identified: competency and qualification, research-to-practice, and knowledge-transfer and implementation gaps. The analysis also identified the draft Professional Standard "Organic Agriculture", comprising five occupational profiles at National Qualifications Framework Levels 6–8 and linking labour functions and professional competencies with relevant fields of higher and postgraduate education. Existing educational, research, methodological, and institutional resources require stronger coordination with producer needs and farm-level implementation.

Conclusion. The findings support an integrated education – research - knowledge transfer - production framework linking professional competencies and education with applied research, risk-based regional technology adaptation, advisory and demonstration services, farm-level adoption, and producer feedback. The study is limited by its documentary evidence and purposive selection of materials and does not include representative producer surveys, labour-market analysis, or implementation-cost assessment.

Keywords: organic agriculture; human capital; adapted technologies; agrarian education; research and educational institutions; standardization.

Introduction

Organic agriculture has become an important component of the transformation of contemporary agri-food systems toward environmental sustainability, biodiversity conservation, climate resilience, and more sustainable resource use. According to The World of Organic Agriculture: Statistics and Emerging Trends 2025, organic agriculture was reported in 188 countries in 2023, with 98.9 million ha of agricultural land under organic management, representing 2.1% of the world's agricultural land. The

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global organic market also continued to expand, with retail sales exceeding EUR 136 billion in 2023 [1]. These trends demonstrate the increasing economic and institutional significance of organic agriculture, while also showing that expansion involves not only growth in certified land but the development of regulatory, knowledge, technological, certification, and market-support systems.

For Kazakhstan, organic agriculture is particularly relevant due to the country's extensive agricultural resource base and diverse agroecological conditions. Kazakhstan has more than 200 million ha of agricultural land, including more than 23 million ha of arable land, while the area reported under certified organic management has fluctuated within a substantially smaller range. *Savin* and *Morgounov* [2] emphasize that Kazakhstan's extensive land resources, relatively low-input farming systems, and diverse agroecological conditions create opportunities for organic crop production, but they also identify constraints related to certification, marketing, the availability of suitable crops and cultivars, and insufficient development and adaptation of organic production technologies. Research on organic agriculture in Kazakhstan further demonstrates that its development is influenced by interacting ecological, economic, institutional, and socio-cultural factors rather than by agricultural land availability alone [3]. Therefore, the national challenge involves not only expanding the area under organic management, but also strengthening the institutional and technological capacity needed to translate the country's agricultural resource potential into sustainable organic production. The regulatory environment has changed substantially in recent years. The Law of the Republic of Kazakhstan dated June 10, 2024, No. 89-VIII "On Production and Turnover of Organic Products" establishes the legal, economic, social, and organizational foundations for organic production and circulation and defines state responsibilities in this field [4]. Its implementation is complemented by the Rules for the Production and Turnover of Organic Products, approved by Order No. 385 of the Minister of Agriculture of the Republic of Kazakhstan dated November 26, 2024. Together with the ongoing development and harmonization of national standards for organic products [5], these regulatory changes provide a formal institutional basis for the sector. The existence of legislation and standards does not in itself ensure that producers have access to appropriately trained specialists, locally adapted technologies, advisory support, and effective mecha-nisms for transferring research results into agricultural practice.

The existing literature on Kazakhstan and Central Asia addresses several important dimensions of organic agriculture, although these are generally examined as separate areas of analysis. Studies on human-capital development emphasize the role of agrarian education and specialist training in supporting the technological development of organic agriculture in Kazakhstan [6]. Research on Kazakhstan and other Central Asian countries has also examined the formation of organic-product markets, highlighting challenges related to international standards, market information, production organization, and pricing [7]. Other studies demonstrate that the development of organic farming in Kazakhstan is influenced by a combination of ecological, economic, and ethno-cultural factors. At the technological level, research has addressed crop diversification, tillage, plant nutrition, biological resources, and plant-protection approaches applicable to organic crop production under Kazakhstan conditions, while emphasizing the importance of adapting agricultural practices to specific production environments. Taken together, these studies provide important evidence on educational, market, institutional, and agronomic aspects of or-ganic agriculture; these dimensions have predominantly been examined separately rather than within an integrated framework linking education, research, technology adaptation, knowledge transfer, and producer-level implementation [8,9,10].

International research provides an important conceptual basis for examining these interfaces. Studies of agricultural technology adoption demonstrate that farmers' decisions are influenced by multiple factors, including access to knowledge, information, training, advisory support, institutional conditions, and the characteristics of particular technologies [11, 12]. More recent research increasingly conceptualizes organic agriculture as a knowledge-intensive innovation system in which technological development depends on interaction among farmers, research and educational institutions, advisory services, producer organizations, and other intermediaries. Systematic evidence indicates that knowledge exchange and innovation processes are particularly important in organic farming because knowledge and technologies must be adapted to heterogeneous farming and production contexts. This perspective is consistent with the Agricultural Knowledge and Innovation Systems (AKIS) approach,

which shifts attention from the isolated generation of scientific knowledge toward the relationships through which knowledge is generated, exchanged, adapted, and applied. Research on organic micro-level Agricultural Knowledge and Innovation Systems (microAKIS) further demonstrates the importance of farmer networks, producer organizations, advisory relationships, and other institutional actors in these process-es [12].

The way in which technical knowledge is acquired can also influence its practical application. Evidence from certified organic farms shows that educational and research institutions, advisory organizations, and sectoral organizations can perform different but complementary functions in knowledge acquisition, while interaction-based and codified forms of learning can reinforce one another. Taken together, these studies support a systems perspective in which research, education, advisory services, producer organizations, and farmers are analysed as interconnected components of knowledge generation and innovation rather than as independent institutional sectors. Knowledge-transfer mechanisms are also increasingly supported by digital forms of agricultural extension. Research indicates that digital extension can influence farmers' adoption of more sustainable production practices [13], while interactive digital advisory services can facilitate access to information, communication, and knowledge exchange but are also constrained by technological, organizational, and user-related barriers [14]. Alt-hough this evidence originates outside Kazakhstan and cannot be directly generalized to national condi-tions, it demonstrates the broader shift from onedirectional dissemination of recommendations toward more interactive and multi-actor approaches to agricultural knowledge transfer [13, 14].

