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DIGITALIZATION OF HUMAN RESOURCES IN THE AGRICULTURAL SECTOR OF THE REPUBLIC OF KAZAKHSTAN

Abstact
The relevance of the research is due to the fact that the level of digitalization of human resources directly affects the effectiveness of the use of modern agricultural technologies, the accuracy of managerial decision-making and the competitiveness of agriculture in Kazakhstan on the world market. As part of the study, an analysis of labor productivity in agriculture in Kazakhstan was conducted, which showed a limitation in the lack of digital competencies of industry workers, a low level of automation of processes in a number of regions and the lack of a systematic approach to training specialists in new technologies. The purpose of the study is to substantiate the need to develop human resources in the agro-industrial complex of Kazakhstan in the context of digitalization affecting labor productivity, as well as to develop recommendations for staff development through the integration of digital technologies. The results of the study. As part of the study, attention was focused on analyzing the main performance indicators and performing calculations for 2025-2027. It was revealed that while maintaining the current growth dynamics and the active introduction of digital technologies, the level of labor productivity can reach 12-14 thousand tenge per employee by 2027 in agriculture. This analysis has formed conclusions indicating the need to strengthen state support for the agricultural sector, in particular, through the development of educational initiatives, the creation of digital solutions for the industry, increasing the level of digital competencies and the integration of modern technologies into the personnel training system. The development of specialized educational programs for rural specialists, the introduction of digital monitoring and management tools for production processes, and the systematic assessment and development of professional skills of employees were proposed.

Keywords: agricultural sector, productivity, digitalization, agriculture, human resources, agritechnologies, government support.

INTRODUCTION

The agricultural sector retains its strategic importance in the context of the active development of the digital economy in Kazakhstan, serving as the basis for food security and employment in rural areas, as well as a key component of export potential. In this regard, the digital transformation of the human resources in the agricultural sector takes on particular significance and is regarded as a priority area of state policy.

The relevance of this study is determined by the need for a systematic approach to development of human resources in the context of the digital economy, as well as by the fact that the agricultural sector of Kazakhstan, despite significant achievements in certain areas.

The aim of this study is justifying the importance of development of human resources in the agro-industrial sector of Kazakhstan in the context of digitalization, identifying its impact on labor productivity, and developing recommendations for improving the system of training and professional development of personnel using digital technologies.

The scientific significance of the study is to deepen theoretical understanding of the relationship between digitalization, human capital, and labor productivity, as well as to expand the methodological tools for analyzing development in the agricultural sector in the context of the digital transformation of the economy.

The digitalization of the human resources capacity for the agricultural sector in Kazakhstan is not just a technological process, but a profound systemic transformation that affects education, motivation, social policy, and sustainable rural development. For successful implementation of this initiative, it is necessary to combine the efforts of the government, educational institutions, the scientific community, and agribusiness, as well as to develop integrated development programs focused on the needs of the real sector of the economy.

LITERATURE REVIEW

The integrative role of human resource management continues to grow as a topic in sustainable and smart agriculture. This dual focus emphasizes new solutions for agricultural businesses and rural areas, combining academic concepts with practical applications to address the pressing challenges that arise when implementing labor-saving technologies. In our knowledge-based society, the importance of human resources is growing, as a well-motivated workforce with useful knowledge and skills plays a fundamental role in economic development of the country and becomes a critical factor in its competitiveness (Qorri et al., 2024). The agricultural sector continues to play a vital role in ensuring food security (Nagy S., 2021) and achieving various United Nations Sustainable Development Goals (SDG) (United Nations, 2023). The agricultural sector is characterized by labor-intensive (agricultural workers) and capital-intensive processes (machinery, technology), resulting in high costs for business owners.

The success of agriculture depends on the quality of the knowledge applied to increase crop yields. The entrepreneurial and organizational skills of farmers are crucial for improving household food security and incomes and fostering sustainable agricultural development. An effective knowledge management process strengthens the whole chain of agricultural activities (Senapathy & Pandikumar, 2023; Opolot et al., 2018). The adoption of new technologies at the farm level leads to a redistribution of activities and resources, while the need to develop new technologies leads to development of new skills and competencies (Charatsari et al., 2023). The effective use of intellectual resources and coordination of business plans with innovative initiatives can contribute to long-term competitive success (Rehman et. al., 2020). This is also confirmed by research (Blanka et al., 2022), which highlight the link between technological innovation and human development. It is necessary to expand the continuous chain of career guidance and staff development to update professional competencies (Suyeubayeva S.N., 2024), and implementation of sectoral strategic goals aimed at further development of human resources in the agricultural sector of the Republic of Kazakhstan (Kydyrbayeva E.O., 2022).

The digitalization of human resources in the agricultural sector of the Republic of Kazakhstan is a strategically important area, and successful implementation of this initiative is crucial to the effectiveness of the whole agricultural production system, achievement of food security goals, and integration of Kazakhstan into global agro-industrial chains. Modern agriculture is not just an industry based on traditional knowledge and experience; it is a high-tech sector that requires constant update of competencies and skills among workers at all levels. Despite the measures taken, Kazakhstan faces challenges that limit development of human resources in the context of digitalization:

- mismatch between the level of digital competencies among personnel and the requirements of digital agriculture. Most workers in the agricultural sector do not have sufficient training in working with digital platforms, software, automated production management systems, and data analysis (Big Data, IoT, agro-IoT, drones, etc.);
- lack of a comprehensive system for training, retraining, and professional development of personnel. Existing educational programs at agricultural universities and colleges do not place sufficient emphasis on practice-oriented training using digital technologies. Regional differences in access to educational resources and infrastructure exacerbate the problem;
- limited employee pool for implementation of innovative solutions. Low motivation among farmers and farm workers to learn new technologies, lack of systematic government support (mentoring programs, accelerations, grants) leads to insufficient readiness of the personnel for digital transformation;
- uneven development of digital platforms and services across regions. The problem is particularly acute in remote and sparsely populated areas, where implementation of digital solutions in the agricultural sector is complicated by weak ICT infrastructure and lack of personnel capable to maintain and develop these systems.

