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MODERNIZATION OF KAZAKHSTAN'S AGRO-INDUSTRIAL COMPLEX BASED ON DIGITALIZATION AND ESG

ЦИФРЛАНДЫРУ ЖӘНЕ ESG НЕГІЗІНДЕ ҚАЗАҚСТАННЫҢ АӨК ЖАҢҒЫРТУ

МОДЕРНИЗАЦИЯ АПК КАЗАХСТАНА НА ОСНОВЕ ЦИФРОВИЗАЦИИ И ESG

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Abstract. Kazakhstan's agricultural sector faces increasing pressure from climate challenges, environmental, social, and governance (ESG) requirements, and the national course toward digital transformation. Understanding how ESG and digitalization impact financial performance is crucial for shaping future strategies. *The goal* is to examine the impact of digital processes and ESG principles on the financial performance of agricultural enterprises in Kazakhstan. *Methods* – using quantitative data from JSC "Atameken-Agro" for 2014–2023, the study assesses how digital modernization and ESG trends influence revenue, net profit, and return on assets (ROA). Empirical indicators are complemented by case analysis to reveal operational characteristics. *Results* – the findings show that investment in ESG standards may initially raise depreciation costs but align with long-term sustainability goals. Digital modernization positively correlates with production outcomes, although its immediate impact is statistically insignificant. However, case studies demonstrate that digital tools help increase transparency in ESG practices and facilitate the spread of ecological innovations, which could generate tangible returns over time. *Conclusions* – as Kazakhstan transitions to mandatory ESG reporting in 2025 and expands digital agriculture initiatives, a stronger long-term synergy between ESG and digital progress is expected. While current monetary effects remain ambiguous, effective government support and technological transformation will enhance this synergy. This research underscores the strategic importance of integrating ESG principles and investment in digitalization as key factors in the transformation of the agricultural sector.

Аңдатпа. Қазақстанның аграрлық секторы Климаттық сын-тегеуріндердің, экологиялық, әлеуметтік және басқару аспектілері (ESG) контекстіндегі талаптардың және цифрлық трансформацияға арналған ұлттық бағыттың өсіп келе жатқан қысымына тап болады. ESG және цифрландырудың экономикалық көрсеткіштерге қалай әсер ететінін түсіну болашақ стратегияларды қалыптастыру үшін өте маңызды. *Мақсаты* – республиканың ауыл шаруашылығы кәсіпорындарының қаржылық нәтижелілігіне цифрлық процесс пен ESG-қағидаттарының әсерін зерттеу. *Әдістері* – 2014-2023 жылдардағы "Атамекен-Агро" АҚ деректерінің сандық сипаттамаларының көмегімен ESG-заңдылықтарын цифрлық жаңарту және енгізу кіріске, таза пайдаға және активтердің рентабельділігіне (ROA) қалай әсер ететіні бағаланады. Эмпирикалық индикаторлар операциялық қызметтің ерекшеліктерін ашатын кейс-талдаумен толықтырылады. *Нәтижелер* – алынған ақпарат ESG стандарттарына инвестициялау бастапқыда амортизациялық шығындарды арттыруы мүмкін екенін көрсетеді, бірақ ұзақ мерзімді тұрақты даму мақсаттарына сәйкес келеді. Цифрлық модернизация өндірістік нәтижелермен оң корреляцияланады, дегенмен оның жедел әсері статистикалық тұрғыдан шамалы. Бұл ретте кейстер цифрлық құралдар ESG-ережелерінің ашықтығын арттыруға және экологиялық инновацияларды таратуға ықпал ететінін көрсетеді,

бұл болашақта материалдық табыс әкелуге мүмкіндік береді. *Қорытындылар* – Қазақстан Республикасының 2025 жылдан бастап міндетті ESG-есептілікке көшуіне және цифрлық ауыл шаруашылығы саласындағы бастамалардың кеңеюіне қарай ESG мен цифрлық прогресс арасындағы ұзақ мерзімді өзара байланысты нығайту күтілуде. Қазіргі монетарлық әсерлер белгісіз болып қалса да, Үкіметтің тиімді қолдауы мен технологиялық трансформациясы олардың синергиясын күшейтеді. Осы зерттеу аграрлық саладағы өзгерістердің негізгі факторлары ретінде цифрландыруға ESG және инвестициялық инвестицияларды біріктірудің стратегиялық маңыздылығын көрсетеді.