With this international background, the Kazakhstan-specific literature reveals an important analytical gap. Existing national and regional studies address individual components of organic-sector development, including agrarian education and human-capital formation, organic-market development, eco-logical and socio-economic conditions, and agronomic technologies. However, considerably less attention has been given to how these components are institutionally connected within Kazakhstan's organic sector. In particular, the relationships between professional competencies and educational provision, between research outputs and regional technology adaptation, and between scientific knowledge, advi-sory mechanisms, and producer-level implementation remain insufficiently examined as parts of a sin-gle institutional system. Accordingly, the purpose of this study is to analyse the contribution of agrarian research and educational institutions to human-capital development and technology adaptation for sus-tainable organic agriculture in Kazakhstan and to identify institutional gaps in the linkages among pro-fessional competencies, educational provision, research outputs, regional technology adaptation, advi-sory support, and producer-oriented knowledge transfer.

The scientific novelty of the study lies in the development of an integrated conceptual institutional framework tailored to the context of Kazakhstan that connects human capital development, professional qualifications, applied research, regional technology adaptation, advisory and knowledge-transfer mechanisms, and producer feedback within a unified framework for sustainable organic agriculture. Using a systems approach, the study identifies the institutional interfaces at which coordination among these components remains insufficient. The integration of evidence on educational programmes, scientific and technical programmes, professional qualification requirements, technology adaptation, adviso-ry structures, and producer-oriented knowledge transfer provides an analytical basis for identifying three interrelated institutional gaps: the competency and qualification gap, the research-to-practice gap, and the knowledge-transfer and implementation gap. The resulting framework provides the conceptual basis for the practical recommendations proposed in the study rather than representing an empirically validated causal model.

Materials and Methods

Data Availability Statement

The study was based primarily on publicly available legislation, policy and institutional documents, educational program materials, scientific and technical program documentation, statistical sources, international reports, and published scientific literature. The analysis additionally included the draft Professional Standard "Organic Agriculture" and official documentary materials concerning its institutional status available to the authors. No original individual-level dataset was generated. Publicly

available sources are identified in the article and reference list; non-public documentary materials may be described or made available subject to applicable institutional and legal restrictions.

The study was designed as a qualitative document-based institutional analysis of organic agriculture in Kazakhstan. The evidence base comprised regulatory and policy documents of the Republic of Kazakhstan, official statistical and institutional materials, educational program documentation from Kazakhstani universities, documentation and reported outputs of scientific and technical program, the draft Professional Standard “Organic Agriculture”, international analytical reports, and peer-reviewed publications. Materials available up to 2026 were considered. Scientific and technical program implemented during 2012–2026 were included to capture both earlier regional initiatives and recent national program. Universities and educational program were selected purposely. Inclusion required documented evidence of at least one educational program, course, or teaching component explicitly related to organic agriculture, organic production, or standardization and certification of organic products. Educational provision was classified by institution, qualification level (bachelor’s, master’s, or doctoral), subject area, and implementation status. Scientific and technical program were included when they were implemented in Kazakhstan, explicitly addressed organic agriculture or its scientific and methodological support, and provided sufficient documentation on objectives, implementation period, participating institutions, and reported outputs.

The documentary evidence also included the draft Professional Standard “Organic Agriculture”. The draft was analysed with respect to occupational profiles, qualification levels, labour functions, professional tasks, required knowledge and skills, professional and personal competencies, and their relationship with the National and Sectoral Qualifications Frameworks and relevant fields of higher and postgraduate education. Because the document had not been formally approved at the time of the study, it was treated as a draft institutional instrument rather than as an existing regulatory professional standard. Official correspondence concerning its proposed further consideration was used only to describe its documented institutional status and was not treated as evidence of formal approval. Documentary evidence was analysed using analytical, comparative, logical, and systems approaches combined with qualitative content analysis. The evidence was organized into five analytical categories: regulatory framework; educational provision and human-capital development; research and technological outputs; professional qualifications and competencies; and knowledge-transfer and advisory mechanisms. Cross-category comparison was then used to assess the institutional interfaces among these components. A gap was recorded where documentary evidence demonstrated the presence of relevant institutional components but insufficient formalized linkage between them. This comparison resulted in three higher-order analytical gaps: the competency and qualification gap, referring to the interface between sec-toral competency requirements and educational provision; the research-to-practice gap, referring to the interface between research outputs and their regional adaptation and farm-level application; and the knowledge-transfer and implementation gap, referring to the interface among research and educational institutions, advisory structures, and agricultural producers. Findings were cross-checked across differ-ent types of documentary sources where possible.

The approach is limited by its reliance on available documentary evidence and purposive rather than exhaustive selection of educational provision. The supporting literature component was structured but was not designed as a systematic review. The study did not include representative surveys of producers, employers, graduates, or advisory-service users, nor did it undertake a labour-market or imple-mentation-cost analysis. Accordingly, the identified institutional gaps are interpreted as documentary-analytical findings rather than statistically established causal relationships.

Results

The document analysis identified three interconnected institutional gaps in Kazakhstan’s organic agriculture system: a competency and qualification gap; a research-to-practice gap; and a knowledge - transfer and implementation gap. Kazakhstan - specific evidence underlying these gaps was identified through the analysis of the national regulatory framework, educational provision, scientific and technical program, research infrastructure, and existing knowledge-transfer mechanisms. The analysis confirmed that Kazakhstan has established a legal basis for the development of organic agriculture. The Law of the Republic of Kazakhstan dated June 10, 2024, No. 89-VIII “On Production and Turnover

of Organic Products" identifies scientific support as one of the areas of public policy in this field. Article 9 provides that scientific support for organic production and turnover is implemented in accordance with legislation regulating the agro-industrial complex and rural territories, while subparagraph 7 of Article 6 assigns the Ministry of Agriculture of the Republic of Kazakhstan responsibility for informational, or-ganizational-methodological, and advisory support to producers of organic products. The regulatory analysis therefore confirms that scientific and advisory support has a formal legal basis within the national organic-production framework. At the time of the analysis, the reviewed regulatory documents did not establish an approved sector-specific professional standard defining a unified set of competencies, labour functions, and qualification requirements for specialists in organic agriculture. Although a draft Professional Standard "Organic Agriculture" was identified and is analysed below, it had not yet completed the formal review and approval procedure. The absence of an approved and implemented sector-specific competency framework therefore constitutes the regulatory component of the competency and qualification gap identified in the study [15]. According to FiBL and IFOAM - Organics International, the 2025 edition of The World of Organic Agriculture, reporting data for 2023, recorded 191,283 ha of organic agricultural land in Kazakhstan [1]. In comparison with the country's total agricultural land resources, this represents a limited share of the available agricultural area. These figures are reported here as contextual characteristics of the sector; the present study does not test the relative contribution of land availability, certification costs, market access, input supply, or other economic factors to the current scale of organic production.

