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WORKFORCE DEVELOPMENT FOR THE AIC OF THE REPUBLIC OF KAZAKHSTAN: NEW TRENDS UNDER DIGITAL ADAPTATION

ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ АӨК ҮШІН КАДРЛАР ДАЯРЛАУ: ЦИФРЛЫҚ БЕЙІМДЕЛУ ЖАҒДАЙЫНДАҒЫ ЖАҢА ТРЕНДТЕР

ПОДГОТОВКА КАДРОВ ДЛЯ АПК РЕСПУБЛИКИ КАЗАХСТАН: НОВЫЕ ТРЕНДЫ В УСЛОВИЯХ ЦИФРОВОЙ АДАПТАЦИИ

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Abstract. The relevance of this study is due to the need for the digital transformation of Kazakhstan's AIC, which represents a strategic priority for ensuring food security and diversifying the national economy. A key success factor is the high-quality training of specialists possessing new competencies in innovative technologies, automation, and big data analytics. *The objective* – is to identify current trends in the development of the republic's agrarian sector in the context of digitalization and to develop scientific and practical recommendations for improving workforce policy. *Methods* – a systematic bibliographic review of the scientific literature was conducted to generalize theoretical approaches and identify prevailing trends. Data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan were analyzed to assess employment dynamics and structural changes within the sector. Expert foresight forecasting (in-depth interviews) was carried out to identify promising future professions. Quantitative surveys of representatives from business, educational institutions, and the general public made it possible to identify current labor market needs and assess its readiness for transformation. *Results* – the study substantiated critical structural problems, including a shortage of qualified specialists, low wage levels, and the outflow of young people into extractive industries. The authors proposed new occupational categories expected to emerge within the next three to five years and identified professional fields that are likely to disappear. *Conclusions* – the study identified the key factors influencing the modernization of the labor sector within the agro-industrial complex and presented a business competency matrix for the workforce of the future, along with an integrated approach to workforce renewal that includes the modernization of educational curricula, the introduction of dual education, and strengthened cooperation among the government, academia, and the private sector. To remain in demand and competitive in the labor market, it is essential

to develop business skills, improve communication abilities, strengthen teamwork capabilities, and foster creative thinking.

Аңдатпа. Зерттеудің өзектілігі азық-түлік қауіпсіздігін қамтамасыз ету және ұлттық экономиканы әртараптандыру үшін стратегиялық басымдық болып табылатын Қазақстанның АӨК-ін цифрлық түрлендіру қажеттілігіне байланысты. Табыстың негізгі факторы инновациялық технологиялар, автоматтандыру және үлкен деректерді талдау саласында жаңа құзыреттіліктері бар кадрларды сапалы даярлау болып табылады. *Мақсаты* – цифрландыру контекстінде республиканың аграрлық секторын дамытудың қазіргі заманғы трендтерін сәйкестендіру және кадр саясатын жетілдіру бойынша ғылыми-практикалық ұсынымдар әзірлеу. *Әдістері* – жүйелік ғылыми әдебиеттерді библиографиялық зерттеу теориялық тәсілдерді жалпылау, үрдістерді анықтау үшін қолданылды. Қазақстан Республикасы Стратегиялық жоспарлау және реформалар агенттігінің Ұлттық статистика бюросының деректерін зерделеу жұмыспен қамту динамикасын, саладағы құрылымдық өзгерістерді бағалау кезінде қолданылды. Перспективалы мамандықтарды анықтау үшін сараптамалық форсайт-болжау (терең сұхбат) жүргізілді. Бизнес, білім және халық өкілдерінің сандық сауалнамалары еңбек нарығының ағымдағы қажеттіліктерін ашуға және оның өзгертілімге дайындығын талдауға мүмкіндік берді. *Нәтижелер* – маңызды құрылымдық проблемалар негізделген: білікті мамандардың тапшылығы, жалақының төмен деңгейі және жастардың өндіруші қызмет бағыттарына кетуі. Авторлар 3-5 жыл ішінде пайда болу көкжиегі бар жұмыс орындарының жаңа түрлерін ұсынды, жойылып бара жатқан кәсіби бағыттар көрсетілді. *Қорытындылар* – зерттеу қорытындысы бойынша агроөнеркәсіптік кешендегі еңбек саласын жаңғыртуға әсер ететін факторлар белгіленді, болашақтың іскерлік бейінінің матрицасы және оқу жоспарларын жаңғыртуды, дуальды оқытуды енгізуді және мемлекет, ғылым және жеке сектор арасындағы өзара іс-қимылды күшейтуді көздейтін кадрлық жаңартуды басқарудың кешенді тәсілі ұсынылды. Сұраныс пен табысты нарықтық бәсекелестік үшін іскерлік дағдыларды игеру, коммуникативтік қабілеттерді жақсарту, командада жұмыс істей білу, креативті ойлау қажет.