Аннотация. Аграрный сектор Казахстана сталкивается с растущим давлением климатических вызовов, требований в контексте экологических, социальных и управленческих аспектов (ESG) и национального курса на цифровую трансформацию. Понимание того, как ESG и цифровизация влияют на экономические показатели, имеет решающее значение для формирования будущих стратегий. *Цель* – исследовать влияние цифрового процесса и ESG-принципов на финансовую результативность сельскохозяйственных предприятий республики. *Методы* – с помощью количественных характеристик данных АО «Атамекен-Агро» за 2014-2023 гг. оценивается как цифровое обновление и внедрение ESG-закономерностей влияют на выручку, чистую прибыль и рентабельность активов (ROA). Эмпирические индикаторы дополняются кейс-анализом, раскрывающим особенности операционной деятельности. *Результаты* – полученная информация показывает, что инвестиции в ESG-стандарты могут изначально увеличивать амортизационные издержки, однако соответствуют долгосрочным целям устойчивого развития. Цифровая модернизация положительно коррелирует с производственными конечными итогами, хотя ее немедленное влияние статистически незначительно. При этом кейсы демонстрируют, что цифровые инструменты способствуют повышению прозрачности ESG-правил и распространению экологических инноваций, что в перспективе позволит приносить материальные доходы. *Выводы* – по мере перехода Республики Казахстан к обязательной ESG-отчетности с 2025 года и расширения инициатив в сфере цифрового сельского хозяйства, ожидается укрепление долговременной взаимосвязи между ESG и цифровым прогрессом. Хотя текущие монетарные эффекты остаются неопределенными, действенная государственная поддержка и технологические преобразования усилят их синергию. Настоящее исследование подчеркивает стратегическую важность интегрирования ESG и инвестиционных вложений в цифровизацию как ключевых факторов преобразований в аграрной сфере.

Keywords: agriculture, digitalization, ESG, precision farming, corporate governance, environmental standards, government support, financial performance.

Түйінді сөздер: ауыл шаруашылығы, цифрландыру, ESG, дәл егіншілік, корпоративтік басқару, экологиялық стандарттар, мемлекеттік қолдау, қаржылық көрсеткіштер.

Ключевые слова: сельское хозяйство, цифровизация, ESG, точное земледелие, корпоративное управление, экологические стандарты, государственная поддержка, финансовые показатели.

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Introduction

In May 2022, at the World Economic Forum in Davos, Kazakhstan reaffirmed its commitment to Environmental, Social and Governance (ESG) goals. Priorities were set on developing a green economy, enhancing energy efficiency, and expanding renewable energy sources. ESG policies have since drawn increasing attention across sectors. Although ESG reporting is currently voluntary, starting January 1, 2025, financial institutions in Kazakhstan will be required to submit ESG reports, strengthening corporate transparency and accountability (Xie H., Lyu X.) [1].

The growing focus on ESG has become a new source of competitive advantage for enterprises. Enhancing ESG compliance is essential for high-quality and sustainable development. At the same time, digital transformation is increasingly recognized as a catalyst for ESG implementation by optimizing resource use, increasing transparency, and supporting green innovation. With adequate policy support and government incentives, digital technologies can enhance corporate ESG performance through strengthened innovation capacity (Yang P., Hao X., Wang L. et al.) [2]. Furthermore, they facilitate stakeholder engagement, improve data-driven decision-making in ESG

planning, and support environmental risk management systems.

