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Analysis of the Level of Agricultural Development in Kazakhstan: Identifying Agro-Hubs

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ABSTRACT

The study examines Kazakhstan's agricultural sector and its potential for developing resilient agro-hubs, focusing on identifying regions that can contribute to the country's long-term agricultural growth. The purpose of this study is to examine essential agricultural indicators, including gross agrarian output, gross crop production, gross livestock production, and agricultural services, in order to identify regions with the potential for agro-hub development. The methodology includes Pearson correlation analysis of data collected from national agricultural reports and regional statistical databases. Data for the study were gathered from national agricultural reports and regional statistical databases, which provide quantitative measures of agricultural output, crop yields, livestock production, and farming services. Results indicate the strongest correlations between Kostanay and North Kazakhstan (0.995 for Gross Agricultural Output and 0.996 for Crop Production, $p < 0.001$). Additionally, significant alignment in crop production was observed between Almaty and South Kazakhstan (0.969, $p = 0.007$), whereas weaknesses in agricultural services were noted, particularly in Kyzylorda and Zhambyl, with a negative correlation. The results highlight the northern and southern regions' potential for forming agro-hubs supported by solid production indicators. The study provides strategic recommendations for policymakers to foster regional collaboration, enhance productivity, and promote sustainable agricultural development across Kazakhstan. Future research will focus on improving infrastructure and developing collaborative agricultural initiatives within agro-hubs to strengthen Kazakhstan's agricultural sector resilience.

KEYWORDS: Agro-Hubs, Regional Development, Cluster Development, Economic Sustainability, Spatial Analysis, Agricultural Modernization, Agricultural Infrastructure

SCSTI: 68.75.01

JEL Code: Q10, Q56, R11, O13

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1. INTRODUCTION

Agriculture is pivotal in ensuring food security, generating income, and supporting rural development in the global economy. The agricultural sector is not only a critical component of the economy in developing countries but also remains essential in many developed nations, where technological advancements and innovation drive significant growth. As the world grapples with increasing population, climate change, and the volatility of global food markets, an urgent need is to enhance agricultural productivity, sustainability, and resilience. Global challenges such as rising food demand, environmental degradation, and economic uncertainty further underscore the importance of identifying regions that can serve as stable agricultural hubs.

In this context, Kazakhstan's agricultural sector presents significant potential. With vast arable land, diverse climatic zones, and a rich agricultural history, Kazakhstan is strategically positioned in the global agricultural market. Agriculture contributes substantially to the national economy, providing livelihoods for many of the population and serving as a critical export sector. However, the industry faces numerous challenges, including climatic variability, uneven regional development, and the need for modernization. Identifying resilient regions that can bolster sustainable agricultural growth is key to enhancing Kazakhstan’s competitiveness in international markets and ensuring national food security.

Creating agro-hubs is one of the government's priorities outlined in the National Program for the Development of the Agro-Industrial Complex for 2021-2025. The program aims to modernize the agricultural sector of Kazakhstan by stimulating innovation, improving infrastructure, and facilitating agro-hub creation. Furthermore, in the President's address to the nation in 2023, it was emphasized that agriculture plays a strategic role in economic diversification and that the development of agro-hubs will serve as a catalyst for innovation and increase the export potential of the sector (Tokayev, 2023).

The agricultural landscape in Kazakhstan varies significantly across its regions, with differences in productivity, resource allocation, and environmental conditions. Understanding these regional dynamics is crucial for informing policy decisions and investment strategies to bolster the agricultural sector. Identifying regions that demonstrate resilience - the ability to maintain or improve agricultural output in the face of economic, environmental, and market pressures - is essential for forming agricultural clusters, enhancing Kazakhstan’s competitiveness, and contributing to the goals outlined in the national development program.

The current study aims to determine Kazakhstan's most favorable and resilient regions for developing agro-hubs by analyzing agricultural trends across two distinct periods, 2013–2017 and 2018–2023. The focus is on critical agricultural indicators such as gross agrarian output, crop production, livestock production, and agricultural services. Through an in-depth correlation analysis of these indicators across Kazakhstan’s regions, the research seeks to identify critical trends, assess regional resilience, and propose strategies for sustainable agricultural development.