Аннотация. Актуальность исследования обусловлена необходимостью цифровой трансформации АПК Казахстана, что является стратегическим приоритетом для обеспечения продовольственной безопасности и диверсификации национальной экономики. Ключевым фактором успеха становится качественная подготовка кадров, обладающих новыми компетенциями в области инновационных технологий, автоматизации и анализа больших данных. *Цель* – идентификация современных трендов развития аграрного сектора республики в контексте цифровизации и разработка научно-практических рекомендаций по совершенствованию кадровой политики. *Методы* – системный библиографическое исследование научной литературы использовался для обобщения теоретических подходов, выявления тенденций. Изучение данных Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан применялось при оценке динамики занятости, структурных изменений отрасли. Для определения перспективных профессий проведено экспертное форсайт-прогнозирование (глубинные интервью). Количественные опросы представителей бизнеса, образования и населения позволили раскрыть текущие потребности рынка труда и проанализировать его готовность к преобразованиям. *Результаты* – обоснованы критические структурные проблемы: дефицит квалифицированных специалистов, низкий уровень заработной платы и отток молодежи в добывающие направления деятельности. Авторами предложены новые виды рабочих мест с горизонтом появления в течение 3–5 лет, показаны исчезающие профессиональные области. *Выводы* – по итогам исследования обозначены факторы, воздействующие на модернизацию трудовой сферы в агропромышленном комплексе, представлены матрица делового профиля будущего и комплексный подход к управлению кадровым обновлением, предполагающий модернизацию учебных планов, внедрение дуального обучения и усиление взаимодействия между государством, наукой и частным сектором. Для востребованности и успешной рыночной конкуренции требуется освоение деловых навыков, улучшение коммуникативных способностей, умение работать в команде, креативное мышление.

Keywords: agro-industrial complex, regional economy, workforce development, digital transformation, dual education, government, science, private sector.

Түйінді сөздер: агроөнеркәсіптік кешен, өңірлік экономика, кадрлық қамтамасыз ету, цифрлық түрлендіру, қос тарапты оқу, мемлекет, ғылым, жеке сектор.

Ключевые слова: агропромышленный комплекс, региональная экономика, кадровое обеспечение, цифровая трансформация, дуальное обучение, государство, наука, частный сектор.

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Introduction

One of the primary development priorities for the agro-industrial complex (AIC) through 2030 is the industrialization of agricultural production. This is to be achieved through a comprehensive set of measures focused on qualitatively improving the technical capacity of AIC sectors, adhering to science-based agricultural technologies, strengthening scientific support, implementing innovative developments, and establishing a human resource provision system aligned with the needs of the real economy (Akilzhanova L., Zhanseitov A., Belgibayeva K. et al.) [1]. The Agro-Industrial Complex integrates sectors such as crop production, animal husbandry, and agricultural processing (The concept of development…) [2].

Generalized analysis of AIC development at the national level often fails to account for regional differentiation within the industry. The formulation of production, resources, and staffing processes within the AIC cannot be effectively realized without an in-depth analysis of regional specificities. Only regional-level research can provide an accurate assessment of the current state of the industry and its future development prospects. In this article, the Atyrau region is selected as the study area. This selection is driven by the availability of an established empirical framework derived from research conducted to develop the Regional Human Resource Demand Map for the Atyrau region. The study aims to identify the challenges and prospects for AIC development amidst the ongoing processes of digitalization and contemporary global trends.

The Atyrau region is one of the key industrial areas of Kazakhstan. Its economic structure is dominated by the oil and gas and chemical industries, with the oil and gas sector accounting for 88% of the region's industrial output. This high concentration of industry creates a significant issue of commodity dependence, rendering the region vulnerable to global oil price fluctuations and constraining the development of other economic sectors. The results and recommendations derived from this region - where the economy is heavily reliant on the resource sector – serve as a practical guide for developing national strategies for AIC advancement and for implementing innovative industry solutions.

The objective of this article is to identify current trends in the development of the Atyrau region's AIC in the context of digitalization and emerging global trends, as well as to propose recommendations for human resource development that can be applied to foster AIC growth at the national level in the Republic of Kazakhstan. The conditions for AIC development, characterized by global shifts, digital transformation, and evolving professional competency requirements, necessitate further in-depth research and rigorous scientific-practical analysis to inform effective human resource policies and industry development strategies on a national scale.