The educational analysis identified several examples of organic-agriculture content within higher education program in Kazakhstan. At S. Seifullin Kazakh Agrotechnical Research University (KAT-RU), the doctoral educational program 8D08102 "Organic Farming" includes the discipline "Scientific Foundations of Organic Farming". Since 2018, the master's program 7M07501 "Standardization, Certification and Metrology" has included the course "Standardization and Certification of Organic Product Production". At Sh. Ualikhanov Kokshetau University, the doctoral educational program 8D08102 "Agronomy: Organic Farming in the Chernozem Zone" has been implemented since the 2022-2023 academic year and includes the discipline «Modern Achievements in "Organic Farming". At S. Toraighyrov Pavlodar State University, the bachelor-level discipline "Development of Organic Agricultural Production" was identified in the reviewed materials as a planned educational component within program 6B08101 "Agronomy"; because implementation was not confirmed by the documentary evidence reviewed, it was not counted as an implemented educational offering. The mapping therefore identified the implemented organic-agriculture content at doctoral and master's levels, together with evidence of planned bachelor-level provision. The reviewed documents did not demonstrate a nationally coordinated competency framework linking these educational components across institutions and qualification levels.

Under scientific and technical program BR21882327 "Development of new technologies for organic production and processing of agricultural products", teaching and methodological complexes were developed in 2024 for the master's level disciplines "Organic farming and crop production", "Organic livestock farming", and "Processing and labelling of organic food products". The materials were prepared by researchers from KATRU in cooperation with specialists from the A.I. Baraev Scientific Production Center for Grain Farming and the North Kazakhstan Agricultural Experimental Station and include syllabi, lecture materials, practical classes, independent-study materials, glossaries, and assess-ment banks. These materials provide documented evidence of a direct link between a national research program and the development of specialized educational content. The documentary evidence reviewed does not provide comparative labour-market, enrolment, graduate-employment, or learning-outcome data that would justify identifying one degree level as the empirically optimal level for specialized or-ganic-agriculture training [16, 17]. Taken together, the educational evidence supports the identification of a competency and qualification gap. Specialized educational components are present, but the reviewed evidence did not demonstrate that they are currently coordinated through an approved sector-specific professional standard or a nationally implemented competency framework. The draft Profes-sional Standard "Organic Agriculture", analysed later in this section, represents a potential mechanism for addressing this interface, but its effects on educational programmes cannot yet be assessed because the standard has not been formally approved or implemented. The analysis identified several

scientific and technical program addressing organic agriculture through technological, regulatory, methodological, educational, and infrastructural outputs. Table 1 summarizes the program reviewed, their lead institutions, principal outputs, interdisciplinary scope, international participation, funding, and implementation periods.

Table 1. Overview of Scientific and Technical Programs in the Field of Organic Production and Circulation

№	Project Title	Lead Institution	Key Outputs	Interdisciplinary Scope	Interna-tional Par-ticipation / Role of Foreign Partners	Funding Source, Administrator, Funding Scheme, and Total Amount (KZT)	Implementation Period
1	Development of a System of Organic Farming Technologies for the Steppe Zone of Kostanay Region	Kostanay Research Institute of Agriculture (KostRIA)	1. Recommended crop rotations and soil tillage methods were developed for the conditions of Northern Kazakh stan. 2. Patent for invention No. 32314, Method of Spring Wheat Cultivation in Organic Farming (2017), was obtained.	Crop produc tion; economics	Not specified	Republican budget; Ministry of Agriculture of the Republic of Kazakhstan; program-targeted funding; total amount not specified	2012-2014
2	Regulatory and methodological Support for the Development of Organic Production in the Republic of Kazakhstan in Accordance with International and Foreign Standards	S. Seifullin Kazakh Agrotechnical Research University (KATRU)	1. The Roadmap for the Development of Organic Agriculture in the Republic of Kazakhstan for 2022-2023 was developed and approved. 2. Concept papers were developed on land suitability assessment, the national registry of organic agricultural seeds, and the PGS-Qazaqstan system. 3. Four national standards of the Republic of Kazakhstan in the field of organic products were developed. 4. A SWOT analysis of the organic products market was conducted.	Ecology; standardiza tion; certification; economics; marketing	Dr. Darko Znaor, Executive Director of the Avalon Foundation (Netherlands)	Republican budget; Ministry of Agriculture of the Republic of Kazakhstan; program- targeted funding; KZT 212,372,740.53	Q3 2021- Q4 2023
3	Development of Organic Farming Technologies for Agricultural Crops with Consideration of Regional Specificity, Digitalization, and Export Orientation	Kazakh Research Institute of Agriculture and Crop Production (Kaz RIACP)	1. A pilot farm for oil flax cultivation was established (50 ha). 2. Crop rotation schemes were introduced for Almaty and Kostanay Regions. 3. Effective green manure crops were identified. 4. Methods for producing biological products and organic fertilizers were developed.	Field crop production; fruit growing; vegetable. production; cotton growing; plant protect; microbiology and bio-technology; economics	Jan Douwe van Mansvelt (IFOAM) delivered lectures to students on inter national experience and the work of IFOAM	Republican budget; Ministry of Agriculture of the Republic of Kazakhstan; program-targeted funding KZT; 1,251,357,450	Q3 2021 - Q4 2023