2. LITERATURE REVIEW

Research into agricultural resilience and agro-hub development is crucial in addressing global challenges such as food security, climate change, and sustainable development. Agriculture plays a central role in many economies, particularly in developing countries, and enhancing regional capacities through agro-hubs has become vital to fostering innovation, improving productivity, and ensuring long-term sustainability.

Many scholars have explored the correlation between sustainability, innovation, and resilience in agricultural systems to frame the significance of agricultural hubs and

resilience in the global context. The exploration of sustainability, innovation, and resilience within agricultural systems has led scholars to highlight the critical role of agro-hubs in fostering sustainable agricultural practices. King (2008) emphasized that modern agro-hubs were essential for promoting sustainable practices by connecting people, food, and agriculture, with a strong focus on biodiversity and resource management, which were crucial for building resilience against environmental pressures and market fluctuations. Lamine (2015) expanded on this by showing that aligning agricultural practices with food and environmental policies enabled these systems to better adapt to changing conditions, reinforcing resilience at multiple levels within agricultural networks. Jagustović et al. (2019) applied systems thinking to climate-smart villages, illustrating how integrating local knowledge and adaptive strategies within complex systems was central to food security and agricultural resilience.

Barrios et al. (2020) added to this framework by introducing the "10 Elements of Agroecology", which facilitated transitions toward sustainable agricultural systems, with visual narratives driving institutional change and fostering the community-level adoption of agroecological practices. Wezel et al. (2020) further emphasized the importance of diversification and ecological balance as agroecological principles, asserting they were vital in creating resilient farming systems capable of withstanding environmental shocks and market instability. Van der Lee et al. (2022) reviewed frameworks for resilience assessment in farming systems, concluding that resilience requires both adaptability to external challenges and internal structural flexibility, highlighting the collaborative efforts of multiple stakeholders in fostering resilience. Thus, resilience in agricultural systems is critical for the successful development of agro-hubs, particularly in regions aiming to enhance their agricultural capacity and stability.

To explore the role of agricultural output in regional resilience, several studies provided essential findings. Nin et al. (2007) assessed livestock productivity in various developing countries and highlighted its role in supporting economic stability. Livestock output significantly impacted agricultural GDP, providing a buffer against external shocks such as fluctuating market conditions and environmental challenges. Rehman et al. (2017) analyzed the relationship between livestock production and agricultural GDP in Pakistan, showing a significant positive correlation between livestock products, such as milk and eggs, and the country's agricultural GDP. The econometric analysis demonstrated how livestock production contributed to economic stability, particularly in rural regions dependent on agriculture. Idris (2020), in a study of agricultural productivity in Sub-Saharan Africa, specifically examined the Nigerian context. Advancements in agricultural output, through modernized farming techniques and improved resource management, contributed to economic stability and fostered resilience within developing regions. Similarly, Ansari and Jadaun (2022) investigated agricultural productivity in India and found that higher productivity levels in the sector directly impacted economic growth. Improvements in agricultural output enhanced regional resilience by contributing to a more robust agricultural GDP.

Agricultural services, such as market access, extension programs, and technological support, promote resilience and sustainable development in rural regions. Research has shown that these services stabilize agricultural output and enhance the adaptive capacity of communities facing environmental and market challenges. Bonuedi et al. (2022) emphasized how improved market access in Sierra Leone supported resilience by ensuring a stable food supply and connecting farmers with buyers, mitigating the effects of agricultural fluctuations. Similarly, Rathi (2022) examined the role of income diversification, noting that non-farm income, through migration and urban employment, helped rural households manage agricultural and environmental uncertainties. Hameed and Sawicka (2023) highlighted the importance of agricultural extension services

in promoting sustainable practices like resource management and crop diversification, strengthening resilience in farming communities.

The literature review showed agro-hubs' importance in fostering regional resilience and sustainability. Studies on agricultural output, market access, and extension services show that diverse factors, including stable production, market connectivity, and the integration of sustainable practices support resilient agricultural systems. Existing studies stress the need for targeted development of agro-hubs that can enhance regional capacity to withstand environmental and economic challenges. The current study analyzes Kazakhstan's agricultural trends, focusing on regions best suited for agro-hub development. Identifying resilient regions through assessing agricultural output, livestock, and crop production and providing agricultural services will help inform strategies for creating sustainable, productive agricultural centers that contribute to Kazakhstan's long-term economic stability and food security.

