

НАУЧНАЯ СТАТЬЯ

УДК 332.12

DOI: 10.26730/2587-5574-2025-4-70-77

КОНЦЕПЦИЯ ЦИФРОВОЙ ТРАНСФОРМАЦИИ АПК: ИНТЕГРАЦИОННЫЙ ПОДХОД К УПРАВЛЕНИЮ ЦЕПОЧКОЙ СОЗДАНИЯ СТОИМОСТИ

Гусева Е.П., Спешиллов Е.А.

Оренбургский филиал Федерального государственного бюджетного учреждения науки Института экономики Уральского Отделения Российской академии наук

**Информация о статье**

Поступила:

09 октября 2025 г.

Одобрена после рецензирования:

15 ноября 2025 г.

Принята к публикации:

05 декабря 2025 г.

Ключевые слова: цифровая трансформация, цепочка создания стоимости, синергетический эффект, региональное развитие АПК.

Аннотация.

В статье рассматривается современное состояние и перспективы цифровой трансформации агропромышленного комплекса Оренбургской области. Исследование базируется на статистических данных за 2021-2023 годы, отражающих уровень внедрения цифровых технологий в сельскохозяйственных предприятиях региона, показано противоречие между высокими показателями цифровизации и критическим отставанием в направлениях цифровой зрелости и рассматриваются финансовые проблемы, характеризующиеся низкими инвестициями в программное обеспечение и минимальными затратами на обучение работников, занятых в сельском хозяйстве. Рассматривается, что точечные решения по внедрению цифровых технологий на отдельных этапах производства не позволяют достичь максимального эффекта. В качестве альтернативы предлагается создание единого цифрового управления всей цепочки создания добавленной стоимости – от производства до сбыта. Рассмотрены практические механизмы интеграции данных между различными звеньями АПК: использование технологий прецизионного земледелия, IoT-мониторинга в переработке, единых логистических платформ и систем прогнозирования спроса. Подчеркиваются важные результаты цифровой трансформации агропромышленного комплекса Оренбургской области, которые должны стать синергетическим эффектом, выражающимся в снижении транзакционных издержек, минимизации потерь на всех этапах и повышении доли доходности.

Для цитирования: Гусева Е.П., Спешиллов Е.А. Концепция цифровой трансформации АПК: интеграционный подход к управлению цепочкой создания стоимости // Экономика и управление инновациями. 2025. № 4 (35). С. 70-77. DOI: 10.26730/2587-5574-2025-4-70-77, EDN: QAJJPS

THE CONCEPT OF THE DIGITAL TRANSFORMATION OF AGRICULTURE: AN INTEGRATIVE APPROACH TO MANAGING THE VALUE CHAIN

Elena P. Guseva, Evgeny F. Spechilov

Orenburg Branch of the Federal State Budgetary Institution of Science of the Institute of Economics of the Ural Branch of the Russian Academy of Sciences

**Article info**

Submitted:

09 October 2025

Approved after reviewing:

15 November 2025

Abstract.

The article discusses the current state and future prospects of the digital transformation of the agricultural industry in the Orenburg region. Based on statistical data from 2021 to 2023, the study reveals a contradiction between the high level of adoption of digital technologies in agricultural enterprises and a significant gap in digital maturity. The study argues for a shift from isolated automation to a comprehensive digital transformation of the region's agricultural industry. Point-based solutions for introducing digital technologies at specific stages of production are not sufficient to achieve maximum benefits. Instead, it proposes creating a unified digital system for managing the entire value chain from production to sales. Practical mechanisms for

Accepted for publication:
05 December 2025

Keywords:

digital transformation, value chain, synergetic effect, regional development of agriculture

data integration between different parts of the agro-industrial complex are discussed, including the use of precision farming technologies, IoT monitoring in production, unified logistics platforms, and demand forecasting systems. The significant outcomes of the digital transformation of the Orenburg Region's agro-industry are highlighted, which should result in a synergistic effect expressed in reduced transaction costs, minimized losses at all stages, and increased profitability.