All this requires a comprehensive, systematic approach that takes into account not only adoption of digital technologies, but also staff training, development of ICT infrastructure, and modernization of production processes in the agricultural sector of Kazakhstan. The digitalization of human resources is directly linked to increased labor productivity in agriculture, as modern technologies enable automation of routine operations, optimization of resources use, minimization of losses, and improvement of production process efficiency. Without the willingness of personnel to master and implement digital tools, it is impossible to achieve long-term growth in labor productivity, which is a key factor in competitiveness and sustainable development of the agricultural sector. Moreover, growth in labor productivity in the agricultural sector of Kazakhstan currently lags significantly behind comparable indicators in European Union countries, highlighting the need for accelerated transformation of personnel policies and implementation of innovative educational programs.

So, formation of human capital with a focus on digital competencies should become a priority area of public policy, aimed at decreasing the productivity gap, increasing the efficiency of agricultural production, and ensuring the food security of the country.

METHODOLOGY AND METHODS

The methodological framework of the study includes systematic and comprehensive approaches to analysis of human resource provision in the agricultural sector in the context of digital transformation:

- economic and statistical analysis - to assess labor productivity levels in agriculture for 2015-2024 and analyze trends;
- forecasting based on trend models - to calculate projected labor productivity indicators, taking into account a scenario of active digital technology adoption;
- comparative analysis method – to compare indicators of Kazakhstan with similar data from the European Union and identify gaps in digitalization and labor productivity;
- content analysis of the regulatory framework and strategic development programs – to identify the direction of government policy regarding the digitalization of the AIC;
- a systematic approach – for formation of comprehensive recommendations on development of human resource capacity and integration of digital technologies into educational programs and management practices.

RESULTS

The modern development of the agrarian sector in the context of digitalization requires not only adoption of innovative technologies but also reassessment of the role of human capital as a key factor in sustainable growth and competitiveness. Internationally, the successful integration of AI, the Internet of Things (IoT), and big data technologies in agriculture is closely linked to effective human resource management (HRM), which ensures development of digital competencies, adaptation of farmers and specialists to new working conditions, and formation of an innovative culture in rural regions.

A comparison of experience of Kazakhstan with foreign countries reveals institutional and organizational differences in approaches to human resource development and the digital transformation of agricultural production. Foreign models (EU, Israel, USA, South Korea, Singapore) demonstrate a systematic interconnection between AI development policy, staff training, and mechanisms to motivate workers to adopt technologies, thereby accelerating the technological modernization of agriculture (Table 1).

Table 1. A Comparative Analysis of Human Resources in the Digital AIC

Comparison	Kazakhstan	Foreign experience	Experience for Kazakhstan
Digital competencies of farmers and agricultural professionals	A shortage of practice-oriented digital skills (Big Data, IoT, agricultural drones, DSS) and significant regional disparities	Mandatory "digital farming" modules, micro-credentials, dual programs with agribusiness; a continuous upskilling model	Introduce micro-credentials (IoT-farming, agro-GIS, analytics), dual tracks with agricultural enterprises, and regional competence centers
Knowledge Management (KM)	Fragmented courses, weak link "science-business-field", and lack of distribution cases	Agroconsulting platforms, demo farms, extension-services, dataset and recipe libraries	Establish a national KM platform + a network of demo-farms and extension services, with KPI for implemented practices
HR Policy and Motivation	Low motivation to learn technology; rare mentoring/ acceleration	HR policies "implementation bonus", upskilling grants, farmer-mentor/coach	Launch "digital yield awards", training grants, and accelerators for innovative farmers
Data and Services Infrastructure	Incomplete access to agro data, weak ICT in remote areas	Open agro datasets, weather/ soil API, low-cost access to satellite data	National agro-Data Hub (soil, weather, and satellite data) + preferential communication/IoT for villages
Industrial Automation	Pilots are disorganized, lack of CV/robotics, PdM	Extensive CV recognition, predictive maintenance, autonomous platforms	Pilots of "quick wins": CV-account of defects/plants diseases, PdM for equipment
Impact Assessment	KPIs are not unified, no industry P4P	Yield/resource KPIs, P4P schemes, and risks insurance	A unified KPI set and P4P for farms implementing digital practices