Continuation of Table 1

4	Development of New Technologies for Organic Production and Processing of Agricultural Products	S. Seifullin Kazakh Agrotechnical Research University (KATRU)	1. A network agrotechnopark was established. 2. Two startup companies and two spin-off projects were launched. 3. Two specialized laboratories were opened. 4. Three organic production operators were certified: the A.I. Baraev Scientific Production Center for Grain Farming, the North Kazakhstan Agricultural Experimental Station, and KATRU. Certification categories included: A - crop production, seed production, and wild plant collection; B - livestock production and raw materials of animal origin; D - food products; E - feed. 5. A certification road-map was developed and implemented.	Crop production; animal husbandry; veterinary science; food processing and food production; plant protection; microbiology and biotechnology; economics; marketing	Registration and certification of organic production in the European Union; International patent-related result reported in the program documentation	Republican budget; Ministry of Science and Higher Education of the Republic of Kazakhstan; program-targeted funding; KZT 4,000,000,000	Q4 2023- Q4 2025
5	Scientific Support for the Technological Development of Organic Agriculture in the Republic of Kazakhstan*	Kazakh Research Institute of Agriculture and Crop Production (KazRIACP)	1. Monitoring of legal acts and standards related to organic production and the circulation of organic products. 2. Formation and deve-lopment of the PGS-Qazaqstan system. 3. Development of statistical reporting tools for organic production and cir-culation. 4. Creation of an information and analytical database of scientific develop-ments and technologies in organic production. 5. Development of recommendations for upgrading laboratory infrastructure for pesticide residue analysis in organic products.	Ecology; standardization; certification; information technology; economics; marketing	Participation in international professional training courses and internships in Latvia, Moldova, and Belgium	Republican budget; Ministry of Agriculture of the Republic of Kazakhstan; program-targeted funding; KZT 1,350,000,000 (total program funding)	Q4 2024- Q4 2026

* The description of this scientific and technical program is limited to the project “Harmonization of Documents on Organic Production and Circulation with Applicable Requirements and the Foundations for the Formation and Functioning of the Participatory Guarantee System in Kazakhstan (PGS-Qazaqstan), and the Development of a Scientific Database on Organic Production”. The annual funding of this project amounts to KZT 55 million.

Rather than reproducing the individual outputs listed in Table 1, the programs can be differentiated according to the types of results documented. The 2012–2014 Kostanay Research Institute of Agriculture (KostRIA) project represents an early region-specific technological initiative focused on crop rotation, soil tillage, and organic crop-production practices for Northern Kazakhstan. The 2021-2023 KATRU program concentrated primarily on regulatory and methodological outputs, including the Road map, concepts related to land suitability, organic seed registration and PGS-Qazaqstan, national standards, and market analysis. The 2021–2023 Kazakh Research Institute of Agriculture and Crop Production (KazRIACP) program combined regional crop-production technologies with field-based activities, including an oil-flax pilot farm, crop-rotation schemes, green-manure crops, and methods for biological products and organic fertilizers. The 2023–2025 KATRU program expanded the institutional and infrastructural components through the establishment of a network agrotechnopark, specialized laboratories, startup and spin-off activities, certification-related outputs, and educational materials. The program comparison therefore shows that national research activity covers several stages of the organic-sector development process - regional production technologies, regulatory and methodological support, educational materials, certification-related activities, research infrastructure, and information systems. The reviewed program documents did not consistently demonstrate a common mechanism through which research outputs are subsequently cotested with producers, regionally validated where necessary, transferred through advisory structures, and monitored after farm-level adoption. This documentary finding constitutes the research-to-practice gap identified in the study.

The institutional mapping identified several organizations and structures whose documented functions are relevant to standardization, coordination, research, demonstration, or knowledge transfer in organic agriculture. These include Technical Committee No. 100 “Organic Products”, the Project Of-fice “ORGANIC”, and the Network Agrotechnopark of Organic Production at KATRU. Technical Committee No. 100 “Organic Products” is associated with the development and review of national standards and regulatory documents in the field of organic products. The Project Office “ORGANIC”, established within the National Chamber of Entrepreneurs of Kazakhstan “Atameken”, provides a platform involving public authorities, science, civil society, and business. The Network Agrotechnopark of Organic Production at KATRU incorporates research, personnel training and retraining, technology-transfer, experimental-production, and demonstration functions.

The reviewed documents confirm the existence and relevant functions of these structures but do not provide sufficient quantitative evidence on their national coverage, number of producers reached, frequency of advisory activities, regional accessibility, or measurable farm-level outcomes. Accordingly, the present study does not classify them as a fully established national extension system. Instead, their documented functions indicate an existing institutional basis that could participate in a more coordinated knowledge-transfer mechanism. This distinction is important because the documentary evidence establishes organizational capacity and assigned functions, but does not by itself demonstrate the effective-ness or reach of producer-oriented advisory services. The absence of systematic evidence on producer participation, regional advisory coverage, demonstration activities, and feedback from farms constitutes the knowledge-transfer and implementation gap identified in the study. The analysis did not identify an approved sector-specific professional standard for organic agriculture.

The analysis identified a draft sector-specific professional standard “Organic Agriculture”, which is currently under development and has not yet been formally approved. The initiative is being undertaken by the Union of Organic Producers of Kazakhstan jointly with the Technical Committee for Standardization No. 100 “Organic Products”, with B.K. Bulashev being directly responsible for draft-ing the document. The work is being carried out on an initiative basis with financial support from CARLSBERG KAZAKHSTAN LLP. The draft was prepared taking into account the Labour Code of the Republic of Kazakhstan, the Law of the Republic of Kazakhstan “On Professional Qualifications”, the Rules for the Development and/or Updating of Professional Standards approved by Order No. 377 of the Minister of Labour and Social Protection of the Population of the Republic of Kazakhstan dated September 7, 2023, and methodological recommendations for the development of professional standards. The occupational profiles were formulated with reference to the General Classification of Economic Activities, the National Classification of Occupations, applicable qualification reference books, and standard qualification characteristics for agricultural positions. Requirements for specialized

knowledge and skills were supplemented by legislation and standardization documents governing the production and circulation of organic products. The draft contains five occupational profiles covering key areas of organic crop production, livestock production, agricultural engineering and digitalization, and organic food processing. The analysis did not identify an approved and implemented sector-specific professional standard for organic agriculture. However, the documentary evidence included a draft Professional Standard "Organic Agriculture", which was under development at the time of the study and had not yet been formally approved. Table 2 summarizes their qualification levels, principal labour functions and competencies, and links with relevant areas of higher and postgraduate education.