3. RESEARCH METHODS

This study analyzes agricultural trends in Kazakhstan by focusing on two distinct periods: 2013–2017 and 2018–2023. The chosen periods reflect significant administrative and regional transformations, including establishing Turkestan and Shymkent as separate administrative entities from 2018 onwards, which has implications for agricultural data collection and regional classification.

To achieve the purpose of the study, a research process was proposed, as shown in Figure 1.

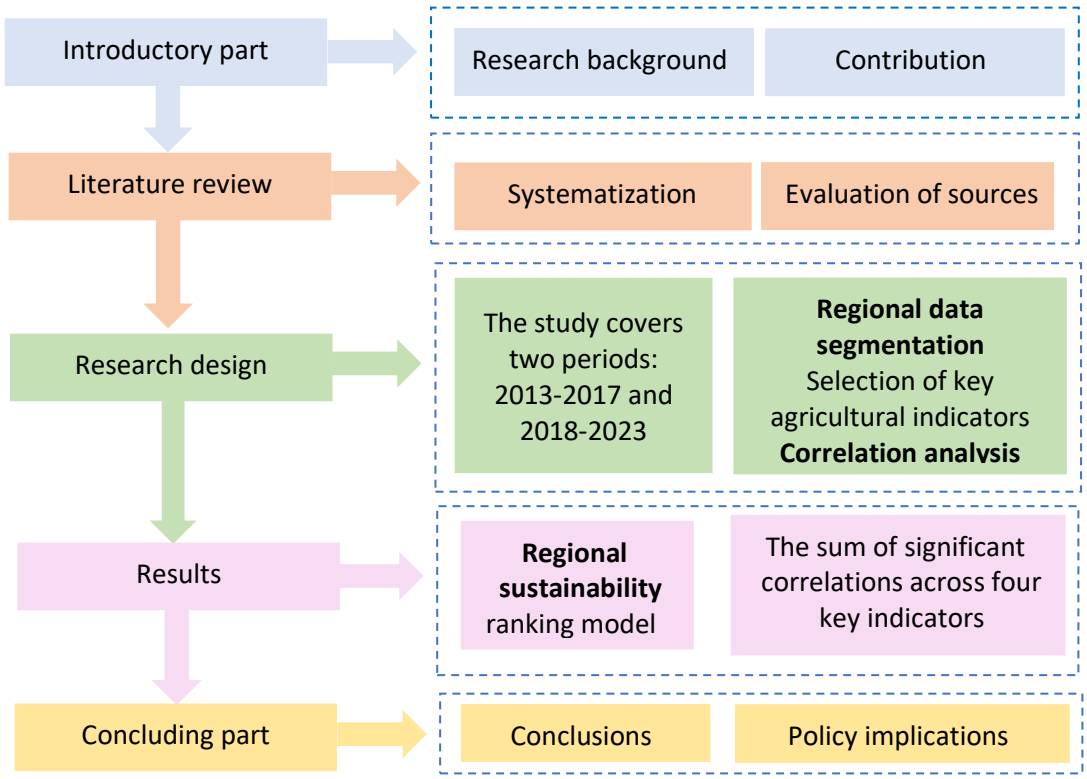

FIGURE 1. The main stages of the study

Note: compiled by authors

For an in-depth analysis, a regional sustainability ranking model was developed to assess the stability of agricultural production and its adaptability to changes in external conditions. This model was based on the values of correlations for crucial indicators, took into account their significance, and allowed to identify the regions with the most extraordinary stability. A high overall score indicated the region's strength and ability to maintain or increase production in changing economic and environmental conditions.

Four leading indicators were selected for the analysis of agriculture in Kazakhstan: gross agricultural output, gross crop production, gross livestock production, and agricultural services. The study focused on assessing regional differences in agricultural productivity, which made it possible to identify the impact of geographical and administrative features on the development of the industry. The Pearson correlation coefficient was used to quantify the relationships between regions. It allowed us to determine the strength and direction of the links between agricultural indicators by region in the specified periods, which provided a deep understanding of their sustainability and potential.