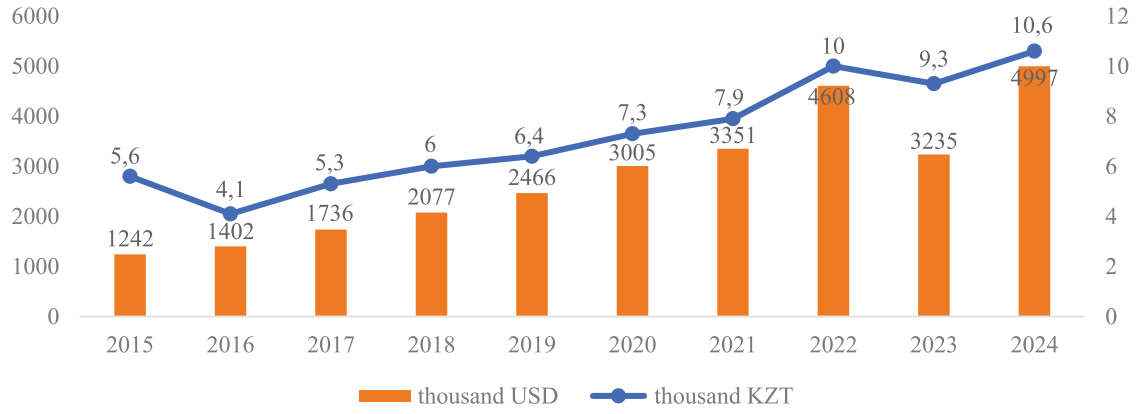
Note: prepared by authors

This analysis for Kazakhstan is of particular importance, as transition to smart agriculture is hampered not only by infrastructure and investment barriers, but also by personnel limitations – a low level of digital competencies, lack of practice-oriented educational programs, and absence of a comprehensive knowledge management system.

DISCUSSION

The agriculture in the Republic of Kazakhstan continues to play an important role in the economy of the country ensuring food security, promoting sustainable development of regions and creating jobs (Figure 1) (Halyk finance, 2025).

Figure 1. Agricultural productivity of the Republic of Kazakhstan for 2015-2024



Source: Prepared by authors on the basis of the source (Halyk finance, 2025)

Forecasting of the indicator "Labor productivity of the agriculture in the Republic of Kazakhstan" was carried out using a growth curve, while we proceeded from the assumption that the additive model of the series can be represented as the sum of two components:

$$y(t) = f(t) + \varepsilon(t), \quad (1)$$

where:
f(t) - some non-accidental (systematic) function of time (t);
ε(t) - random component expressing residual deviation (error) of the model due to random factors.

The function f(t), describing the structural component of a time series, defines a trend, which represents the tendency averaged over the studied series of observations, its external manifestation. Initially, the time series was tested for presence of anomalous observations, using the Irwin criterion (Table 2) (Halyk finance, 2025).

Table 2. Check for presence of anomalous observations in a time series

Year	Labor productivity in the agriculture of the Republic of Kazakhstan, thousand tenge	Observed value of the Irwin criterion	Calculation formulas
2015	5,6		Observed value of the Irwin criterion
2016	4,1	0,.693	$\lambda_t = \frac{\lvert y_t - y_{(t-1)} \rvert}{\sigma_y}$, t = 2,14
2017	5,3	0,555	
2018	6	0,323	Critical value of the Irwin criterion
2019	6,4	0,185	$\lambda_{0,05}$ = 1,5
2020	7,3	0,416	
2021	7,9	0,277	
2022	10	0,97	
2023	9,3	0,323	
2024	10,6	0,601	

Source: Prepared by authors on the basis of the source (Halyk finance, 2025)

The obtained results indicate that the original time series does not contain anomalous observations with 95% probability, as all observed values of the Irwin criterion are less than the critical value.

A hypothesis was made regarding presence of a trend in the analyzed time series, which was confirmed using "ascending" and "descending" series criterion.

1 Check for presence of a trend - general form of the "ascending" and "descending" series criterion (at least one inequality is sufficient for a trend):

- formula for the number of series (Kmax):

$$\nu(n) > \left[\frac{2n-1}{3} - 1{,}96\sqrt{\frac{16n-29}{90}}\right], \text{put } n = 10$$

$$\nu(10) > \left[\frac{19}{3} - 1{,}96\sqrt{1{,}455 = 6{,}33 - 2{,}36 = 3{,}97}\right]$$

$$\nu(10) = 3{,}97$$

$$\nu(n) > \left[\frac{2 * 10 - 1}{3} - 1{,}96\sqrt{\frac{16 * 10 - 29}{90}}\right]$$

$$1{,}96 * 1{,}206 = 2{,}363$$

$$\nu(n) > 5{,}333 - 2{,}363 = 2{,}97$$

The critical value of the criterion for n = 10 is 2.97 (Table 3).

Table 3. Trend presence indicators

Indicator	Result	Criterion	Conclusion
Number of series (K)	4	≤2,97 (Kmax)	Trend is available
ν(10)	3,97	-	Check of second conditions
Note: prepared by the authors on the basis of performed calculations			

The analytical method for assessment of non-accidental component of a time series using a growth curve was implemented within the framework of a regression model, where the analyzed indicator (variable y_t) served as the dependent variable, and time t as the only explanatory variable. The growth curve parameters were estimated using the least squares method, i.e., they were selected that the growth curve function graph was located at a minimum distance from the original data points. According to this method, all observations were assigned equal weights while estimating the model parameters, i.e., their information value was considered equal, and development trend over the whole observation period was constant. A first-degree polynomial was selected as the growth curve:

$$y_t = a_0 + a_1 t + \varepsilon_t, \quad (2)$$

The following trend model was obtained in the result of the calculations:

$$y_t = 4{,}927 + 0{,}564 * t$$

The resulting model was assessed in two areas: adequacy verification and model accuracy assessment. To test adequacy of the model, a series of residuals was examined, i.e., discrepancy between the levels calculated by the model and actual observations. The most important properties of the residual component are: equality of the mathematical expectation to zero, randomness of the residuals, and their conformity to the normal distribution law. To test the hypothesis of equality of the mathematical expectation to zero t-statistics $t_{(obs.)} = 0$ was determined, which is less than the critical value of $t_{(crit.)} = 2{,}18$, confirming the hypothesis with 95% probability.