Literature review

The AIC is one of the strategically vital sectors for Kazakhstan. Scientific literature underscores the critical role of agriculture in national economies and in ensuring food security. Agriculture not only provides food at the local level – thereby reducing dependence on imports and strengthening the internal regional economy – but also serves as a crucial source of rural employment, contributing to poverty reduction and improving the quality of life (Kenzhin ZH., Kunyazov E., Serikbaev S. et al.; Kusmoldaeva ZH., Bel'gibaeva ZH., Abraliev O.) [3, 4].

Agricultural production is often the largest sector in terms of both output and employment. The role of agriculture is to promote the expansion of production, that is, the process of industrialization (Grabowski R., Self Sh.) [5].

Drawing upon both contemporary and seminal research, World Bank experts identified empirical patterns confirming that agricultural growth is generally two to three times more effective at reducing poverty than equivalent growth in non-agricultural sectors; the elasticity of demand regarding growth in agroprocessing is sometimes even higher. In contrast, the poverty-reduction effect of equivalent growth in sectors such as mining, finance, business, and public services is significantly more limited (Christiaensen L., Martin W.) [6].

Most authors (Lloyd J.; Touri M.) [7, 8] converge on the consensus that human capital, technical progress, and innovation are the most critical factors in the context of digital transformation. Furthermore, the interaction of these factors creates a multiplicative effect: the training of qualified personnel and the enhancement of professional competencies among farmers and their employees are essential prerequisites for the successful implementation of innovation. Digitalization (automation, Big Data, artificial intelligence and ICT), viewed as a key vector for innovative development, contributes to productivity growth only when supported by a qualified workforce (Kleemann L., Ole Semrau F.) [9].

Authors (Madiev G., Kerimova U., Nigmadzhanov U.) [10] note a series of systemic problems hindering the development of Kazakhstan's agricultural sector, particularly in the face of radical transformation. These include a lack of effective mechanisms to stimulate innovation, insufficient collaboration between the state and the private sector, inadequate integration of science and education, and low levels of funding for research and development in the AIC.

The transition toward the parameters of a new technological order, driven by the proliferation of digital technologies, requires addressing a range of issues related to human resource training. The widespread adoption of digital technologies necessitates that universities prepare graduates with specific competencies and review agricultural curricula to place a greater emphasis on practical training (Tulegenova A.; Trukhachev V., Bobrishev A., Khokhlova E. et al.) [11, 12].

Creating a truly revolutionary “Agriculture 4.0” requires an effective state policy focused on integrating monitoring technologies, decision-support systems, and improved communication across the entire agri-food chain (MacPherson J., Voglhuber-Slavinsky A., Olbrisch M. et al.) [13], alongside investments in education and infrastructure.

Materials and methods

The materials presented in this article are part of a comprehensive socio-economic study conducted to develop the Regional Human Resource Demand Map for the Atyrau region. The research employed a combination of empirical methods (quantitative and qualitative) and strategic approaches. A bibliographical analysis was conducted to systematize and evaluate existing scientific literature, allowing for the identification of common patterns in current scientific and expert approaches. Economic-statistical and balance-of-payment methods were utilized to analyze and evaluate the current situation. The empirical framework of the study relied on statistical data from the Bureau of National Statistics of the Agency for Strategic Planning and Reform of the Republic of Kazakhstan.

A strategic analysis of the regional AIC, as a priority sector for economic diversification, allowed for the identification of systemic industry problems contributing to labor shortages. Expert forecasting served as the key methodological tool for identifying trends, threats, and opportunities, as well as determining the pool of emerging, transforming, scarce, and declining professions within the region’s AIC in the era of digital transformation. This expert forecasting included a foresight session and in-depth interviews with regional experts across various fields, including business, education, science, and public administration.

These results were supplemented by quantitative analysis, specifically surveys conducted among the general population, educational institutions, and business representatives. The surveys aimed to assess residents' job satisfaction, analyze challenges in human resource training, and determine the requirements for new professional competencies.