For citation: Guseva E.P., Spechilov E.F. The concept of the digital transformation of agriculture: an integrative approach to managing the value chain. *Economics and Innovation Management*, 2025, no. 4 (35), pp. 70-77. DOI: 10.26730/2587-5574-2025-4-70-77, EDN: QAJJPS

1 Introduction / Введение

The agro-industrial complex (AIC) of Russia is at a turning point, determined by the global trend towards digital transformation, which has ceased to be an instrument of competitive advantage. In conditions of increasing pressure on agroecosystems, climatic instability and the need to ensure food security, the introduction of Industry 4.0 technologies is becoming a key factor in increasing productivity, resource efficiency and manageability of the industry, defined by the concept of "Agriculture 4.0" [1, p. 15]. In the context of increasing challenges related to climate instability, growing demographic pressure and the need to ensure food security, digital transformation is no longer an exclusive tool for improving efficiency, becoming a strategic requirement for sustainable development, which is mandatory and unconditional to fulfill [2]. Russia, with significant agricultural resources, has actively joined this process, which is reflected in national projects and government programs such as Digital Agriculture [3].

The Orenburg region, being one of the significant agricultural regions of the country with high potential in crop production and animal husbandry, demonstrates a contradictory picture of readiness for this transition. At the moment, the digitalization of the agro-industrial complex of the region is fragmented [4]. Large agricultural holdings are actively implementing elements of precision farming, such as GPS navigation and differentiated fertilization, transport monitoring systems and basic accounting systems. However, the vast majority of medium and small agricultural enterprises are characterized by the use of disparate solutions that are not integrated into a single digital environment. Technologies based on complex big data analysis, predictive analytics, and artificial intelligence remain rare. The critical constraints are the weak development of digital infrastructure in rural areas, manifested in insufficient Internet coverage, as well as an acute shortage of personnel with both agricultural and digital competencies. Thus, the current situation can be characterized as a stage of initial uneven digitalization of individual processes in the absence of a comprehensive digital transformation, implying a profound change in the management system [5].

The study is conditioned by a systemic challenge related to the need to ensure the food security of the Russian Federation in the context of external constraints and global changes. As Academician of the Russian Academy of Sciences I.G.Ushachev notes, "the current state of the agricultural sector of the economy requires a scientific rethink of the fundamental and practical foundations for the formation of sustainable, efficient and competitive production" [6].

The problems of digitalization of the agro-industrial complex are in the focus of attention of numerous domestic and foreign scientists. The terms "digitalization" and "digital transformation" are often used synonymously. In modern scientific and managerial practice, they denote fundamentally different stages and depth of changes in the agro-industrial complex [7]. The digitalization of the agro-industrial complex is an initial and tactical stage, the essence of which is the introduction of digital technologies to automate existing processes and increase their efficiency. This is the process of converting analog information into digital form and using digital tools to solve local problems. Digitalization is the "rejuvenation" of traditional approaches through technology, including the replacement of paper magazines and reports, the use of GPS navigators on agricultural machinery for parallel driving, which reduces production costs, and the installation of sensors (Internet of Things, IoT) in livestock complexes to monitor temperature and humidity., using satellite imagery to visually assess the condition of crops. The key result of digitalization is an increase in operational efficiency (saving resources, reducing labor costs and minimizing human errors in certain areas of work [8].

2 Materials and methods / Материалы и методы

The digital transformation of the agro-industrial complex of the Orenburg Region is a key factor for increasing its efficiency and moving towards a sustainable development model. This process includes the introduction of a range of technologies, from precision farming and satellite monitoring to the Internet of Things (IoT) for monitoring machinery and animals, as well as platforms for big data analysis. Their use helps farmers optimize the use of resources, reduce costs and increase productivity. Despite the potential, the path of digitalization is fraught with a number of challenges. Digitalization of the agro-industrial complex of the Orenburg region has gone through several stages, transforming from simple automation to the introduction of complex intelligent systems (Fig. 1) [9,10].