The randomness of the residual series levels was tested using the turning point criterion:

$$p = 6 > \left[\frac{2}{3}(n-2) - 1{,}96\sqrt{\frac{16n-29}{90}}\right] = 5$$

Inequality was confirmed by calculations; therefore, the model is adequate according to this criterion. The conformity of the residuals to the normal distribution law was determined using RS-criterion:

$$RS = \frac{e_{max} - e_{min}}{S} = 4{,}10$$

The calculated value was within the boundary value range of the criterion (2.96–4.14), confirming the normal distribution. To assess the accuracy of the model, the average relative approximation error was calculated, which value indicates an acceptable level of model accuracy:

$$E_{rel.} = \frac{1}{n}\sum_{i=1}^{n}\frac{|e_t|}{y_t} \cdot 100\% = 9{,}01\%,$$

where:
n – number of observations (10 years in our case, from 2015 to 2024);
e_t - approximation error at time t (the difference between the actual and calculated values);
y_t - the actual value of the indicator at time t.

The model is qualitative and can be used for forecasting. To calculate a point forecast, the corresponding values of the time factor were put into the constructed model. To construct an interval forecast, a confidence interval was determined at a significance level of α = 0,05. The width of the confidence interval was calculated using the formula:

$$U(k) = S_e t_\alpha \sqrt{1 + \frac{1}{n} + \frac{(n+k-\bar{t})^2}{\sum_{t=1}^{n}(t-\bar{t})^2}}, \quad (3)$$

The results of point and interval forecasts for 2025-2027 are presented in Table 4.

Table 4. Point and interval forecasts of livestock number for 2025-2027, thousand tenge

Year	Point forecast, livestock number	Interval forecast, livestock number	
		Upper boundary	Lower boundary
2025	10,966	8,918	13,014
2026	11,642	9,495	13,789
2027	12,318	10,060	14,575

Note: prepared by authors on the basis of performed calculations

An analysis of labor productivity in agriculture for 2015-2024, as well as forecasts for 2025-2027, demonstrates positive trends, reflecting a gradual improvement in efficiency in the industry. The increase in labor productivity from 5.6 thousand tenge in 2015 to 10.6 thousand tenge in 2024 (+89.3% over the period) is due not only to technical upgrades but also to introduction of digital technologies in agricultural production management. The constructed model of labor productivity growth in agriculture of Kazakhstan reflects the general trend of changes in this indicator over time and allows for medium-term forecasting. However, despite its statistical adequacy and acceptable approximation accuracy (E_{otn} = 9,01%) this model has a number of limitations that should be considered while interpreting the results:

- firstly, the model is based on a single-factor time series, where the explanatory variable is the time factor t, meaning that the impact of external social and economic and natural and climatic conditions on labor productivity is not included in the calculation. The model captures a linear trend but does not reflect fluctuations caused by changes in price environment, investment levels, agricultural policy, or weather conditions;

- secondly, the model assumes stationarity of impact of factors over time, i.e. equal importance of all observations and invariant trend. This assumption is rare in real economic processes, especially in agriculture, where structural shifts, seasonality and cyclicality are observed, as well as impact of exogenous shocks (droughts, pandemics, geopolitical risks);

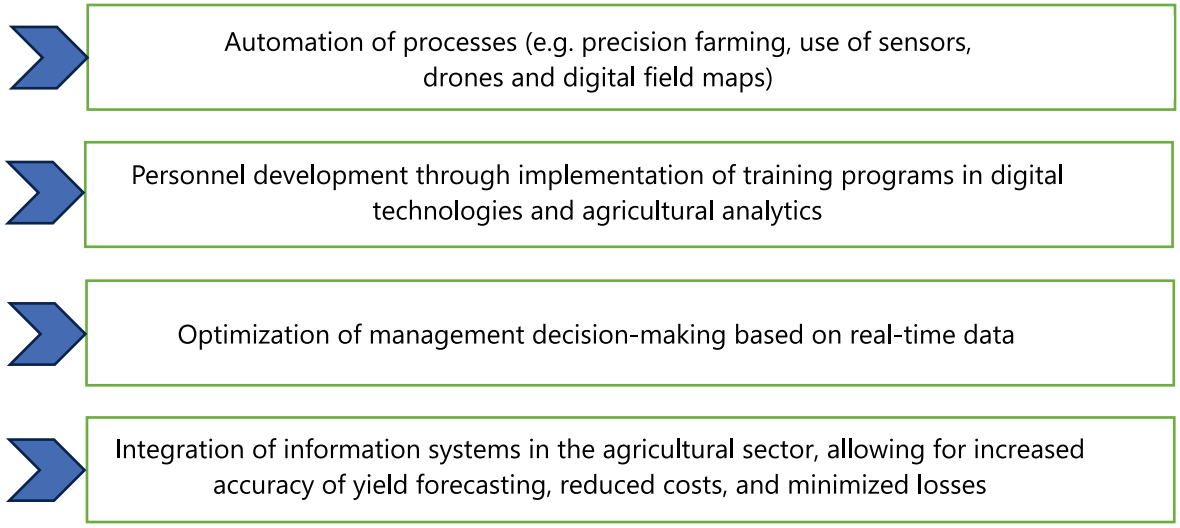
- thirdly, the model does not take into account regional heterogeneity, although according to statistics of the Republic of Kazakhstan, labor productivity in the AIC varies significantly between regions (the difference between the leading and lagging regions in 2024 exceeded 1.8 times), limiting the possibility of direct use of the model for development of regional forecasts and support programs.