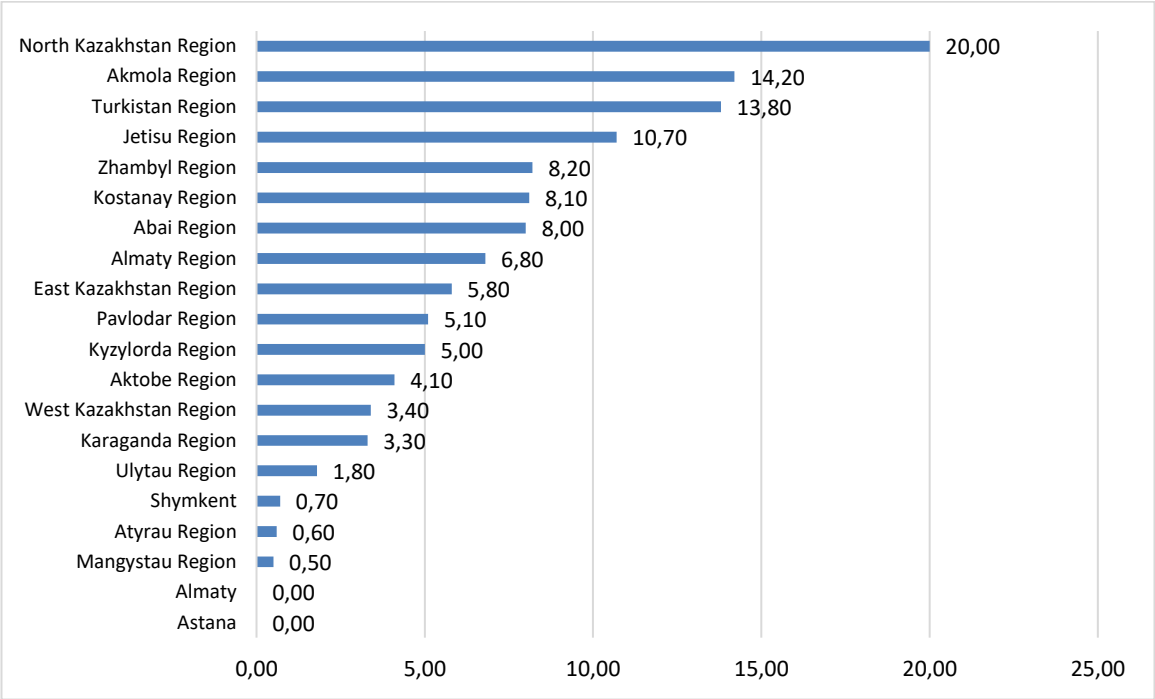
Results

AIC plays a strategically important role in the socio-economic well-being of our state. However, their development in recent years cannot be considered entirely successful, as alongside successes and high performance indicators in certain areas (record harvests, export growth, and the launch of large investment projects for deep processing) (The concept of development…) [2], there are deep structural problems hindering effective development (equipment wear, import dependence, technological lag, underdeveloped infrastructure, and a shortage of personnel) (Madiev G., Kerimova U., Nigmadzhanov U.) [10]. Consequently, Kazakhstan continues to import finished agricultural products across many categories, even though the republic could meet the population's needs for these products through its own production. In practice, other states purchase raw materials from us for their processing, and the reasons for this lie in the systemic structural problems within the agricultural sector.

It is noted, that the measures taken are insufficient to fully realize the significant potential of the domestic AIC. As a result of the current situation, the share of agriculture in the economy declined from 5.4% in 2020 to 3.9% in 2024 and, according to preliminary data, to 3.7% in 2025 (figure 1).

The lowest share of agriculture in the Gross Regional Product (GRP) is observed in the Mangistau and Atyrau regions, where the oil and gas and mining industries prevail.

According to official statistics, the declining share of the AIC in the economy is directly linked to a reduction in employment in the agricultural sector. From 2021 to 2025, the number of employees in the industry decreased from 1 176 382 to 985 900, representing a decline of approximately 16.2% (or 1.19 times). In addition, low levels, insufficient training of young specialists and the reluctance to live and work in rural areas further highlight the low competetiveness of the sector in attracting labor. In addition, the current shortage specialists, including veterinarians and livestock experts, points to serious structural problems in human resource management (Tulegenova A.) [11].



Note: compiled by the authors based on (Bureau of National Statistics of the Agency …) [14]

Figure 1 - Share of agriculture, forestry, and fisheries by region of the Republic of Kazakhstan for the first 9 months of 2025, %

According to official statistics published on December 30, 2025, the number of students enrolled in technical, vocational, and post-secondary education institutions in Kazakhstan at the beginning of the 2025/2026 academic year was 562 084 people (across 12 educational programs). Of this total, only about 2.2% are pursuing education in the fields of agriculture, forestry, fisheries, and veterinary science, amounting to 12 360 individuals. In terms of geographical distribution, 40.4% originates from rural areas and 59.6% from urban areas; by institution type, 41.3% are enrolled in higher colleges and 58.7% in standard colleges.

In the current academic year, 14 564 students are pursuing higher and postgraduate education, of whom 13 860 are undergraduates, 389 are master's students (85% of whom are funded by the state order), and 315 are doctoral students (97.2% funded by the state). The latter highlights another issue - the low percentage of faculty members in agricultural universities with advanced academic degrees. For example, statistics for 2025 show that a total of 55 doctoral students graduated (85.5% of whom were state-funded), yet only 2 doctoral students (who studied at their own expense) successfully defended their dissertations. The state invests significant funds into training qualified personnel, yet the return is very low. The analysis in this category was conducted across 6 educational programs (EP): agronomy, animal husbandry, forestry and fisheries, agricultural engineering, and veterinary medicine.