While digitalization has been shown to improve ESG outcomes in high-tech and high-emission industries (Qin X., Xie G.) [3], its role in agriculture remains underexplored. Studies suggest that digital tools improve ESG efficiency and disclosure, but their direct impact on financial performance in agriculture is still unclear. In emerging markets like Kazakhstan, the effectiveness of ESG and digitalization strategies depends on regulatory frameworks, adoption rates, digital literacy, and infrastructure investment (Katenova M., Qudrat-Ullah H.) [4].

Kazakhstan's agricultural sector continues to face systemic issues - low productivity, underdeveloped ESG practices, limited innovation, and delayed digital adoption (Zhanaltay Z.) [5]. These challenges constrain the country's efforts to modernize and remain competetive globally. Additionally, environmental degradation, inefficient land use, and social disparities further weaken the sector's sustainability. Amid rising ESG expectations and the global agtech revolution, Kazakhstan must accelerate agricultural transformation to achieve long-term resilience and sustainability.

This study uses the example of leading enterprises such as «Atameken-Agro» JSC to conduct a quantitative assessment of the relationship between ESG ratings, digital transformation, and financial performance. A data-driven model is developed to identify how ESG and digital integration function as dual drivers of agricultural modernization and sustainable value creation in the national economy, contributing to inclusive growth and long-term strategic priorities.

Literature Review

The integration of digital technologies plays a vital role in advancing environmental and ESG goals, especially in agriculture. Mondejar M.E., Avtar R., Diaz H.L. et al. [6] highlight that tools such as the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain contribute to reducing carbon footprints, promoting resource efficiency, and supporting the Sustainable Development Goals. Precision farming systems, in particular, have demonstrated potential in lowering water and fertilizer consumption, thus aligning with sustainable land management and ESG criteria.

Digitalization also fosters broader socioeconomic benefits. Weber R., Frank M., Braun J. [7] show that smart sensors, digital financial services, and traceability systems improve farmers' access to markets, information, and financing, which in turn strengthens economic resilience and social equity in rural regions. In Kazakhstan, Kaldiyarov D.A., Kalymbekova Z.K., Zhumanazarov K.B. [8] emphasize that platforms like Qoldau Digital have been introduced to enhance transparency in budget allocation and optimize operational processes in the agro-industrial sector.

Kazakhstan's enterprises are actively adopting integrated approaches to digitalization and ESG. «Atameken-Agro» JSC, for instance, has introduced international technological standards and sustainability principles to boost productivity while minimizing environmental impacts (Atameken-Agro. Annual report) [9]. «Aitas KZ» JSC combines environmental responsibility and community engagement with technological innovation, setting a strong example for ESG compliance and regional leadership in sustainable development (Aitas KZ. ESG report 2023) [10].

The government of Kazakhstan is also advancing agri-digital strategies. A national stakeholder review emphasizes the country's focus on implementing satellite monitoring, AI-driven analytics, and smart irrigation systems between 2025 and 2026 to increase yields, reduce water consumption, and optimize labor (Government of Kazakhstan...) [11]. These initiatives reflect an institutional commitment to aligning agricultural modernization with green economic priorities.

Kazakhstan's researchers Shalbayeva A.R., Tamenova S.S., Umbetaliev A.D. [12] emphasize the application of the ESG concept in the country's agricultural sector as a source of competitive advantage. Their study highlights how ESG implementation enhances sustainability, improves access to responsible investment, and strengthens trust among stakeholders, ultimately contributing to the long-term competitiveness of Kazakhstan's agri-food enterprises.

Their findings underscore the relevance of national context, policy coherence, and institutional capacity in ensuring the success of ESG and digital transformation in Kazakhstan's agricultural sector. In addition, Mohsin A.F., Barlykbay N., Mamanova S. [13] address technical limitations in the scalability and integration of IoT systems within Kazakhstan's agri-sector, emphasizing the need for improved infrastructure and system interoperability to fully realize the potential of digital agriculture.