Additional factors that can significantly impact labor productivity dynamics in agriculture include:

- climatic conditions – changes in temperature, precipitation, drought frequency, soil degradation, water resources availability, which directly impact crop yields and employment;
- institutional factors – effectiveness of agricultural policy, access to loans and subsidies, management quality, and the level of digitalization of the agricultural sector;
- technological factors – paces of adoption of automation, precision farming, drones and agro-IoT; the level of mechanization and power availability per man;
- human capital – the level of qualifications and digital competencies of workers, availability of HR programs, motivation of farmers to learn innovations;
- Investment and infrastructure conditions – availability of transport, power and ICT infrastructure, investments in logistics and product storage;
- economic conditions – prices for agricultural products and fuel, inflation level, foreign trade restrictions.

Accounting of these factors in future models will improve the predictive accuracy and analytical value of the results. It will be reasonable to expand the model to a multiple regression for this purpose, incorporating key macro- and meso economic indicators (capital investment volume, agricultural production index, employment level, irrigated land area, R&D expenditures, etc.), as well as cluster or panel methods to identify regional differences. The current model is basic and allows for determining the overall growth trajectory; however, strategic forecasting of labor productivity in the agriculture of Kazakhstan requires a transition to comprehensive economic and mathematical models that take into account both economic and natural-institutional determinants. Digitalization of human resources plays a key role in accelerating these processes. Modern technologies, such as agribusiness management systems (AgroTech), automated platforms for planning, accounting, and control, the use of satellite monitoring, Big Data, and IoT (Internet of Things), require new competencies of specialists. Training and retraining of personnel in this area become a strategic direction of state policy in the AIC of the Republic of Kazakhstan, reflected in a number of national programs (e.g., the National project for development of the AIC of the Republic of Kazakhstan for 2021-2025). The increase in labor productivity identified in the calculations is related to a number of factors (Figure 2).

Figure 2. Factors affecting the increase in labor productivity

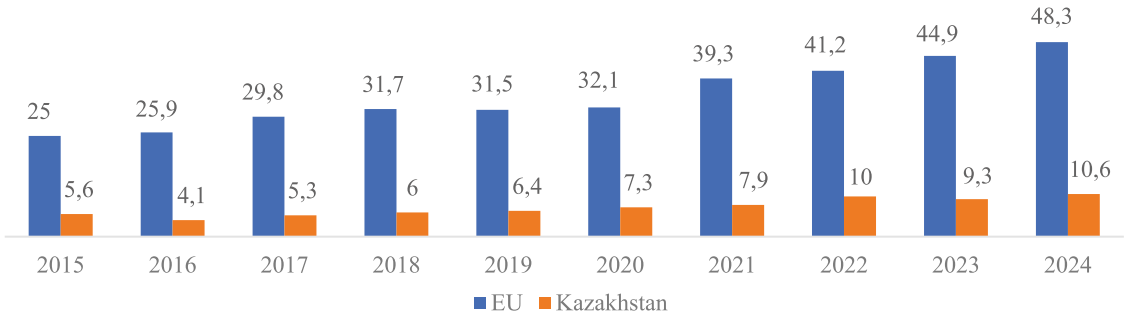


Source: Prepared by authors

Forecasts for 2025-2027 confirm that continued digitalization of human resources will remain a key driver of efficiency growth in the agriculture of Kazakhstan. It is important that the digitalization process be accompanied

by measures to improve availability of technology for agricultural enterprises, formation of digital literacy among rural staff and ensure active government support. Productivity in the agriculture of the Republic of Kazakhstan in 2024 was $10,600 per employee, compared to $48,300 in the EU, representing 4.5-fold gap. Labor productivity in the agriculture of the EU is consistently 4-5 times higher than in Kazakhstan. The gap in 2024 is approximately 4.5 times – €48,300 versus €10,600 per employee. The EU has demonstrated steady positive dynamics with an average annual growth rate of approximately 7.6% over the whole period (Figure 3).

Figure 3. Labor productivity of the agriculture compared to the EU and Kazakhstan for 2015-2024



Source: Prepared by authors on the basis of the source (Halyk finance, 2025)

The growth rates in Kazakhstan are more volatile - with a sharp decline in 2016 (-26.8%), followed by alternating peaks and declines. Overall, growth from 2015 to 2024 was about 89% (Table 5).