Table 2. Occupational profiles, qualification levels, labour functions, competencies, and educational alignment in the draft Professional Standard "Organic Agriculture"

Occupational profile	Qualification level (NQF*)	Core labour functions	Key professional competencies	Link with education and qualifications
Engineer for the Introduction of New Machinery and Technologies	6	Application of automated agricultural systems and robotic technologies;	Application of automated and digital technologies in organic production; use and interpretation of spatial data; monitoring of crop conditions; application of innovative technological solutions; compliance with organic-production and standardization requirements	Higher education in Automation and Control and related engineering and agricultural program; competencies and learning outcomes aligned with NQF Level 6
Chief Agronomist	8	Organizational and technological management of organic crop production and seed production; development and implementation of scientifically based organic farming systems	Organic farming systems; biologization of agricultural production; crop rotation; maintenance of soil fertility; use of organic fertilizers and biological plant-protection products; organization of field operations; production documentation and traceability	Higher and postgraduate education in Agronomy, organic farming, and related agricultural program; competencies aligned with NQF Level 8
Livestock Farm Manager	7	Organization of production and marketing of organic livestock products; rationalization of production processes; organization and control of organic livestock-farm operations	Management of organic livestock production; organization and optimization of production processes; compliance with organic-production requirements; quality management, traceability, documentation, and operational control	Higher/ postgraduate education in Technology of Livestock Production and related agricultural program; competencies aligned with NQF Level 7
Chief Engineer (Agriculture)	6	Organization of animal registration and identification; reproduction, housing, and feeding of animals in organic livestock production; operation of information systems for animal registration and traceability	Animal identification and record keeping; application of information systems; traceability; organization of reproduction, housing, and feeding in accordance with organic-production requirements; digital documentation	Higher education in agricultural engineering, Technology of Live-stock Production, and related program; competencies aligned with NQF Level 6

Continuation of Table 2

Process Engineer	6	Organization, operation, and management of technological processes for organic meat and dairy production; control of the quality and safety of raw materials, semi-finished products, and finished products	Organic food-processing technologies; quality and safety control; conformity with organic-production and certification requirements; traceability; application of standardization documents; production documentation	Higher education in Food Production Technology and related program; competencies aligned with NQF Level 6

* NQF - National Qualifications Framework of the Republic of Kazakhstan. For each occupational profile, the draft professional standard further specifies professional tasks, required skills and knowledge, and personal competencies. Cross-cutting competencies include knowledge of organic-production and certification requirements, application of standardization documents, traceability and record keeping, product quality and safety control, use of digital and innovative technologies, analytical thinking, independence, responsibility, teamwork, and managerial decision-making.

Source: Compiled by the authors based on the draft Professional Standard “Organic Agriculture.”

Table 2 demonstrates that the draft professional standard establishes a structured relationship between occupational profiles, labour functions, professional tasks, required knowledge and skills, competencies, and qualification levels. The five occupational profiles are assigned to NQF Levels 6-8 and cover technological, managerial, digital, agronomic, livestock-production, and food-processing functions relevant to organic agriculture. Cross-cutting requirements include knowledge of organic-production and certification requirements, application of standardization documents, traceability and record keeping, quality and safety control, digital and innovative technologies, analytical thinking, responsibility, teamwork, and managerial decision-making. The draft also provides an interface between the National Qualifications System and education by linking occupational requirements with relevant fields of higher and postgraduate education. This relationship can be represented as a sequence: labour function - professional task - knowledge and skills - competencies - qualification level - educational learning outcomes. The draft may therefore provide a common competency basis for the future revision or development of educational programmes related to organic agriculture. However, it remained a draft at the time of the study and should not be interpreted as an approved regulatory instrument. Its potential contribution to educational and qualification alignment therefore remains prospective until formal re-view, stakeholder validation, approval, and implementation. According to official correspondence available to the authors, further formal consideration of the Professional Standard “Organic Agriculture” is planned for 2027. Because this information reflects the documented status available at the time of analysis rather than formal approval, Table 2 should be interpreted as a description of the current draft rather than of an enacted professional standard.

Discussion

The Kazakhstan-specific findings indicate that the main analytical issue is the quality of institutional linkages between education, research, qualification systems, advisory structures, and producers. This pattern is consistent with international research that treats agricultural innovation as an interactive system rather than as a linear transfer of knowledge. Accordingly, the three institutional gaps identified in the Results - the competency and qualification gap, the research-to-practice gap, and the knowledge - transfer and implementation gap are discussed below in relation to international evidence and their implications for Kazakhstan.

The identified competency and qualification gap is consistent with international evidence showing that human capital contributes to the development and adoption capacity of agricultural systems. *Tomaš Simin* et al. [18], based on semi-structured interviews with 64 certified organic farmers in Serbia, demonstrated that education, foreign-language competence, ICT use, experience, and participation in