The evolution of digitalization of the agro-industrial complex of the Orenburg region is characterized by the sequential passage of several key stages. The initial stage laid the fundamental foundation for further development based on the creation of prerequisites for improving and strengthening food security in the region. At the second stage, efficiency improvements were demonstrated by individual advanced farms, but there was no widespread innovation. The main constraints were high capital expenditures, an unobvious short-term payback for most enterprises, and an acute shortage of qualified personnel capable of working with new technologies. The third stage is a transition in which digitalization has become a mandatory element for large agricultural holdings. The active implementation of digital solutions has allowed us to reach a new level of operational efficiency, optimize the resource base and move to data-based management decisions. The current stage is determined by the introduction of artificial intelligence and digital farm boards, which shows the transition of the region to "smart agriculture". The key task at this level is the integration of all market participants into a single digital value chain - "from the field to the counter".

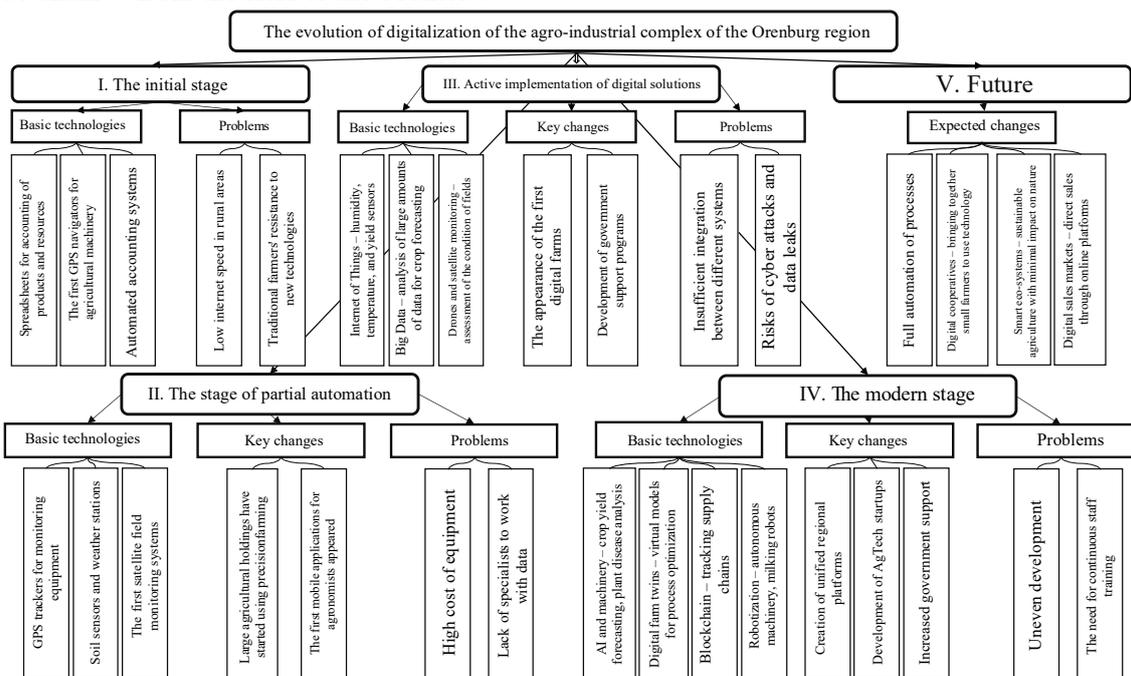


Fig. 1. The evolution of digitalization of the agro-industrial complex of the Orenburg region

Without solutions to this problem, innovative solutions remain fragmented, which makes it impossible to realize the synergetic potential and leads to significant losses in economic efficiency. The promising (future) stage is the stage of complete digital transformation, which will be conditioned by the need to ensure two critical factors: cybersecurity of data and energy security of digital infrastructure in remote rural areas [7]. The creation of these conditions is essential for the smooth functioning of systems, information protection and maximizing the impact of implemented technologies for the sustainable development of the regional agro-industrial complex (Fig. 2) [11].