According to the medium-term forecast for 2023–2030 prepared by the Human Resources Development Center (Medium-term forecast of personnel…) [15], the total new demand for the agricultural sector (base scenario) for 2026 is approximately 23 200 people, including 11 200 in expected new demand, of which about 80% can formally be met by new graduates from universities and technical, vocational and post-secondary educational institutions in the current year.

The shortage of personnel in the fields of veterinary medicine, agronomy, and mechanization is felt particularly acute. The main reasons are low wages, a lack of proper infrastructure in rural areas, and the outflow of young people. Graduates with diplomas do not return to rural areas. All these internal systemic problems are exacerbated by global challenges such as digitalization and technological transformation. Today, there is a significant gap between current human resource training and the needs of Industry 4.0: 86% of the necessary educational programs for this sector are absent in the region's universities and colleges.

To identify trends and draw conclusions on a national scale, the problem and its causes were localized using the Atyrau region as a case study. The socio-economic analysis of the agricultural sector's development reveals a few

systemic problems creating a personnel deficit at the regional level:

1. The average monthly wage for employees in agricultural sectors is the lowest: in agriculture, forestry, and fishing – 155 893 tenge; in crop and livestock production, hunting, and related service activities – 196 138 tenge; and even lower in fishing and aquaculture – 104 928 tenge, while in the mining industry it exceeds 1.9 million tenge, and in the manufacturing industry – 1.2 million tenge. Such income differentiation makes the agricultural sector the least attractive for young people and qualified specialists, provoking their outflow to extractive and industrial companies.

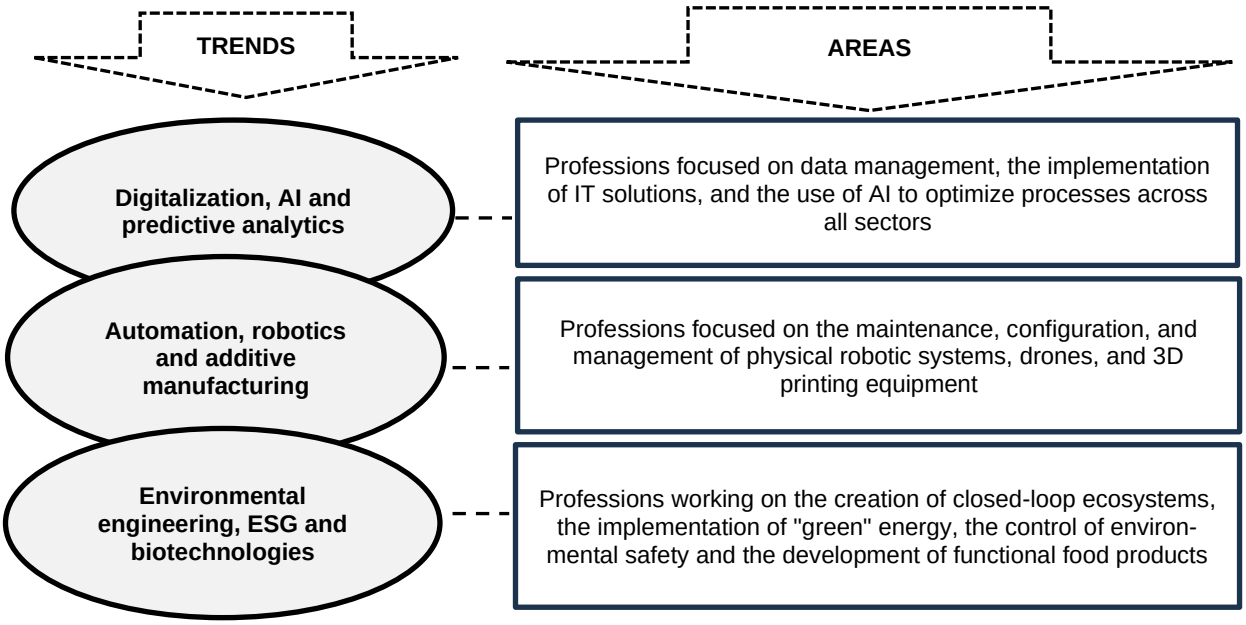
2. The industry's labor resources are concentrated in agricultural districts and are used inefficiently, which is confirmed by statistical indicators. Thus, the highest unemployment rate (4.9%) is recorded in agricultural districts - Inder, Kurmangazy, Kyzylkoga, and Makhambet. In these districts, work is seasonal and unstable, which requires the creation of permanent jobs through the development of processing enterprises.