The critical agricultural indicators examined in this study include Gross Agricultural Output (Agro_GDP), Gross Crop Production (Agro_GCP), Gross Livestock Production (Agro_GLP), and Agricultural Services (Agro_SERVICE). These indicators were selected because they are relevant to measuring the overall performance of the agricultural sector and helpful in highlighting the production dynamics of crops and livestock alongside the contribution of farming services.

Data for the analysis were gathered from national agricultural reports and regional statistical databases, which provide quantitative measures of agricultural output, crop yields, livestock production, and farming services. Specifically, data include measures such as total agricultural production volumes, regional crop yields per hectare, livestock population and output, and the availability and quality of agricultural support services, all disaggregated by region. By segmenting the data in this manner, the study aims to derive insights into how geographical features and administrative boundaries have influenced the development of agricultural production over the two periods.

These findings are presented in Table 1, which provides a detailed comparison of critical agricultural indicators across the identified time frames and regional classifications.

TABLE 1. Regional categories

Regional zone	Region, 2013–2017	Region, 2018–2023
Western Kazakhstan	Atyrau, West Kazakhstan, Mangystau, Aktobe	Atyrau, West Kazakhstan, Mangystau, Aktobe
Central Kazakhstan	Akmola, Karaganda, Pavlodar	Akmola, Karaganda, Pavlodar
Eastern Kazakhstan	East Kazakhstan	East Kazakhstan
Southern Kazakhstan	Zhambyl, Kyzylorda, Almaty,	Zhambyl, Kyzylorda, Almaty, Turkestan
Northern Kazakhstan	North Kazakhstan, Kostanay	North Kazakhstan, Kostanay
Cities of Republican Significance	Almaty, Astana	Almaty, Shymkent, Astana

Note: compiled by authors

The Pearson correlation coefficient was conducted to identify relationships between selected agricultural indicators across regions, allowing for the quantification of the strength and direction of these relationships. A correlation coefficient close to 1 indicates a strong positive relationship, while values near -1 indicate a strong negative relationship. The

analysis compared correlation results across the two periods to identify changes in regional agricultural dynamics, particularly in response to policy changes, market conditions, and environmental factors.

A resilience ranking model was developed to refine the analysis further, evaluating the agricultural stability and potential of regions across Kazakhstan over the two periods: 2013–2017 and 2018–2023. The resilience rankings were calculated by considering the consistency and strength of correlations in key agricultural indicators: Gross Agricultural Output (Agro_GDP), Gross Crop Production (Agro_GCP), Gross Livestock Production (Agro_GLP), and Agricultural Services (Agro_SERVICE). Each region's performance in these categories was measured using Pearson correlation coefficients to identify those regions that consistently exhibited stable agricultural productivity and adaptability to changing market and environmental conditions. The methodology involved calculating an overall resilience score based on the sum of significant correlations across the four key indicators. A higher score indicated stronger resilience, while a lower score reflected more variability or potential vulnerabilities in the region's agricultural sector. The ranking approach considered the magnitude of correlations and the significance level (p-value), ensuring that the final rankings were grounded in statistically robust results.

4. RESULTS AND DISCUSSION

The present analysis focuses on Kazakhstan's agricultural regions over two distinct periods: 2013–2017 and 2018–2023, reflecting significant administrative changes, including the establishment of Turkestan and Shymkent as separate administrative units. The analysis begins by evaluating the agricultural performance across the categorized regions, emphasizing the most significant correlations observed within each period to examine the dynamics in agricultural output, crop production, livestock production, and agricultural services. This approach enables a comprehensive understanding of regional strengths and potential areas for collaboration within Kazakhstan's agricultural sector, ultimately assessing the evolution of regional alignments and their implications for farm development and policy-making.