The analysis of data on the digitalization of agriculture in the Orenburg region for 2022-2023 makes it possible to identify a number of key trends. The level of penetration of basic digital technologies into the agro-industrial complex of the region is high and continues to grow. Thus, the share of agricultural organizations using personal computers increased from 88.7% to 90.6%, which exceeds the average for

all types of economic activity (87.5%). A similar positive trend is observed in server usage: an increase from 42.5% to 44.8%, with an average of 41.7%. This indicates that agricultural enterprises are actively developing their IT infrastructure. Internet connection also shows progress. Fixed-line access usage increased from 85.8% to 89.6%, while mobile access remained at a high level, although it decreased from 46.2% to 43.8%. At the same time, the presence of a website as a key tool for digital presence has become more widespread, with the corresponding indicator rising from 21.7% to 26.0%. Despite this growth, it is more than twice as low as the average for all types of industries (51.8%), which indicates a significant potential for improving digital marketing and customer interaction in the agricultural sector. Broadband Internet access, which is the main one for using modern cloud-based data-intensive solutions, was available to 82.3% of rural organizations in 2023, and its prevalence is steadily increasing [12].

The use of specialized software for managing business processes demonstrates an ambiguous picture. The implementation of procurement management systems increased slightly from 304.5% to 34.4% and is consistently ahead of the average. The use of programs to manage the overall indicator decreased from 19.8% to 16.7%, which is significantly lower than the overall indicator of 22.6%. This indicates a shift from digitalization to supply optimization or the presence of barriers in the implementation of appropriate solutions [12].

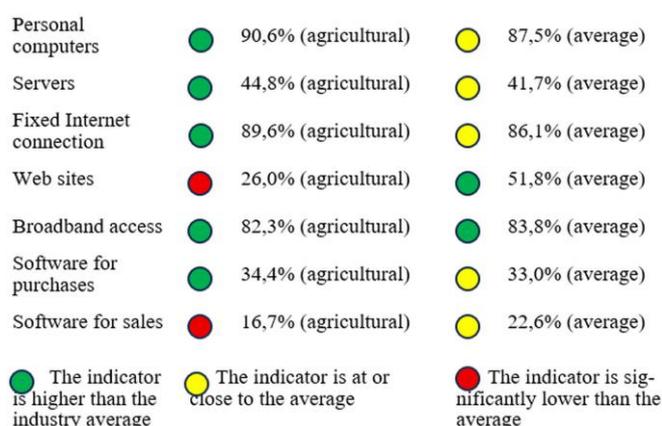


Fig. 2. The use of digital technologies in agriculture Orenburg region in 2023

The financial side of the digital transformation of the industry is characterized by a low volume of absolute costs. In 2023, the total expenses of agricultural organizations for the introduction and use of digital technologies amounted to only 42.5 million rubles, disproportionately small in the regional economy. The largest share of funds is allocated to pay for communication services (12.2 million rubles), the cost of purchasing computing equipment – 7.7 million rubles, and most importantly, software – 3.1 million rubles remain very modest. This correlates with data on the cost structure in 2021-2023 as a whole, where internal costs dominate – 77.7% in 2023, and they are based on the purchase and maintenance of equipment – 46.1%. At the same time, investments in the development of human capital are very small (0.1%) throughout the entire period [12].