Table 5. Increase in agricultural productivity in the EU and Kazakhstan

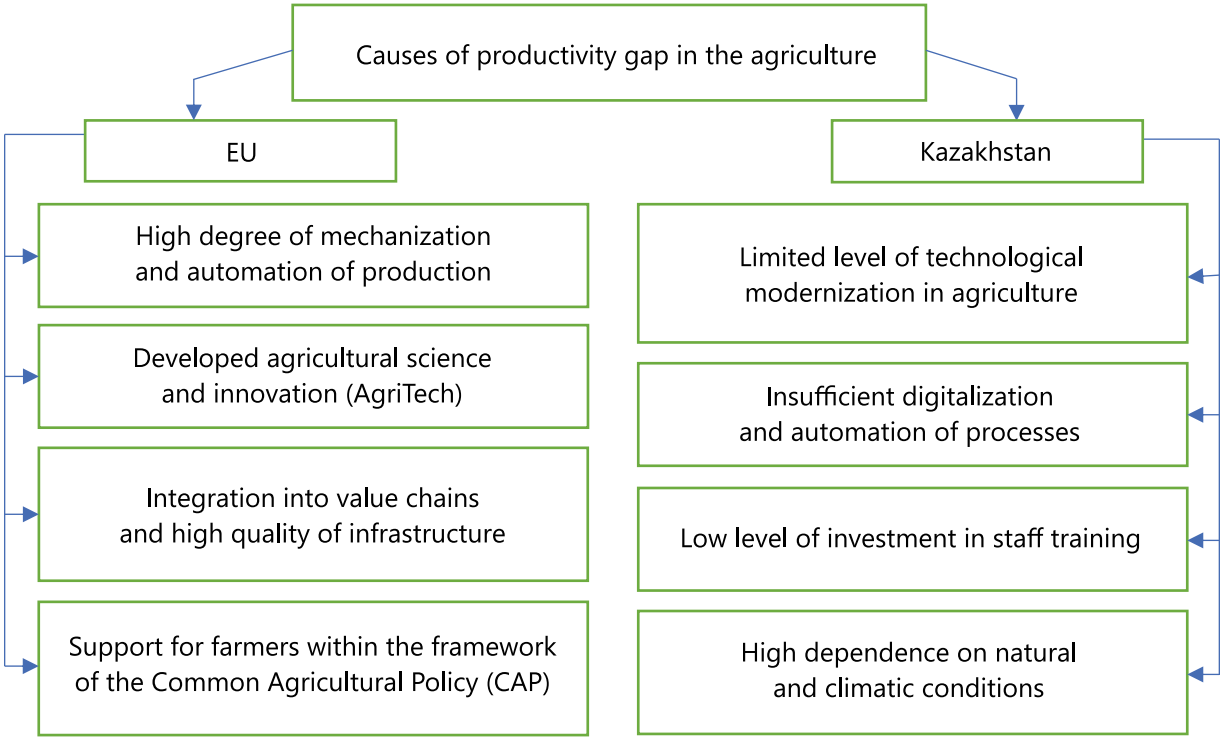
Year	Increase in the EU, %	Increase in the Republic of Kazakhstan, %
2015	-	-
2016	+3,6	-26,8
2017	+15,1	+29,3
2018	+6,4	+13,2
2019	-0,6	+6,7
2020	+1,9	+14,1
2021	+22,4	+8,2
2022	+4,8	+26,6
2023	+9,0	-7,0
2024	+7,6	+14,0

Note: prepared by authors on the basis of performed calculations

The highest growth in the EU was in 2021 (+22.4%), possibly due to integration of new technologies or financial support during the post-COVID recovery. The peak growth in Kazakhstan is observed in 2022 (+26.6%), related to investments in agriculture and industry development programs. The causes for the productivity gap between the EU and Kazakhstan have unique features (Figure 4).

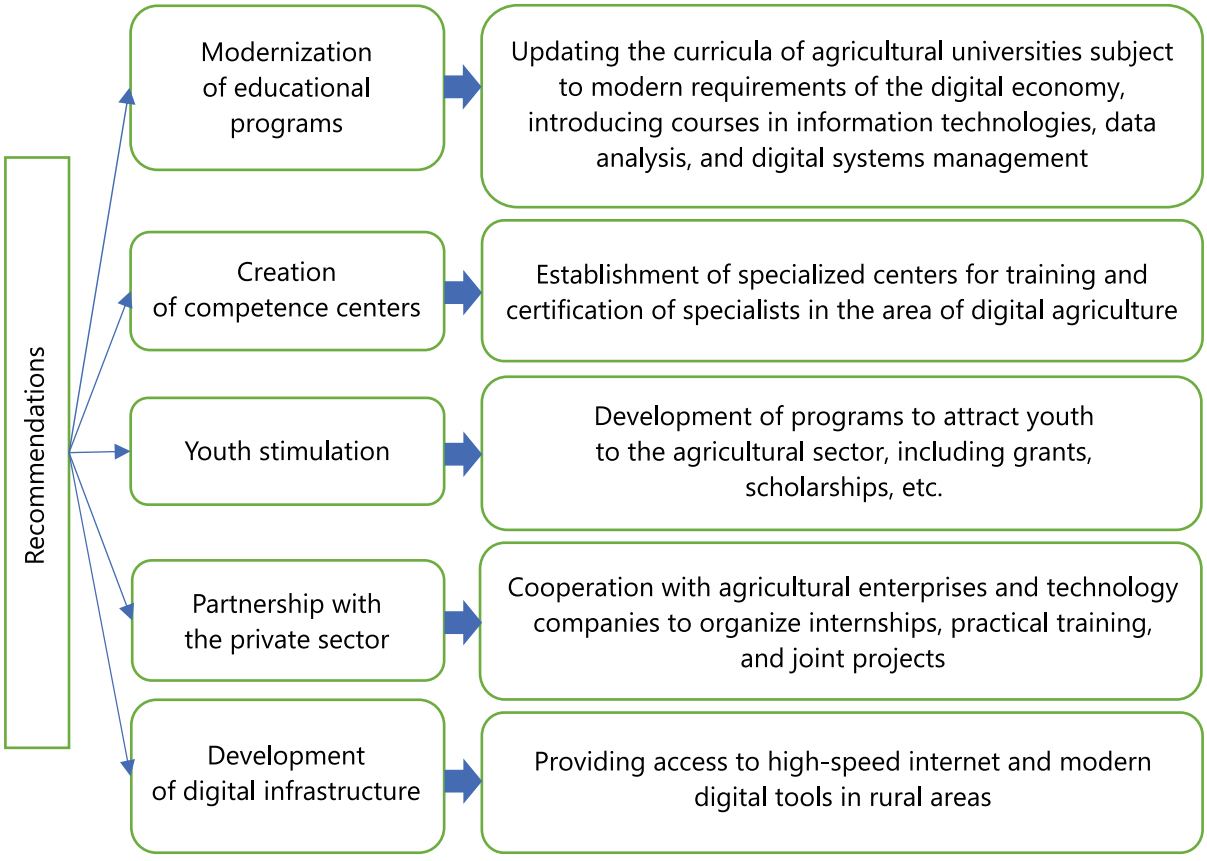
Development of digital human resources in the agricultural sector of Kazakhstan requires a comprehensive approach, including modernization of the educational system, creating conditions for attraction and retaining of qualified specialists, development of digital infrastructure in rural areas (Figure 5).