Agro_GDP (Gross Agricultural Output)

During the analyzed period (2013–2017), several regions of Kazakhstan exhibited significant correlations in key agricultural indicators, including Agro_GDP (Gross Agricultural Output). The strongest positive correlation was observed between Kostanay and North Kazakhstan regions ($r = 0.995^*$, $p < 0.001$), reflecting a high level of similarity in agricultural output trends. A similar pattern was evident between Akmola and Karaganda regions ($r = 0.998^*$, $p < 0.001$), as well as Almaty and Zhambyl regions ($r = 0.967$, $p < 0.01$). Additionally, Almaty and Kyzylorda regions displayed a notable, though slightly weaker, correlation ($r = 0.869$, $p = 0.056$). Shared agricultural practices and environmental conditions likely influenced comparable agricultural production trends across these regions.

Agro_GCP (Gross Crop Production)

In the Agro_GCP (Gross Crop Production) indicator, high correlations were observed between several regions. Kostanay and North Kazakhstan regions showed a robust correlation ($r = 0.995^*$, $p < 0.001$), indicating parallel crop production trends. Almaty and Zhambyl regions also strongly correlated ($r = 0.985$, $p < 0.01$). In contrast, South Kazakhstan and Kyzylorda regions displayed moderate correlations with their neighboring areas, reflecting similarities in crop output trajectories during this period.

Agro_GLP (Gross Livestock Production)

Significant correlations were present across many regions for Agro_GLP (Gross Livestock Production). Kostanay and North Kazakhstan regions maintained a strong correlation ($r = 0.995^*$, $p < 0.001$), while Akmola and Karaganda regions displayed a similarly high correlation ($r = 0.991^*$, $p < 0.001$). Almaty and South Kazakhstan regions also had high correlations ($r = 0.997^*$, $p < 0.001$), indicating

aligned developments in livestock production across these areas. Almaty and Kyzylorda regions presented moderate correlations (r = 0.832, p = 0.080), reflecting partial similarities in livestock management practices.

Agro_SERVICE (Agricultural Services)

In the Agro_SERVICE (Agricultural Services) category, correlations were less pronounced but still noteworthy. Kostanay and North Kazakhstan regions demonstrated a positive correlation (r = 0.935, p < 0.05), reflecting shared patterns in the provision of agricultural services. Other regions, including Kyzylorda and South Kazakhstan, displayed weaker or negligible correlations, highlighting differences in service delivery approaches across these regions.

The key results of the correlation analysis across regions, based on gross agricultural output (Agro_GDP), gross crop production (Agro_GCP), gross livestock production (Agro_GLP), and agricultural services (Agro_SERVICE), are summarized in the table. Strong correlations were most evident between regions such as Kostanay and North Kazakhstan and Akmola and Karaganda, indicating a high degree of alignment in agricultural development, particularly in crop and livestock production, from 2013 to 2017. Moderate correlations involving Kyzylorda also indicated shared trends in agricultural practices, though with distinct regional characteristics.

Table 2 presents the most significant regional correlations in key agricultural indicators. Regions showed the strongest alignment in agricultural output, crop production, livestock production, and agricultural services during the period analyzed.

TABLE 2. Significant correlation results for 2013-2017

Region	Agro_GDP	Agro_GCP	Agro_GLP	Agro_SERVICE
Kostanay ↔ North Kazakhstan	0.995***	0.995***	0.995***	0.935*
Almaty ↔ Zhambyl	0.967**	0.985**	0.985**	—
Akmola ↔ Karaganda	0.998***	0.990**	0.991***	0.953*
Aktobe ↔ West Kazakhstan	0.987**	0.994***	0.998***	—
Astana ↔ Almaty	—	-0.879*	0.923*	0.885*
Aktobe ↔ Mangystau	0.938*	0.942*	0.943*	0.800
Karaganda ↔ Pavlodar	0.959*	0.986**	0.990**	—
East Kazakhstan ↔ South Kazakhstan	0.987**	0.953*	0.997***	—
$p < 0.05$ — *, $p < 0.01$ — **, $p < 0.001$ — ***				

Note: compiled by authors based on calculations

Agro_GDP (Gross Agricultural Output) 2013-2017

Kostanay and North Kazakhstan regions exhibited the strongest correlation (r = 0.995***), reflecting nearly identical trends in agricultural output. This alignment suggested that these regions shared similar agricultural strategies, making them prime candidates for an agricultural cluster focused on maximizing production efficiency. Akmola and Karaganda (r = 0.998***) also showed highly correlated output trends, as did Aktobe and West Kazakhstan (r = 0.987**), indicating the potential for a northern agricultural hub. The correlation between East Kazakhstan and South Kazakhstan (r = 0.987**) further suggested a unified growth pattern in southeastern Kazakhstan, making these regions suitable for a collaborative agricultural corridor.