3 Results and Discussions / Результаты и обсуждение

Agriculture in the Orenburg region has significant potential in crop and livestock production and shows a contradictory picture in terms of readiness for digital transformation. On the one hand, there are positive macroeconomic and institutional prerequisites – existing state programs to support "Digital agriculture" within the framework of the state program for the development of agriculture, there is an understanding of the importance of this area at the regional level, and large agricultural holdings have already begun active implementation of elements of precision agriculture (GPS navigation, differentiated fertilizer distribution), a system of monitoring of transport and databases on animal husbandry. The real level of digital technology adoption in most agricultural enterprises, especially medium and small ones, is affected by a significant digital divide. Separate enterprises that are not integrated into a single digital ecosystem are being implemented. Digitalization mainly affects the operational level, and technologies based on big data analysis, predictive analytics and artificial intelligence to support management decisions. A critical limitation is the state of human resources, which has both competencies in the field of agriculture and skills of working with digital technologies. The problem of digital infrastructure in rural areas, low speed and instability of Internet connection, especially in remote areas of the region,

make it impossible to use cloud services and Internet of Things (IoT) technologies in real time. The investment attractiveness of digitalization is due to high initial costs, long payback periods and the lack of evidence of the direct economic effect of complex digital solutions. The current state can be described as the stage of initial digitalization in the absence of an integrated approach to digital transformation, which involves improving individual stages of work and management models, a set of interrelated problems arises (Fig. 3).

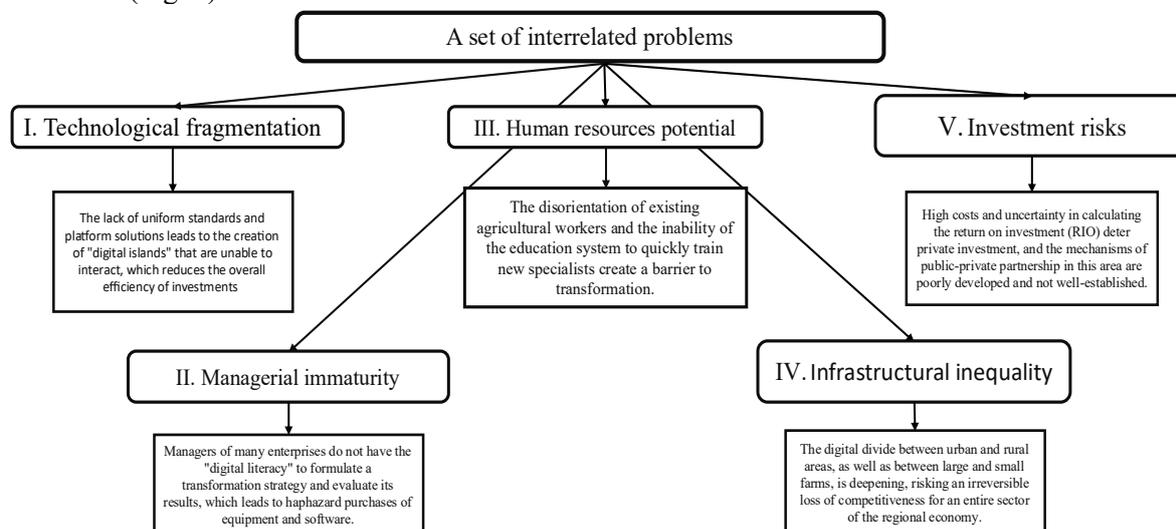


Fig. 3. A set of interrelated problems

The current situation is a natural consequence of the approach to digitalization, when investments in technical equipment are not supported by adequate development of software solutions and digital competencies, which is manifested in a critical lag in terms of maturity, 26% of agricultural organizations have websites, and only 16% use systems for sales management. The technical infrastructure does not provide a real increase in the efficiency of agricultural production. Low investments in software and minimal staff training costs indicate a systemic crisis of the current digitalization model.