3. The net total migration balance shows a migratory outflow - a phase of "demographic contraction" and the outflow of young people to major metropolises (Almaty and Astana), which deprives the industry of potential future personnel.

4. Structural analysis of the AIC's share in the regional economy demonstrates the necessity of transitioning from a raw-material model to a processing-oriented one. Thus, the gross output of agricultural products (services) amounted to 138 114.1 million tenge. Agriculture includes the following economic sectors: crop production (share in agriculture is about 40%), livestock production (57.54%), hunting and trapping, including services in these areas (0.03%), forestry and logging (0.003%), and fishing and aquaculture (1.6%).

5. The sectoral structure of the region's Gross regional product is characterized by a high share of industry dominated by the raw-material sector – 49.5%, of which about 43.7% accounts for the mining sector and about 4.6% for manufacturing, whereas agriculture accounts for only 0.6%. In general, goods form slightly more than 50% of the GRP, and services account for about 37.5%.

Analysis of technological transformation: a foresight forecast. Based on in-depth interviews with industry experts, an analysis of survey results from business, educational, and public representatives, as well as forecasts from the foresight session, 11 key trends in the transformation of the AIC were identified (Atlas Atyrau region…) [16]. These trends are grouped into three main categories, within which a demand for new areas of professional activity and specialization is expected to emerge within a 3-5 year horizon (figure 2).



Note: compiled by the authors

Figure 2 – Key trends in AIC transformation using the Atyrau region as a case study

To forecast labor market transformations and identify new areas of activity that may emerge as a result "technological obsolescence" (loss of value) of traditional professions, we analyzed macro-environmental factors (technological, environmental, socio-political, political, and format-related). These factors, along with professions of the future that are

transforming under the influence of current trends, are presented in table 1. Understanding these new development vectors is essential for the timely modernization of the educational system.

Table 1 - Macro-environmental factors and competency transformation matrix in the AIC using the Atyrau region as a case study

Factors		Transforming professions (new competency)
TECHNOLOGICAL	Water-saving technologies	Smart irrigation systems management specialist. Farm water balance engineer
	Breeding technologies	Agro-geneticist for adaptive varieties. Plant bio-monitoring specialist
	Feed systems	Digital feed station operator. Feed ration modeling technologist
	Agricultural robotization	AIC robotics engineer. Autonomous agro-bot fleet operator
	Digital farms and AI-monitoring	Agro-data analyst (AgroData Scientist). Digital farm specialist
	RAS (fish farming)	RAS technologist. Aquaculture automation specialist
ENVIRONMENTAL	Land degradation	Regenerative agriculture specialist. Agro-ecologist analyst
	Reduction of water resources	Farm water sustainability manager. AIC water systems engineer
	Greening	AIC environmental auditor. Green production control specialist
	Climate change	AIC climate manager. Crop climate-adaptation specialist
	Waste processing	Bio-fertilizer specialist. Agro-waste processing engineer
SOCIO-POLITICAL	Demand for local products	Local agro-market manager. Regional brand specialist
	Scientific training	Science-to-Farmer coordinator. Agro-technology instructor
	Subsidization	AIC financial manager (AgroFinance). Subsidy and state program specialist
POLITICAL	Water and land use regulation	Land and water management specialist. Regulatory agro-control expert
	Eco-standards	Carbon footprint specialist. Eco-product auditor
FORMAT RELATED	Farmer cooperation	Cooperation manager. Joint agro-management specialist
	Agro-industrial hubs	Agro-hub operator. Hub logistics manager
	Science-Farmer-Production	Agro-technology transfer specialist. Experimental field coordinator
Note: compiled based on the authors' research		

Despite the natural and climatic constraints of the Atyrau region, the development of its Agro-Industrial Complex necessitates the adoption of digital technologies, biotechnologies, and automation. These trends drive demand for entirely new professional specializations required to build a high-tech, adaptive, and sustainable agricultural system. In table 2, new professions for the AIC are proposed, categorized according to the "Atlas" of professions.