Agro_GCP (Gross Crop Production) 2013-2017

Kostanay and North Kazakhstan once again led with a near-perfect correlation (r =

0.995***), underscoring the strong potential for these regions to become specialized crop production hubs. Akmola and Karaganda (r = 0.990**) and Aktobe and West Kazakhstan (r = 0.994***) also demonstrated strong correlations in crop production, suggesting that these regions were well-suited for forming crop-focused clusters. In southern Kazakhstan, Almaty and Zhambyl (r = 0.985**) shared similar crop production dynamics, pointing toward opportunities for collaborative programs to increase yields in these regions.

Agro_GLP (Gross Livestock Production) 2013-2017

Livestock production correlations further revealed strong alignments. Kostanay and North Kazakhstan (r = 0.995***) and Akmola and Karaganda (r = 0.991***) had the highest correlations, suggesting that these regions could have formed a livestock production cluster. Aktobe and West Kazakhstan (r = 0.998***) also exhibited significant alignment in livestock output, indicating a capacity for joint growth in animal husbandry. Similarly, East Kazakhstan and South Kazakhstan (r = 0.997***) reflected the potential for collaboration in livestock production, driven by shared environmental and agricultural conditions.

Agro_SERVICE (Agricultural Services) 2013-2017

Although correlations in agricultural services were generally lower, Kostanay and North Kazakhstan (r = 0.935*) displayed a significant relationship in their approach to providing agricultural support services. This suggested these regions could have formed the backbone of service-oriented agrarian hubs. Almaty and Astana (r = 0.885*) also aligned agricultural services, indicating their potential as central players in developing advanced agricultural technologies and support systems. These regions were positioned to lead the modernization of agricultural services and drive innovation in the sector.

The patterns in these correlations revealed several regions that were ideally positioned for forming agricultural clusters. Kostanay and North Kazakhstan, with consistently high correlations across all indicators, emerged as strong candidates for becoming a central agricultural hub, particularly in crop and livestock production. Akmola, Karaganda, Aktobe, and West Kazakhstan also showed potential for forming vital agricultural corridors in the north and west. Almaty, Zhambyl, and South Kazakhstan regions demonstrated strong alignment in the south, making them suitable for crop and livestock production cooperative growth.

In the second phase of the analysis, covering the period from 2018 to 2023, the correlations were recalculated, incorporating newly established regions such as Turkestan and Shymkent. This expanded the scope of the analysis, focusing on regional agricultural performance across Kazakhstan. The correlations between areas were examined to understand the alignments and divergences in agricultural practices during this period, with particular attention to the impact of regional restructuring.

Agro_GDP (Gross Agricultural Output) 2018-2023

Regarding Agro_GDP, strong correlations were observed, particularly between Kostanay and North Kazakhstan ($r = 0.959$, $p = 0.002$), indicating aligned agricultural productivity trends that likely stem from similar farming practices and economic conditions. Zhambyl and Turkestan also found a high correlation ($r = 0.995$, $p < 0.001$), reflecting synchronized growth patterns that can enhance regional economic stability. However, a significant negative correlation between Astana and Shymkent ($r = -0.817$, $p = 0.047$) highlights divergent agricultural performances, likely due to different economic policies, investment levels, and market access in these cities.

Regions showing strong synergies could benefit from policy efforts to establish agricultural clusters. Such clusters would strengthen production efficiencies, improve market access, and foster technological innovation. Akmola, Karaganda, and Pavlodar—each showing consistently strong correlations in Agro_GDP, Agro_GCP, and Agro_GLP—represent a promising foundation

for the development of a tri-regional hub focused on crop and livestock production.