Figure 4. Causes of productivity gap in the agriculture



Note: prepared by authors

Figure 5. Recommendations for development of human capital in the AIC



Note: prepared by authors

It will be possible to ensure sustainable development of the AIC and increase of international competitiveness only through the effective implementation of these measures.

Development of human resources in agricultural sector of Kazakhstan requires not only development of individual initiatives but also their institutional integration into existing national and sectoral development programs of the AIC. Specifically, the proposed measures can be implemented within the framework of:

1. The National project "Development of the AIC of Kazakhstan for 2021-2027" which could additionally include:

- the subproject "Digital staff of the AIC" which includes updating educational standards for agricultural universities, emphasizing competencies in AI, precision farming, agricultural analytics, and automated control systems;
- formation of a network of regional digital competency centers based at agricultural colleges and research institutes, providing training to farmers and small agribusiness specialists in modern digital technologies;
- implementation of a grant and voucher system for farmers and agribusinesses to improve their digital skills.

2. State Program "Digital Kazakhstan" through:

- integration of Smart Agriculture and AgroData Hub modules into the e-Gov infrastructure and government data platform;
- use of PPP mechanisms to create cloud services, training simulators, and IoT platforms for agricultural regions.

3. Program "Rural Development – 2027" through:

- inclusion of digital infrastructure measures in priority areas of rural development (high-speed internet, satellite monitoring, agro-IoT);
- implementation of pilot projects for remote learning and support for rural specialists using digital educational platforms.

4. Strategies for sustainable development of agricultural education and science until 2030, proposing:

- development of inter-university Master's and MBA programs in digital agribusiness management;
- creation of a dual training system together with large agricultural holdings and IT companies;
- organization of an industry council on digital competencies under the Ministry of Agriculture.

So, the proposed measures do not require creation of a separate program, but can be integrated into the existing architecture of strategic management of the AIC, strengthening its human resources and innovation blocks, allowing for a transition from point initiatives to a systemic model - a digital ecosystem of human capital in agriculture, where education, science, business and the state act in a coordinated manner to increase labor productivity, technological level and export potential of the industry.

CONCLUSION

The conducted analysis demonstrates that the digitization of human resources in the agricultural sector is not only necessary but also has a positive impact on labor productivity growth, thereby forming a sustainable foundation for further development of agro-industrial complex in Kazakhstan. Based on the analysis, projections were made for 2025–2027, according to which, if current growth rates are maintained and digital solutions are actively implemented, labor productivity in the agricultural sector of Kazakhstan could reach 12–14 thousand tenge per worker. The conclusions of the study emphasize the need for state support for development of human capital through:

- development of specialized educational programs;
- implementation of digital platforms for agricultural production management;
- regular monitoring of the level of digital competencies among personnel in the agro-industrial complex;
- promotion of professional development and digital literacy programs among agricultural workers.

So, the digitalization of human resources is considered as a key tool for improvement of labor productivity, quality of agricultural products, and competitiveness of agriculture in Kazakhstan.

Promising areas for further research involve deepening the quantitative and applied analysis of the impact of the digitalization of human resources on development of the agricultural sector; therefore, it is reasonable to:

1. Develop econometric models that allow for a quantitative assessment of impact of digital competencies of workers on labor productivity, taking into account regional differences and sectoral specialization:

- application of alternative forecasting models to improve the accuracy and practical applicability of forecasts;
- application of factor analysis (PCA) to detect hidden patterns affecting labor productivity.

2. Conduct a cluster analysis of the regions of Kazakhstan based on the level of digitalization of the AIC and human resources potential to identify spatial disproportions and form targeted development policies, particularly:

- clustering of regions by the level of digitalization of human resources potential;
- comparison of clusters with labor productivity indicators;

- identification of growth points and lagging regions.