agricultural associations contribute to human-capital formation in organic agriculture. Their findings emphasize that professional capacity extends beyond formal education to include practical knowledge, skills, networks, and sector-specific experience. The Kazakhstan-specific findings add a qualification-system dimension to this discussion. The issue identified in the present study is not the complete absence of work on professional competencies, because a draft Professional Standard "Organic Agriculture" has already been developed. Rather, the current gap lies in the absence of a formally approved and implemented sector-specific framework capable of systematically connecting labour-market requirements with educational outcomes. The draft analysed in this study provides a potential basis for such a framework by specifying occupational profiles, labour functions, professional competencies, and qualification levels and linking them with relevant fields of higher and postgraduate education. The existence of a draft document should not be equated with demonstrated institutional impact. Its contribution remains prospective until stakeholder consultation, expert review, formal approval, implementation, and subsequent incorporation into relevant educational and qualification processes. The draft should therefore be interpreted as an emerging institutional response to the competency and qualification gap rather than evidence that the gap has already been resolved. This distinction is important because the effectiveness of a professional standard ultimately depends not only on its formal content but also on its use by educational institutions, employers, qualification bodies, certification organizations, and other sectoral actors. *Ukpe* [19] found that education expenditure, health expenditure, agricultural labour, and land use jointly explained 78% of variation in agricultural production in Cameroon, with these variables exerting positive and statistically significant effects. Although the economic and institutional context differs substantially from Kazakhstan and the study was not restricted to organic agriculture, it supports the broader proposition that investment in human capital can contribute to agricultural productive capacity. For organic agriculture, this issue is particularly relevant because professional competence combines agronomic knowledge with certification procedures, record keeping, traceability, environmental management, processing and labelling requirements, and the capacity to adapt production practices. In this context, the absence of a sector-specific professional standard identified in the results can be inter-preted as a coordination gap between labour-market requirements and educational outcomes rather than simply as the absence of another regulatory document. The second gap concerns the interface between research outputs and their practical application under regional production conditions. A meta-analysis of 367 regression models found that farmer education, access to extension services, credit, land tenure, farm size, and membership in producer organizations were, on average, positively associated with agricultural technology adoption. At the same time, substantial variation across technologies, geographical settings, and socio-economic contexts indicates that measures supporting technology adoption need to reflect local conditions [20]. This evidence is particularly relevant to Kazakhstan because it highlights an important distinction between technology transfer and technology adaptation. A technology developed experimentally or introduced from another production system cannot be assumed to be directly applicable to Kazakhstan's organic sector. Its practical suitability may depend on regional agroecological conditions, resource requirements, production characteristics, economic feasibility, and compliance with organic-production requirements. This is particularly important in organic agriculture, where crop rotation, soil fertility management, biological plant protection, seed and breed selection, contamination prevention, certification, processing, and marketing form an interconnected production system. Consequently, the practical value of an applied research output depends not only on its scientific validity, but also on its compatibility with the production environment in which it is expected to be implemented. International evidence supports this interpretation. Education and access to information, technical sup-port, resource availability, collaboration, and knowledge exchange among farmers have been identified as important enabling conditions for the adoption of sustainable agricultural innovations, whereas tech-nological complexity, reluctance to adopt innovations, and limited perceived control can constrain their implementation [21]. Thus, technological development cannot be considered separately from the knowledge, competencies, institutional support, and resources available to producers. The Kazakhstan-specific findings provide evidence of an emerging linkage between research and education. Under the scientific and technical program IRN BR21882327, research activities generated teaching and method-ological materials for

specialized disciplines in organic crop production, livestock production, and organic food processing and labelling. The significance of this example is not the content of the individual teaching materials, which was presented in the Results, but the fact that a scientific and technical program generated outputs that were directly incorporated into professional education. However, linking research with education represents only one stage in translating scientific outputs into practice. The subsequent stages may require regional testing where local conditions materially affect technology per-formance, demonstration activities, advisory support, and producer participation. Research on the de-velopment of organic agriculture in Switzerland has demonstrated the value of knowledge coproduction involving farmers, researchers, and extension agents rather than relying exclusively on one-directional transfer of scientific information [22]. For Kazakhstan, this approach may be relevant because agroecological and production conditions vary considerably across regions. Demonstration and cotesting sites could therefore function not only as locations for presenting completed technologies, but also as platforms for testing their regional applicability and facilitating feedback among researchers, advisers, students, and producers. The third gap concerns the institutional mechanisms through which scientific and technical knowledge reaches producers and, equally importantly, through which producer experience and implementation constraints are communicated back to research and education. This two-way relationship is essential because knowledge transfer in organic agriculture involves not simply the dissemination of recommendations, but also their interpretation and adaptation to specific production conditions.

International evidence indicates that support mechanisms for organic agriculture cannot be applied uniformly across different agricultural systems. A global systematic review based on 120 studies found that policy and support recommendations vary according to production conditions, agricultural productivity, the maturity of the organic sector, and the stage of the adoption process [23]. This finding is particularly relevant to emerging organic sectors because institutional arrangements developed in mature organic markets cannot necessarily be transferred directly without considering differences in regulatory capacity, advisory infrastructure, producer experience, market development, and regional production conditions. For Kazakhstan, the results identified existing organizations and structures with functions relevant to standardization, coordination, research, demonstration, and knowledge transfer. The documentary evidence did not demonstrate the existence of a fully coordinated national mechanism that systematically connects these functions with producer-level advisory support and feedback. The issue is therefore not simply the presence or absence of individual institutions, but the quality of the linkages among research, education, advisory structures, certification expertise, producer organizations, and farms. A more integrated knowledge-transfer mechanism would require interaction in both directions: research and educational institutions provide scientific, technological, and methodological knowledge to producers, while producers communicate practical constraints, regional needs, and implementation experience back to researchers and educators. Such feedback can help identify research priorities, im-prove the regional relevance of technologies, inform advisory activities, and update educational content. In this sense, knowledge transfer becomes a continuous learning process rather than the final stage of technology dissemination. For Kazakhstan, this means that strengthening knowledge transfer requires more than disseminating research publications or educational materials. Advisory interaction, demon-stration activities, producer organizations, certification expertise, and feedback mechanisms need to be connected so that research and training can respond to problems encountered in production. Such an approach also avoids assuming that institutional models developed in European organic sectors can be reproduced unchanged under Kazakhstan's regulatory, market, climatic, and organizational conditions [24].

Taken together, the international comparison suggests that the three Kazakhstan-specific gaps represent connected institutional interfaces rather than isolated deficiencies. The competency and qualification gap concerns the interface between sector requirements and education; the research-to-practice gap concerns the interface between scientific outputs and regionally applicable technologies; and the knowledge-transfer and implementation gap concerns the interface between research, advisory structures, and producers. The three gaps should be distinguished from the eight stages presented in Figure 1. The three gaps are analytical findings derived from the Kazakhstan-specific documentary analysis, whereas the eight stages constitute the authors' proposed institutional response pathway.

Thus, Figure 1 does not introduce an additional classification of institutional deficiencies; rather, it translates the three identified gaps into a cyclical sequence of institutional actions and feedback mechanisms. On the basis of the document analysis and international comparison, the authors therefore propose an integrated in-stitutional pathway: Professional standard - competency-based education - applied research - regional technology adaptation - demonstration and advisory services - farm-level adoption - producer feedback - further research and training. Based on the identified relationships between education, research, knowledge transfer, and farm-level implementation, the authors developed an integrated cyclical model for organic agriculture in Kazakhstan.