This review supports the conclusion that the synergy between digital transformation and ESG implementation represents a viable and forward-looking model for agricultural modernization in Kazakhstan. It addresses both environmental and social challenges while enhancing productivity and investment attractiveness.

Materials and methods

This study applies a quantitative empirical method combined with a case study approach to assess the influence of ESG practices and digitalization on financial performance in Kazakhstan's agricultural sector. The focus is placed on the evolution of sustainability and technological innovation in «Atameken-Agro» JSC, one of the country's leading agro-industrial enterprises (Atameken -Agro. Annual report) [9].

To estimate ESG performance, the Weighted Scoring Model was used, drawing on international standards from the Global Reporting Initiative. GRI Standards [14] and the Sustainability Accounting Standards Board [15]. The composite ESG score is calculated using a weighted formula: ESG Score = 0.4E + 0.3S + 0.3G. The company's annual reports from 2014 to 2023 served as the basis for evaluating environmental actions, social policies, and corporate governance reforms.

Financial data such as revenue, net profit, return on assets (ROA), and debt ratio were collected from the same reports for the 2014-2023 period. A Digitalization Index was also developed based on the implementation of precision farming, artificial intelligence (AI), and Internet of Things (IoT) technologies. To enhance validity, the digitalization metrics were cross-verified with sectoral policy documents and expert interviews.

All analytical outcomes derived from the data are presented and interpreted in the Results section, including visual trends and the relationship between ESG indicators, digital transformation, and financial metrics.

Results

Kazakhstan has vast arable land and great potential for the development of modern agriculture. In recent years, the government has placed strong emphasis on integrating ESG concepts and digital technologies into the agricultural sector. In addition to public support, major enterprises have actively aligned with national ESG and digitalization priorities. Kazakhstan is now using drones, IoT systems, and satellite imaging for precision monitoring and soil management (Mohsin A.F., Barlykbay N., Mamanova S.) [13], (Mamytov A., Toktarov A., Abdygalieva S. et al.) [16]. For instance, «Atameken-Agro» JSC has introduced international financing to upgrade equipment, raise efficiency, and reduce its environmental impact (Atameken- Agro. Annual report) [9]. Similarly, Aitas KZ JSC has established a corporate environmental fund to support regional ecological programs during expansion phases (Aitas KZ. ESG report) [10]. These enterprises set a benchmark for the integration of ESG and digital technologies in the agricultural sector.

In a recent roundtable on Kazakhstan's digital transformation (Government of Kazakhstan...) [11], innovation sector leaders highlighted emerging technologies such as AI-driven predictive tools, autonomous agricultural robots, and smart soil analysis systems. These innovations are projected to boost crop yields and resource efficiency, with phased implementation expected between 2025 and 2026.

The structure used to assess ESG performance at «Atameken-Agro» JSC is summarized below (table 1).

The company's financial indicators and ESG scores from 2014 to 2023 are presented below (table 2).

Tabel 1 – ESG Rating Framework

ESG Dimension	Key Indicators	Score Range	Atameken-Agro Progress
Environmental (E)	Low-carbon agriculture technology	0-30	Adoption of No-Till farming in 2016, Precision Agriculture in 2020
	Renewable energy	0-10	Introduction of solar irrigation in 2021
Social (S)	Labor conditions	0-20	Improved employee welfare and training (2018-2021)
	Sustainable supply chain	0-10	Implementation of sustainable supply chain management in 2022
Governance (G)	ESG transparency	0-10	First ESG report published in 2021, meeting international standards by 2023
	Green finance	0-10	Adoption of EBRD green financing in 2022
Note: «Atameken-Agro» JSC annual reports (2014-2023), compiled by the author			