Table 1 – The value-added chain of the agro-industrial complex

	Problems of the region	Spot automation	Digital transformation of the entire link
Production (link I)	Droughts, soil erosion, the need to save water and fertilizers	Setting humidity sensors on one field	Implementation of a precision farming system based on remote sensing of the Earth
Recycling (link II)	Loss of raw materials, low processing depth, quality control	Automation of accounting at the entrance to the enterprise	Implementation of an IoT monitoring system for raw material parameters in real time, which allows flexible reconfiguration of production lines to optimize output and minimize waste
Storage and logistics (Link III)	Large distances, spoilage of products during storage, route optimization	GPS tracker on the truck	Creation of a single logistics platform that links data from fields with the availability of free elevators and warehouses; optimizes routes based on road conditions and weather; monitors temperature and humidity in real time, automatically preventing spoilage
Sales and marketing (link IV)	Search for sales markets, brand formation, obtaining a fair price	The company's business card website	Using data from all previous stages for traceability, demand forecasting, goal formation

Overcoming such interrelated challenges requires not only the sum of technological solutions, but also the restructuring of the entire business model. In this regard, the Orenburg Region, with its specific natural and climatic conditions (risk of droughts, wind erosion of soils, uneven precipitation distribution), is in urgent need of a transition from precise automation to a comprehensive digital transformation of all links in the value chain (Table 1).

The main purpose of the transformation of all links is not just to improve each of them individually, but to link them into a single contour, that is, data on the projected harvest (link I) is automatically transmitted to the logistics service (link III) and the sales department (link IV), data on the quality of raw materials at acceptance (link II) helps Agronomist (link I) to adjust agricultural technologies. To overcome the specific risks of the Orenburg Region, it is not enough to purchase smart tractors; it is necessary to create a single digital data space where information flows freely along the entire chain, allowing for a cumulative economic effect that is many times greater than the sum of the effects of disparate solutions. This is exactly the essence of the real digital transformation of the agro-industrial complex of the Orenburg region.

4 Conclusion / Заключение

Research indicates the need to move from fragmented digitalization to building an integrated ecosystem for managing the agro-industrial complex. The main condition for effective transformation is the creation of a single digital platform that ensures end-to-end data integration of the entire value chain.

Agriculture in the Orenburg region is showing good progress in the field of digitalization (computers, Internet, servers), but is facing problems at more mature stages of transformation. These include weak digital representation in the form of websites, a decrease in the use of sales management software, as well as limited investments in software and the development of digital competencies of staff. The current cost model is infrastructural and operational in nature, rather than investment in innovative technologies, which may constrain the transition to precision engineering and these management approaches. The digital transformation of the agro-industrial complex of the Orenburg region should be considered as a systemic investment project aimed at creating an integrated value chain, where the synergistic effect of the interaction of all links is many times greater than the sum of individual improvements. The key economic advantage of this approach is the transition from an extensive development model based on compensation for natural risks to an intensive model based on optimizing resource consumption and creating added value through digital management of the entire production and distribution chain. The economic efficiency of digital transformation is achieved by reducing transaction costs between chain links through the creation of a single information space; minimizing losses at all stages - from production to sales (optimizing water and fertilizer costs, reducing logistics costs, reducing product spoilage); increasing revenue share through deeper processing and brand formation based on quality traceability; reducing the systemic risks of agricultural production through predictive analytics and adaptive management.

Acknowledgement / Благодарности

The article was prepared in accordance with the state assignment of the Ministry of Education and Science of the Russian Federation for the Institute of Economics of the Ural Branch of the Russian Academy of Sciences for 2025