Figure 1. Proposed institutional education – research - knowledge transfer - production cycle for organic agriculture in Kazakhstan

Source: Developed by the authors based on the Kazakhstan-specific documentary analysis and synthesis of the international literature reviewed in this study. The eight stages represent a proposed in-stitutional response pathway to the three analytical gaps identified in the study.

The pathway is presented as a discussion-derived conceptual model rather than as an empirically validated causal model. Its purpose is to integrate the three gaps identified in the Kazakhstan analysis with mechanisms described in the international literature. Unlike a linear “research - publication - producer” model, the proposed pathway incorporates feedback from producers into research and education and places regional adaptation between technology development and farm-level implementation. Table 3 aligns each institutional gap with its observed barrier manifestations, proposed measures, and the organizations that could participate in implementation.

Table 3. Alignment of identified institutional gaps, observed barriers, proposed measures, and implementation responsibilities

Institutional gap	Observed barriers	Proposed measure	Responsible/ participating organizations
1. Competency and qualification gap	Absence of a formally approved and implemented sector-specific professional standard; uneven integration of organic-agriculture competencies across educational provision	Complete stakeholder consultation, expert review, validation, and formal approval of the existing draft Professional Standard “Organic Agriculture”; subsequently map and align relevant educational program and specialized training with the approved competencies	Ministry of Labour and Social Protection; Ministry of Agriculture; Ministry of Science and Higher Education; relevant Sectoral Council for Professional Qualifications; National Body for Professional Qualifications; universities; employers and producer organizations; certification and qualification-assessment bodies

Continuation of Table 3

2. Research-to-practice gap	Weak cooperation between research/ education institutions and agribusiness; insufficient practical orientation of some research assignments.	Apply risk-based regional validation and producer cotesting to research outputs for which agroecological, technological, regulatory, or production conditions are expected to materially affect performance.	Ministry of Science and Higher Education; Ministry of Agriculture; research institutes; universities; regional experimental stations; producer organizations.
3. Knowledge-transfer and implementation gap	Low producer awareness; insufficient systematic advisory and demonstration mechanisms; limited producer feedback.	Develop regional demonstration and advisory mechanisms and a feedback loop linking producers, researchers, educators, and certification specialists.	Ministry of Agriculture; regional administrations; universities and research institutes; Atameken / Project Office ORGANIC; Network Agrotechnopark; producer associations.

The measures in Table 3 should be interpreted as proposed institutional responses rather than as established causal solutions. Their implementation would require further assessment of institutional mandates, staffing, financing, regional capacity, and the relationship with existing advisory and certification structures. In particular, regional validation should be targeted to technologies for which local agroecological or production conditions are likely to materially affect performance, rather than imposed as a mandatory additional stage for every technology. This would reduce the risk of unnecessary costs and delays while preserving the objective of context-specific adaptation. Regional validation should therefore follow a risk-based principle and should be required only where agroecological, technologi-cal, regulatory, or production conditions are reasonably expected to affect technology performance or compliance. Requiring additional field validation for every technology irrespective of the existing evi-dence could duplicate previous testing, increase implementation costs, delay adoption, and create un-necessary administrative burdens.

The interpretation of these findings should take into account several limitations. First, the study is based primarily on document analysis, mapping of educational and research activities, and comparison with published international evidence; it does not include a representative survey of organic producers, employers, graduates, or advisory-service users. Second, the proposed role of different educational levels, including master's-level specialization, has not been tested against labour-market demand or comparative graduate outcomes. Third, the study identifies institutional gaps and proposes a conceptual pathway but does not estimate the costs, staffing requirements, or implementation effects of the proposed measures. Finally, the international evidence reviewed originates from countries and agricultural systems with different institutional, economic, and agroecological conditions; therefore, the proposed mechanisms require further validation in Kazakhstan. These limitations mean that the pathway presented in Figure 1 should be treated as a framework for institutional development and subsequent empirical testing rather than as a demonstrated causal model. In addition, because the Professional Standard "Or-ganic Agriculture" was still a draft at the time of analysis, the study evaluates its structure and potential institutional role rather than its implementation effects.

Conclusion

The study shows that Kazakhstan has established several important components required for the development of organic agriculture, including a regulatory framework, university-based educational provision, scientific and technical program, research infrastructure, and organizations with functions relevant to standardization, demonstration, and knowledge transfer. The documentary analysis identified three interconnected institutional gaps: a competency and qualification gap, a research-to-practice gap, and a knowledge-transfer and implementation gap. The central challenge is therefore not simply the absence of individual institutional components, but insufficient coordination among professional qualifications, education, research, technology adaptation, advisory mechanisms, and producers.

The analysis of the draft Professional Standard "Organic Agriculture" demonstrates that an institutional basis for addressing the competency and qualification gap is emerging. The draft contains

five occupational profiles at NQF Levels 6-8 and links labour functions and professional competencies with relevant fields of higher and postgraduate education. Because the standard has not yet been formally approved or implemented, its contribution remains prospective. The immediate priority is therefore to complete stakeholder consultation, expert review, formal validation, and approval of the existing draft and subsequently align relevant educational program with the approved competencies. For the research-to-practice gap, regional validation and producer co-testing should follow a risk-based approach and be applied where local agroecological, technological, regulatory, or production conditions are expected to materially affect technology performance. For the knowledge-transfer and implementation gap, existing universities, research institutes, experimental stations, producer organizations, certification expertise, and demonstration infrastructure should be connected through regional advisory and feedback mechanisms.

Overall, the proposed education - research - knowledge transfer - production framework should be interpreted as a conceptual institutional pathway for coordinating existing and emerging components of Kazakhstan's organic sector rather than as an empirically validated causal model. Further research involving producers, employers, graduates, certification and qualification bodies, and advisory organizations is required to assess implementation costs, labour-market relevance, institutional capacity, and the effectiveness of the proposed mechanisms under different regional conditions of Kazakhstan.

Authors' Contributions

BB: conceptualization, formulation of the research objectives, development of the research methodology, data analysis, and preparation of the manuscript. GO and AI: conducted a comprehensive literature review, contributed to manuscript preparation and study design, and performed editing and preparation of the article for publication. All authors read, reviewed, and approved the final version of the manuscript.