Tabel 2 - Atameken-Agro's financial data from 2014 to 2023

Year	ESG Score	Digitalization Index	Revenue (KZT)	Net Profit (KZT)	ROA (%)	Debt Ratio (%)
2014	40	20	8.14	-2.8	-8.18%	113.05 %
2015	45	25	10.88	-5.01	-12.73%	124.10 %
2016	50	30	15.86	-1.61	-2.66%	86.98 %
2017	55	40	20.96	0.06	0.08 %	72.87 %
2018	60	50	15.64	-5.64	-7.54%	77.28 %
2019	65	60	26.77	3.12	4.23 %	82.52 %
2020	70	70	28.6	12.93	15.22 %	67.40 %
2021	75	80	41.65	4.4	4.85 %	78.89 %
2022	80	85	54.61	18.2	16.27 %	69.69 %
2023	85	90	44.66	-19.9	-17.98%	76.51 %
Note: «Atameken-Agro» JSC annual report (2014-2023), compiled by the author.						

The empirical analysis reveals that ESG investments and digitalization have complex effects on financial performance. The correlation analysis indicates that ESG Score has a weak relationship with ROA and net profit, suggesting that ESG adoption may not yield immediate financial benefits. In contrast, the Digitalization Index shows a slightly stronger correlation with financial performance, but the relationship remains statistically weak, implying that digital transformation alone is not a guaranteed driver of financial success.

Regression analysis further confirms these trends. ESG investments negatively impact ROA and net profit, with coefficients of -2.25 and -2.75, respectively, suggesting that ESG-related expenditures may increase operational costs in the short term. Digitalization, on the other hand, has a positive but statistically insignificant effect on financial performance, with a coefficient of 1.46 for ROA and 1.67 for net profit. These results imply that while digital transformation may enhance efficiency and transparency, its direct financial impact remains uncertain.

The lack of a significant interaction effect between ESG and digitalization suggests that these two factors may function independently rather than as immediate financial performance drivers. This could be attributed to the early-stage nature of ESG adoption in Kazakhstan's agricultural sector, where ESG investments primarily focus on compliance and long-term sustainability rather than immediate profitability. Similarly, digitalization efforts may be enhancing operational efficiency but not yet translating into measurable financial gains.

Future research should consider whether sustained investment in both ESG and digital transformation could yield stronger long-term synergies. The explanatory power (R^2) of the models is moderate, with ESG and digitalization together explaining only 21-25% of financial performance variations.

In summary, ESG and digitalization may function as independent factors rather than immediate synergistic drivers of financial success. ESG adoption may require a longer timeframe to demonstrate financial benefits, while digitalization's impact could depend on further industry developments and policy support. These findings highlight the need for longitudinal studies and policy-driven incentives to better understand the long-term economic implications of ESG and digital transformation in Kazakhstan's agricultural sector.

Despite the short-term financial challenges identified in regression models, qualitative insights from «Atameken-Agro» JSC suggest that digitalization and ESG adoption contribute to long-term sustainability. As an industry pioneer, «Atameken-Agro» JSC has integrated digitalization into agricultural production management at an early stage. In 2016, the company took the lead in introducing the technology of «Agrostream», a local agricultural digital solution provider, and deployed a unique agricultural information integrated system throughout the group.

This move made «Atameken-Agro» JSC the first domestic agricultural enterprise to "take the lead", and by learning from international experience, modern information technology was "implanted" into the vast farmland of Kazakhstan. Practice has proved that the implementation of this digital system has greatly improved production efficiency and output. In 2019, one of Atameken's farms set a national record for winter wheat yields of 71.4 quintals per hectare (7.14 tons per hectare), far above the industry average (the average farm yield is also 50 quintals per hectare). The farm's management directly attributes this success to the stable and efficient operation of the information system that the company chose to deploy.

By optimizing the cultivation plan and agricultural inputs through digital means, the farm has achieved high and stable yields, proving the great value of digital agriculture. The Agrostream system of «Atameken-Agro» JSC covers multiple functional modules and realizes fine control of the production process. On the one hand, the field operation module monitors and dispatches all agricultural machinery in real time, tracks the operating status and idle time of combine harvesters, planters, and transport trucks, and optimizes the operation schedule, making the sowing, harvesting and transportation links seamless, continuous and efficient. This significantly shortens the production cycle and almost eliminates human delays.