Список источников

1. Efremov A. Evolution of the institutional mechanism of digitalization of the agro-industrial complex of the Republic of Belarus in the context of new challenges // *Agrarian Economics*. – 2024. – № 5(348). – pp. 17-27.
2. Smith J., Miller K. Digital Agriculture in the Global Context: Trends and Prospects // *Agricultural Systems*. – 2021. – Vol. 189. – pp. 103-125.
3. Государственная программа развития сельского хозяйства на 2023-2025 года. URL. <http://government.ru/rugovclassifier/815/events/> (дата обращения 15.10.2025 г.)
4. Пивоварова О.В., Орлов С.Л., Хачатрян А.А. Цифровая экосистема агропромышленного комплекса Российской Федерации: возможности и ограничения имплементации // *Аграрная наука*. – 2025. – № 1. – С. 140-153.
5. Киселев С.В., Филимонов И.В., Самсонов В.А., Сеитов С.К. Влияние цифровизации на теневую экономику сельского хозяйства в Российской Федерации // *Ars Administrandi (Искусство управления)*. – 2024. – Т. 16, № 2. – С. 240-260.
6. Ушачев И.Г. Стратегические направления развития сельского хозяйства Российской Федерации // *Прикладные экономические исследования*. – 2017. – № 6(22). – С. 4-10.

7. Банников С.А., Гарбузова Т.Г., Ковалева Т.Н. Сущность и этапы цифровой трансформация в АПК // Вестник НГИЭИ. – 2023. – № 11(150). – С. 65-76.
8. Гагаринская Г.П., Хоровинников А.А., Хоровинникова Е.Г., Журавлев Д.А. Повышение эффективности управления производительностью труда организации на основе безопасных цифровых технологий // Вестник евразийской науки. – 2021. – Т. 13, № 1. – С. 24.
9. Mitrofanova I.V., Inshakova E.I., Dovbiy I.P. Digitalization of the Russian agro-industrial complex: modern trends and development problems // Journal of Volgograd State University. Economics. – 2023. – Vol. 25, No. 2. – P. 59-71.
10. Косенчук О.В., Зинич А.В., Ревякин П.И. Инновационная веб-карта животноводства и ее роль в развитии регионального АПК // Вопросы инновационной экономики. – 2024. – Т. 14, № 4. – С. 1497-1512.
11. Сидоров В.П. Цифровая трансформация АПК: от точного земледелия к умным агроэкосистемам. – М.: Издательство РГАУ-МСХА, 2022. – 210 с.
12. Территориальный орган Федеральной службы государственной статистики по Оренбургской области. URL: <https://56.rosstat.gov.ru/folder/248896> (последнее обращение: 15.10.2025).

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

© 2025 Авторы. Издательство Кузбасского государственного технического университета имени Т.Ф. Горбачева. Эта статья доступна по лицензии Creative Commons «Attribution» («Атрибуция») 4.0 Всемирная (<https://creativecommons.org/licenses/by/4.0/>)

Авторы

Гусева Елена Петровна – научный сотрудник

Оренбургский филиал Федерального государственного бюджетного учреждения науки Института экономики Уральского отделения Российской академии наук
460000, г. Оренбург, ул. Пионерская, 11
e-mail: erguseva@mail.ru

Спешипов Евгений Алексеевич – младший научный сотрудник

Оренбургский филиал Федерального государственного бюджетного учреждения науки Института экономики Уральского отделения Российской академии наук
460000, г. Оренбург, ул. Пионерская, 11
e-mail: evgenij.sp@mail.ru