Table 2 - New professions for the AIC in the context of global digital transformation

New professions	Functions	New professions	Functions
Agro-IT specialist	Automates farm processes, implements software and sensor systems	Biosafety specialist	Controls sanitary and biological risks
Data-driven agronomist	Analyzes data from drones, sensors, and satellites	Agro-AI specialist	Analyzes big data in agriculture
Digital farm veterinarian	Monitors animal health via sensors and monitoring systems	Electric tractor engineer	Services and repairs electric agricultural machinery
Smart machinery engineer	Maintains and configures smart equipment and robots	Agricultural drone operator	Performs field monitoring
Plant and animal breeder-geneticist	Works with genomic data of plants and animals	Greenhouse climate control specialist	Manages greenhouse microclimate
Aquaponics specialist	Cultivates fish and plants in an integrated system	Digital livestock farming specialist	Monitors animal health and productivity
Agricultural robotics engineer	Implements and maintains agricultural robots	Food robotics line operator	Manages automated processing lines
Agronomy analyst	Analyzes soil and crop data	Agro-robot operator	Deploys and monitors agricultural robots
Precision farming specialist	Configures GPS systems and sensors	Automated warehouse operator	Manages digital warehouse systems
Agro-data center specialist	Supports the agricultural sector's IT infrastructure	Smart irrigation system operator	Configures automated irrigation systems
Biosensor engineer	Develops sensors for plant health monitoring		
Note: compiled by the authors			

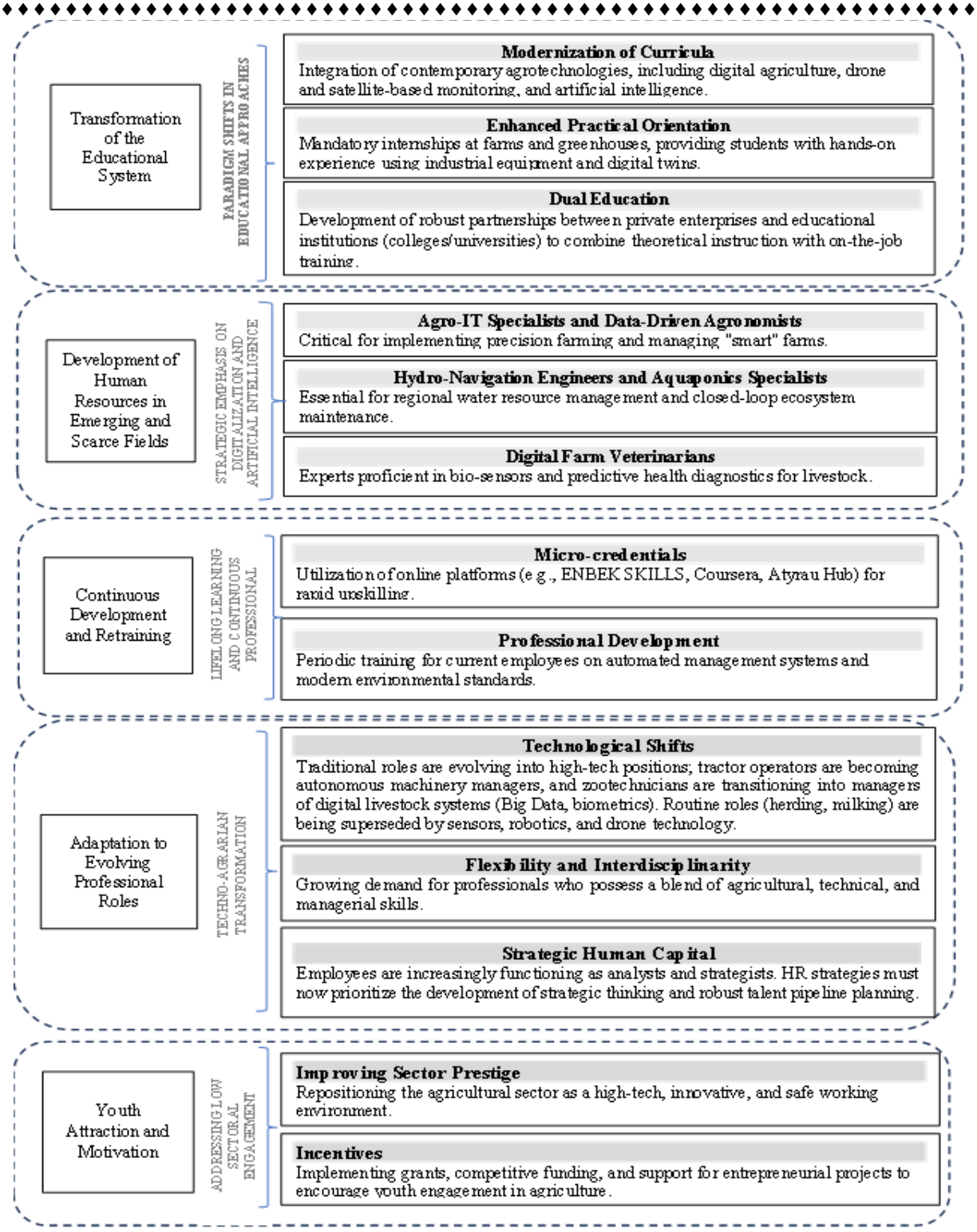
Figure 3 presents the generalized trends and key human resource management strategies identified by the expert panel.