On the other hand, the warehousing and logistics module digitizes the entire process of grain flow from harvest in the field: all data from grain storage, drying, grading, storage to loading and unloading are recorded, and warehouse operators can view the location and status of different batches of grain in real time. With the help of this module, the internal processes of the warehouse (such as grain receiving-warehouse-turning-cleaning-mixing-out of the warehouse, etc.) become completely transparent, effectively preventing the mixing of grains of different qualities and quantity losses. The system can also automatically generate transportation documents, compare the actual weight and the converted weight, and promptly detect quality anomalies or human errors.

Through these digital measures, «Atameken-Agro» JSC has greatly strengthened the traceability and internal control capabilities of the supply chain, won the trust of customers with highly transparent and reliable operations, and is regarded as a reliable partner for grain procurement. While practicing digitalization, «Atameken-Agro» JSC also pays attention to environmental and social goals in ESG. The company vigorously promotes sustainable farming methods. For example, the no-till technology mentioned above is applied to most of its arable land, which not only reduces soil erosion and conserves water and soil, but also reduces fuel consumption for mechanical operations.

In addition, «Atameken-Agro» JSC has achieved green technology upgrades by introducing foreign financial support: in 2023, the European Bank for Reconstruction and Development provided «Atameken-Agro» JSC with a loan of US$ 10 million to replace old agricultural machinery (tractors, combine harvesters and sprayers). This investment will help «Atameken-Agro» JSC further improve production efficiency and reduce carbon emissions, and provide employees with training opportunities to operate new equipment and cultivate skilled talents to adapt to future agriculture. In exchange, «Atameken-Agro» JSC needs to meet the environmental and social standards of international financial institutions, and its overall ESG performance has been continuously improved.

Through the two-pronged approach of «digitalization + ESG», «Atameken-Agro» JSC has successfully built itself into a high-yield, efficient and sustainable modern agricultural enterprise. It not only has outstanding econo-mic performance, but also sets an example for the industry to achieve parallel development of digital agriculture and green development.

While existing literature often highlights the long-term benefits of ESG adoption, our findings align with research suggesting that ESG initially increases costs due to compliance expenses, green technology investments, and operational restructuring. These short-term financial burdens may explain the negative relationship between ESG scores and financial performance in our empirical model.

Digitalization, though its direct financial impact remains uncertain, plays a crucial role in ESG compliance and transparency. Tools such as AI-driven ESG analytics, IoT-based resource management, and blockchain-enabled supply chain tracking improve reporting accuracy and operational efficiency. While digitalization may not immediately boost profitability, it acts as a key enabler for ESG-driven transformation.

The Technology-Organization-Environment (TOE) framework and Resource-Based View (RBV) theory help explain the integration of ESG and digitalization. TOE highlights how technological capabilities, organizational structure, and external factors drive ESG and digital adoption, while RBV emphasizes that firms leveraging digital tools for sustainability gain a competitive edge. For example, «Atameken-Agro» JSC uses digital systems to enhance operational efficiency while securing green financing, demonstrating how ESG and digitalization reinforce each other.

Kazakhstan’s agricultural sector is undergoing a transformation driven by ESG principles and digital innovation. The adoption of precision agriculture, IoT, and AI-driven solutions has significantly improved productivity, optimized resource use, and reduced environmental impact. Programs like Digital Kazakhstan and government subsidies for water-saving irrigation and sustainable farming are key enablers of this transition.

However, challenges such as limited rural digital infrastructure and slow ESG adoption remain barriers to scaling these initiatives. Agricultural enterprises must proactively integrate digital tools, adopt climate-smart practices, and improve ESG transparency to stay competitive in evolving global markets.