References

1. Efremov A. Evolution of the institutional mechanism of digitalization of the agro-industrial complex of the Republic of Belarus in the context of new challenges. *Agrarian Economics*. 2024. Vol. 5(348). pp. 17-27.
2. Smith J., Miller K. Digital Agriculture in the Global Context: Trends and Prospects. *Agricultural Systems*. 2021. Vol. 189. pp. 103-125.
3. Gosudarstvennaja programma razvitija sel'skogo hozjajstva na 2023-2025 goda [State Program for the Development of Agriculture for 2023-2025]. URL: <http://government.ru/rugovclassifier/815/events/> (last access: 15.10.2025)
4. Pivovarova O.V., Orlov S.L., Hachatrjan A.A. Cifrovaja jekosistema agropromyshlennogo kompleksa Rossijskoj Federacii: vozmozhnosti i ogranichenija implementacii [State Program for the Development of Agriculture for 2023-2025]. *Agrarnaja nauka = Agrarian science*. 2025. Vol. 1. pp. 140-153.
5. Kiselev S.V., Filimonov I.V., Samsonov V.A., Seitov S.K. Vlijanie cifrovizacii na teneviju jekonomiku sel'skogo hozjajstva v Rossijskoj Federacii [The impact of digitalization on the shadow economy of agriculture in the Russian Federation]. *Ars Administrandi (Iskusstvo upravlenija) = (The art of management)*. 2024. Vol. 16, Issue 2. pp. 240-260.
6. Ushachev I.G. Strategicheskie napravlenija razvitija sel'skogo hozjajstva Rossijskoj Federacii [Strategic directions for the development of agriculture in the Russian Federation]. *Prikladnye jekonomicheskie issledovanija = Applied economic research*. 2017. Vol. 6(22). pp. 4-10.
7. Bannikov S.A., Garbuzova T.G., Kovaleva T.N. Sushhnost' i jetapy cifrovoj transformacija v APK [The essence and stages of digital transformation in the agro-industrial comple]. *Vestnik NGIJel = The essence and stages of digital transformation in the agro-industrial complex*. 2023. Vol. 11(150). pp. 65-76.
8. Gagarsinskaja G.P., Horovinnikov A.A., Horovinnikova E.G., Zhuravlev D.A. Povyshenie jeffektivnosti upravlenija proizvoditel'nost'ju truda organizacii na osnove bezopasnyh cifrovnyh tehnologij [Improving the efficiency of labor productivity management in an organization based on secure digital technologies]. *Vestnik evrazijskoj nauki = Bulletin of Eurasian Science*. 2021. Vol. 13, Issue 1. pp. 24.
9. Mitrofanova I.V., Inshakova E.I., Dovbiy I.P. Digitalization of the Russian agro-industrial complex: modern trends and development problems [Digitalization of the Russian agro-industrial complex: modern trends and development problems]. *Journal of Volgograd State University. Economics = Journal of Volgograd State University. Economics*. 2023. Vol. 25, No. 2. pp. 59-71.

10. Kosenchuk O.V., Zinich A.V., Revjakin P.I. Innovacionnaja veb-karta zhivotnovodstva i ee rol' v razvitii regional'nogo APK [Innovative web map of livestock production and its role in the development of the regional agro-industrial complex]. *Voprosy innovacionnoj jekonomiki = Issues of innovation economics*. 2024. Vol. 14, Issue 4. pp. 1497-1512.

11. Sidorov V.P. Cifrovaja transformacija APK: ot tochnogo zemledelija k umnym agrojekosistemam [Digital transformation of the agro-industrial complex: from precision farming to smart agroecosystems]. Moscow: Izdatel'stvo RGAU-MSHA, 2022. 210 p.

12. Territorial'nyj organ Federal'noj sluzhby gosudarstvennoj statistiki po Orenburgskoj oblasti [Territorial body of the Federal State Statistics Service for the Orenburg Region]. URL. <https://56.rosstat.gov.ru/folder/248896> (last access: 15.10.2025).

Conflicts of Interest

The authors declare no conflict of interest.

© 2025 The Authors. Published by T. F. Gorbachev Kuzbass State Technical University. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Authors

Elena Guseva – research associate

Orenburg Branch of the Federal State Budgetary Institution of Science, Institute of Economics, Ural Branch of the Russian Academy of Sciences

460000, Orenburg, Pionerskaya St., 11

e-mail: epguseva@mail.ru

Evgeny Speshilov – junior research assistant

Orenburg Branch of the Federal State Budgetary Institution of Science, Institute of Economics, Ural Branch of the Russian Academy of Sciences

460000, Orenburg, Pionerskaya St., 11

e-mail: evgenij.sp@mail.ru