The supply of qualified labor in the agricultural sector is constrained by a range of training-related issues, such as low levels of engagement in vocational training and higher education. Strengthened partnerships between the state and the agricultural sector could be instrumental in addressing the sector's diverse training and human resource development needs.

Increased investment in on-the-job training and professional development must be complemented by improved access to new information and technologies. Both public and private advisory services continue to play a central role in facilitating the exchange of knowledge and information with farmers. It is expected that enhancing the effectiveness of agricultural advisory services will bolster farmers' innovative potential and, consequently, increase farm productivity.

In the context of digital transformation, there is a mass obsolescence of professions based on manual labor (e.g., herders, milkers, timekeepers) and the emergence of demand for fundamentally new competencies in the fields of AI, IoT, robotics, and additive technologies. The core strategic directions for the region's human resource policy include the modernization of educational programs, the strengthening of practical training, the implementation of dual education and lifelong learning systems, the creation of regional competency centers, and the development of microcredentials to facilitate the rapid adaptation of personnel to the new industrial model.

The process of managing human resource transformation requires a comprehensive approach. To effectively manage the staffing of the region's agricultural sector under current conditions, it is, above all, necessary to bridge the gap between education and the real needs of the industry.



Note: compiled based on the authors' research

Figure 3 - Key areas of human resource management

Discussions

The results of this analysis confirm that the agricultural sector is a vital component of regional socio-economic development. In the face of contemporary challenges, questions regarding industry advancement have gained heightened significance. A major barrier remains the low level of digitalization in agricultural processes. With the adoption of digital solutions, modern technology, and automated management systems, the AIC could become a technologically advanced and sustainable sector, regardless of regional climatic constraints. Expanding opportunities for innovation and digitalization acts as a key growth driver for the region's agricultural sector.

The implementation of the Concept of Development of Agro-Industrial Complex of the

Republic of Kazakhstan (2021–2030) and the Concept of Digital Transformation, Development of the ICT and Cybersecurity Industry (2023–2029) has had a positive effect, identifying AgriTech and green energy-efficient technologies as priority vectors.

However, international and domestic research consistently indicates that innovation is hampered by limited professional competencies and low qualifications among management. Digitalization only yields dividends when supported by robust human capital. The persistent "talent gap" remains the primary obstacle to industry growth. Furthermore, lower wage levels in agriculture compared to other sectors exacerbate the outflow of labor and increase the scarcity of specialists. Our analysis of the Atyrau region confirms that these problems are most acute in regions with heavy commodity dependence.

Consequently, addressing these challenges requires coordinated efforts between state agencies, educational institutions, and the agricultural community. Modernizing production processes, building qualified human potential, and increasing access to digital innovation are the foundations upon which a competitive agricultural economy must be built.

Conclusion

1. The agro-industrial complex, which covers such vital sectors as crop production, animal husbandry and processing of agricultural products, is a key sector of the economy that ensures food security and development of the country. The development of the agricultural sector is facing numerous structural problems - weak material and technical resources, technological backwardness, low level of automation of processes and a shortage of both qualified and unskilled personnel. Labor problems in the agricultural sector are systemic and manifest themselves in low wages, a massive outflow of young people, lack of stability among the teaching staff, and a mismatch between education and the real needs of industry.

2. Regions specializing in raw materials are the most vulnerable in terms of agribusiness development (for example, Atyrau region); in these regions, it is necessary to strengthen measures to create conditions for the transition from a raw material model to a processing and technologically intensive agricultural system, including personnel training, rural infrastructure development and industrial diversification.

3. The existing problems are compounded by global trends (digitalization, automation, artificial intelligence and ESG approaches). Digital transformation in Kazakhstan is strategically necessary, but its effectiveness is directly limited by the shortage of qualified personnel and the inconsistency of the existing training system with the requirements of Industry 4.0.

4. Therefore, it is extremely important to identify the needs for new professions and the transformation of existing professions, to identify the necessary new competencies and skills for future and current industry professionals. Effective management of the personnel transformation of the agro-industrial complex is possible only with the coordination of the state, education, science and business.

5. It is necessary to review the structure of personnel training in higher education institutions and technical, vocational and post-secondary educational institutions to promptly begin implementing practice-oriented forms and training programs, to review existing educational programs, including the development of dual training, competence centers and continuous professional development systems.

Authors' contribution: Sarina Bakytgul: a literary review on the topic of research, analysis and collection of information; Smagulova Zubirash: choice of research methodology, editing and finalization of publication; Baltabayev Bolat: analysis of foreign literature, interpretation of study results.

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