Agricultural cooperatives play a crucial role in modernizing Kazakhstan's farming industry by enhancing economies of scale, improving market access, and facilitating technology adoption. However, participation remains low (only ~2% of farmers) due to historical mistrust, dependence on state subsidies, and lack of awareness. Strengthening cooperative incentives, such as preferential loans, tax breaks, and training programs, can encourage farmers to collaborate. Governments should also shift their role from direct financial support to creating an enabling environment that fosters self-sustaining cooperatives and shared agricultural success.

To enhance sustainability and competetiveness, agricultural enterprises should invest in digital transformation, adopt ESG-driven practices, and engage in cooperative partnerships. Strategies such as smart irrigation, renewable energy use, blockchain-based traceability, and cooperative-led market integration can significantly improve financial performance and sustainability outcomes.

While our findings do not establish an immediate financial benefit from ESG adoption, they align with global research suggesting that sustainability investments yield long-term gains. The digitalization of Kazakhstan's agricultural sector remains in its early stages, and the full potential of smart farming technologies, AI-driven resource optimization, and precision agriculture has yet to be realized. Moreover, the upcoming 2025 ESG reporting requirements are expected to enhance corporate accountability and attract sustainable investments. The combination of digitalization and ESG compliance, supported by favorable policies and financial incentives, will likely enhance the sector's competitiveness in the coming years.

Government policies should continue to support digital skill development, improve rural connectivity, and expand green financing options. By embracing innovation, collaboration, and responsible resource management, Kazakhstan's agricultural sector can achieve long-term growth while meeting global sustainability standards.

Discussion

Given the early-stage nature of ESG and digitalization adoption in Kazakhstan's agricultural sector, government policies will play a crucial role in bridging the gap between sustainability goals and financial viability. Specific measures include expanding ESG-linked financing mechanisms, such as low-interest green bonds and sustainability-linked credit incentives, to support agricultural enterprises investing in digital transformation. Additionally, tax benefits for ESG-compliant companies and direct subsidies for precision agriculture technologies could enhance adoption rates. Furthermore, a phased ESG reporting mandate could help firms gradually integrate sustainability practices without facing immediate financial strain.

First, ESG-linked financial incentives should be expanded, including low-interest green finance options, tax breaks for ESG-compliant enterprises, and sustainability-linked credit programs. Government-backed financing mechanisms, such as «KazAgroFinance" JSC green leasing program, could be further leveraged to support sustainable agricultural technologies.

Second, the government should strengthen digital agriculture initiatives by providing subsidies for smart farming technologies, AI-driven precision agriculture, and IoT-based resource management systems. Developing a national ESG-digitalization integration framework would also help standardize ESG implementation across the agricultural sector.

Finally, improving ESG regulatory frameworks will be critical to ensuring compliance and transparency. The government should introduce a phased ESG reporting system, starting with large enterprises and gradually expanding to small and medium enterprises (SMEs), allowing businesses time to adapt. Establishing a centralized ESG data platform would further enhance investor access to sustainability performance metrics, encouraging corporate accountability and ESG-driven investments.

Conclusion

1. This study provides empirical evidence on ESG and digitalization's role in Kazakhstan's agricultural transformation. The findings suggest that while ESG investments may initially increase costs, their long-term benefits are promising.

2. Digitalization, though not immediately linked to financial performance, serves as a key enabler for ESG implementation by improving transparency and efficiency.

3. While ESG and digitalization have yet to demonstrate immediate financial synergies in Kazakhstan's agricultural sector, their long-term impact remains promising.

4. As regulatory requirements evolve and government incentives strengthen, ESG in-

vestments may transition from compliance-driven costs to competitive advantages.

5. Future research should employ longitudinal data analysis to assess how sustained ESG commitments influence financial outcomes over time. Additionally, exploring the role of government policies as a moderating factor in ESG-digitalization interactions could provide valuable insights into optimizing sustainability-driven business strategies in emerging markets.

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