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Қазақстандағы органикалық ауыл шаруашылығын тұрақты дамыту үшін адами капиталды дамыту және технологияларды бейімдеу: білім беру, ғылым және білім трансфері

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Түйін

Алғышарттар мен мақсат. Қазақстанда органикалық ауыл шаруашылығын тұрақты дамыту білікті кадрларды, қолданбалы зерттеулерді, өңірлік жағдайларға бейімделген технологияларды және білім трансферінің тиімді тетіктерін қажет етеді. Нормативтік-құқықтық базаның қалыптасқанына және ауыл шаруашылығы ресурстарының елеулі әлеуетіне қарамастан, білім беру, ғылым, біліктілік жүйесі, консультациялық қызметтер және әзірлемелерді практи-каға енгізу арасындағы институционалдық байланыстар жеткілікті деңгейде дамымаған. Зерттеудің мақсаты – аграрлық ғылыми және білім беру ұйымдарының адами капиталды дамытуға және технологияларды бейімдеуге қосатын үлесін бағалау, сондай-ақ органикалық секторды нығайтуға бағытталған шараларды айқындау.

Материалдар мен әдістер. Аналитикалық, салыстырмалы, логикалық, жүйелік тәсілдер мен контент-талдауды қолдану арқылы құжаттарға сапалық институционалдық талдау жүргізілді. Дереккөздер базасына Қазақстанның нормативтік және институционалдық құжаттары, жоғары оқу орындарының білім беру бағдарламалары, 2012–2026 жылдары іске асырылған ғылыми-техникалық бағдарламалар, «Органикалық ауыл шаруашылығы» кәсіптік стандартының жобасы, халықаралық талдамалық есептер және рецензияланатын ғылыми жа-рияланымдар енгізілді.

Нәтижелер. Өзара байланысты үш институционалдық алшақтық анықталды: құзыреттер мен біліктіліктердегі алшақтық; ғылыми зерттеулер мен практика арасындағы алшақтық; білім трансфері мен практикалық енгізудегі алшақтық. Сонымен қатар, Ұлттық біліктілік шеңберінің 6–8-деңгейлеріне жататын бес кәсіптік карточканы қамтитын және еңбек функциялары мен кәсіби құзыреттерді жоғары және жоғары оқу орнынан кейінгі білім берудің тиісті бағыттарымен байланыстыратын «Органикалық ауыл шаруашылығы» кәсіптік стандартының жобасы анықталды. Қолданыстағы білім беру, ғылыми, әдістемелік және институционалдық ресурстарды өндірушілердің қажеттіліктерімен және шаруашылықтар деңгейінде практикалық енгізумен неғұрлым тығыз үйлестіру қажет.

Қорытынды. Нәтижелер кәсіби құзыреттер мен білім беруді қолданбалы зерттеулермен, технологияларды тәуекелге бағдарланған өңірлік бейімдеумен, демонстрациялық және консультациялық қызметтермен, шаруашылықтар деңгейінде енгізумен және өндірушілермен кері байланыспен ұштастыратын «білім беру – ғылым - білім трансфері - өндіріс» интеграцияланған схемасының қажеттілігін негіздейді. Зерттеудің шектеулері құжаттық дереккөздерді пайдаланумен және материалдарды мақсатты іріктеумен байланысты; зерттеу өндірушілердің репрезентативті сауалнамасын, еңбек нарығын талдауды және ұсынылған шараларды іске асыру шығындарын бағалауды қамтымады.

Кілт сөздер: органикалық ауыл шаруашылығы; адами капитал; бейімделген технологиялар; аграрлық білім беру; ғылыми және білім беру ұйымдары; стандарттау.

Развитие человеческого капитала и адаптация технологий для устойчивого развития органического сельского хозяйства в Казахстане: образование, наука и трансфер знаний

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Аннотация

Предпосылки и цель. Устойчивое развитие органического сельского хозяйства в Казахстане требует наличия квалифицированных кадров, развития прикладных исследований, внедрения технологий, адаптированных к региональным условиям, и эффективного трансфера знаний. Несмотря на сформированную нормативно-правовую базу и значительные сельскохозяйственные ресурсы, институциональные связи между образованием, наукой, системой квалификаций, консультационными службами и практическим внедрением разработок остаются недостаточно развитыми. Цель исследования – оценить вклад аграрных научных и образовательных учреждений в развитие человеческого капитала и адаптацию технологий, а также определить меры по укреплению органического сектора.

Материалы и методы. Проведен качественный институциональный анализ документов с использованием аналитического, сравнительного, логического, системного подходов и контент-анализа. Источниковую базу составили нормативные и институциональные документы Казахстана, образовательные программы университетов, научно-технические программы, реализованные в 2012–2026 гг., проект профессионального стандарта «Органическое сельское хозяйство», международные аналитические отчеты и рецензируемые научные публикации.

Результаты. Выявлены три взаимосвязанных институциональных разрыва: в компетенциях и квалификациях; между научными исследованиями и практикой; в трансфере знаний и практическом внедрении. Также выявлен проект профессионального стандарта «Органическое сельское хозяйство», включающий пять карточек профессий 6-8-го уровней Национальной рамки квалификаций и связывающий трудовые функции и профессиональные компетенции с соответствующими направлениями высшего и послевузовского образования. Существующие образовательные, научные, методические и институциональные ресурсы требуют более тесной координации с потребностями производителей и практическим внедрением на уровне хозяйств.

Заключение. Результаты обосновывают интегрированную схему «образование – наука - трансфер знаний - производство», связывающую профессиональные компетенции и образование с прикладными исследованиями, риск-ориентированной региональной адаптацией технологий, демонстрационными и консультационными услугами, внедрением на уровне хозяйств и обратной связью с производителями. Ограничения исследования связаны с использованием документальных источников и целевым отбором материалов; исследование не включало репрезентативные опросы производителей, анализ рынка труда и оценку затрат на реализацию предлагаемых мер.

Ключевые слова: органическое сельское хозяйство; человеческий капитал; адаптированные технологии; аграрное образование; научные и образовательные учреждения; стандартизация.