3. Explore the effectiveness of implementation of specific digital technologies (precision farming, IoT, agricultural platforms) in terms of their impact on production indicators and costs.

4. Assess the impact of digitalization on sustainability of rural areas, including reduced dependence on climatic factors and increased adaptability of agricultural production.

5. Develop an integrated index of digitalization of the human resources potential in the AIC, including indicators of digital literacy, automation levels, and the use of digital solutions.

6. Conduct a comparative international analysis (Kazakhstan - EU - EAEU countries) to identify best practices for development of digital competencies in agriculture.

7. Study institutional mechanisms for stimulating digitalization, including the effectiveness of state programs, subsidies, and public-private partnership mechanisms.

The implementation of the proposed approaches will improve the accuracy of assessments, validity of conclusions, and practical significance of research results.

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ЦИФРОВИЗАЦИЯ КАДРОВОГО ПОТЕНЦИАЛА В АГРАРНОМ СЕКТОРЕ РЕСПУБЛИКИ КАЗАХСТАН

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Аннотация

Актуальность исследования обусловлена тем, что уровень цифровизации кадрового потенциала напрямую влияет на эффективность использования современных агротехнологий, точность принятия

управленческих решений и конкурентоспособность сельского хозяйства Казахстана на мировом рынке. В рамках проведенного исследования был проведен анализ производительности труда в сельском хозяйстве Казахстана, который показал ограничение в недостаточности цифровых компетенций работников отрасли, низком уровне автоматизации процессов в ряде регионов и отсутствии системного подхода к обучению специалистов новым технологиям. Целью исследования является обоснование необходимости развития кадрового потенциала в АПК Казахстана в контексте цифровизации, влияющих на производительность труда, а также разработка рекомендаций по повышению квалификации кадров через интеграцию цифровых технологий. Результаты исследования. В рамках исследования внимание было сконцентрировано на анализе основных показателей производительности, выполнении расчетов на 2025-2027гг. Было выявлено, что при сохранении текущей динамики роста и активном внедрении цифровых технологий уровень производительности труда может достигнуть 12-14 тысяч тенге на одного работника к 2027 году в сельском хозяйстве. Данный анализ сформировал выводы, указывающие на необходимость усиления господдержки аграрного сектора, в частности, через развитие образовательных инициатив, создание цифровых решений для отрасли, повышение уровня цифровых компетенций и интеграцию современных технологий в систему подготовки кадров. Были предложены разработка специализированных образовательных программ для сельских специалистов, внедрение инструментов цифрового мониторинга и управления производственными процессами, систематическая оценка и развитие профессиональных навыков работников.

Ключевые слова: агросектор, производительность, цифровизация, сельское хозяйство, кадровый потенциал, агротехнологии, господдержка

ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ АГРАРЛЫҚ СЕКТОРЫНДАҒЫ КАДРЛЫҚ ӘЛЕУЕТТІ ЦИФРЛАНДЫРУ

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Аңдатпа
Зерттеудің өзектілігі кадрлық әлеуетті цифрландыру деңгейі қазіргі заманғы агротехнологияларды пайдалану тиімділігіне, басқару шешімдерін қабылдау дәлдігіне және Қазақстан ауыл шаруашылығының әлемдік нарықтағы бәсекеге қабілеттілігіне тікелей әсер ететіндігімен байланысты. Жүргізілген зерттеу шеңберінде Қазақстанның ауыл шаруашылығындағы еңбек өнімділігіне талдау жүргізілді, бұл сала қызметкерлерінің цифрлық құзыреттерінің жеткіліксіздігінің шектелуін, бірқатар өңірлердегі процестерді автоматтандырудың төмен деңгейін және мамандарды жаңа технологияларға оқытуға жүйелі көзқарастың жоқтығын көрсетті. Зерттеудің мақсаты еңбек өнімділігіне әсер ететін цифрландыру контекстінде Қазақстанның АӨК-де кадрлық әлеуетті дамыту қажеттілігін негіздеу, сондай-ақ цифрлық технологияларды интеграциялау арқылы кадрлардың біліктілігін арттыру бойынша ұсынымдар әзірлеу болып табылады. Зерттеу аясында өнімділіктің негізгі көрсеткіштерін талдауға, 2025-2027 жылдарға арналған есептеулерді орындауға назар аударылды. ағымдағы өсу динамикасын сақтай отырып және цифрлық технологияларды белсенді енгізе отырып, еңбек өнімділігінің деңгейі ауыл шаруашылығында 2027 жылға қарай бір қызметкерге 12-14 мың теңгеге жетуі мүмкін екендігі анықталды. Бұл талдау аграрлық секторды мемлекеттік қолдауды күшейту қажеттігін, атап айтқанда, білім беру бастамаларын дамыту, сала үшін цифрлық шешімдер жасау, цифрлық құзыреттер деңгейін арттыру және қазіргі заманғы технологияларды кадрлар даярлау жүйесіне интеграциялау арқылы тұжырымдарды қалыптастырды. Ауыл мамандары үшін мамандандырылған Білім беру бағдарламаларын әзірлеу, цифрлық мониторинг және өндірістік процестерді басқару құралдарын енгізу, қызметкерлердің кәсіби дағдыларын жүйелі бағалау және дамыту ұсынылды.

Түйінді сөздер: агросектор, өнімділік, цифрландыру, ауыл шаруашылығы, кадрлық әлеует, Агротехнология, мемлекеттік қолдау