Agro_GCP (Gross Crop Production) 2018-2023

The Agro_GCP metric revealed even stronger correlations, with Kostanay and North Kazakhstan exhibiting nearly perfect correlation ($r = 0.996$, $p < 0.001$). This indicates that both regions experience almost identical crop production trends, influenced by similar climatic conditions and effective agricultural practices. A significant correlation was also noted between Almaty and South Kazakhstan ($r = 0.969$, $p = 0.007$), as well as between Zhambyl and Turkestan ($r = 0.997$, $p < 0.001$), further emphasizing synchronicity in crop production in the southern regions. Such strong correlations underscore the importance of regional cooperation in agricultural policy and practices, which can lead to increased productivity and economic growth.

Agro_GLP (Gross Livestock Production) 2018-2023

As reflected by the Agro_GLP metric, Livestock production in Kazakhstan showed significant correlations among various regions. The strongest correlation is observed between Kostanay and North Kazakhstan ($r = 0.962^{**}$, $p = 0.002$) and Akmola and Pavlodar ($r = 0.924^{**}$, $p = 0.008$). These findings confirm that these regions employ similar livestock production strategies influenced by comparable environmental conditions, such as climate and geography, and shared infrastructure for animal husbandry. An exceptionally high correlation exists between Kyzylorda and Turkestan ($r = 0.980^{***}$, $p < 0.001$), indicating the development of integrated livestock value chains. Revealed integration provides a framework for optimizing production and distribution processes, enhancing competitiveness by establishing large-scale meat and dairy processing facilities tailored to meet domestic and export demands.

Agro_SERVICE (Agricultural Services) 2018-2023

The correlations in agricultural services were generally weaker, with notable exceptions. A negative correlation between Kyzylorda and Zhambyl ($r = -0.838^{*}$, $p = 0.037$) indicates differences in agricultural service delivery, likely due to varying privatization, investment in infrastructure, and government support across these regions. Conversely, the positive correlation between Kyzylorda and Kostanay ($r = 0.925^{*}$, $p = 0.024$) demonstrates a more consistent service provision model that can be effectively replicated in other areas. Regions with complementary strengths in agricultural services can implement collaborative efforts to improve service efficiency, enhance knowledge sharing, and drive innovation in agricultural technologies, ultimately benefiting local farmers and the broader agricultural economy.

The correlation results confirm that regions like Kostanay, North Kazakhstan, Zhambyl, and Turkestan have the potential to form specialized agro-industrial clusters. These clusters can promote efficiency, innovation, and sustainable development, serving as models for other regions in Kazakhstan. Strong internal alignment within these areas indicates they are well-positioned to leverage their agricultural strengths and enhance their contributions to the national economy. Conversely, regions with weaker correlations, such as Kyzylorda and Zhambyl, require targeted interventions to improve service delivery and enhance productivity.

These interventions may include investments in infrastructure, training programs for farmers, and policies that foster cooperation between different agricultural stakeholders. Comparing the periods of 2013-2017 and 2018-2023 shows that the earlier period exhibited stronger correlations and more stable agricultural growth, indicating a more unified approach to agricultural development across the country. In contrast, the latter period reveals a more complex landscape with emerging negative correlations, particularly in Agro_GLP and Agro_SERVICE. This shift reflects increasing regional differentiation in agricultural strategies, driven by policy changes, market

dynamics, and external factors such as climate variability.

Thus, Kostanay, North Kazakhstan, Zhambyl, and Turkestan consistently demonstrate strong potential for agro-hub development, characterized by their ability to produce and process agricultural goods efficiently. Meanwhile, Astana and Shymkent require strategic interventions to align their agricultural services and production with critical regions, enhancing overall productivity and competitiveness in Kazakhstan's agricultural sector. By fostering collaboration and sharing best practices across regions, Kazakhstan can strengthen its agricultural economy and improve food security for its population.

Table 3 presents the most significant regional correlations in key agricultural indicators from 2018 to 2023.

TABLE 3. Significant correlation results for 2018-2023

Region	Agro_GDP	Agro_GCP	Agro_GLP	Agro_SERVICE
Kostanay ↔ North Kazakhstan	0.959**	0.996***	0.962**	—
Almaty ↔ South Kazakhstan	0.996***	0.969**	0.987**	0.992***
Zhambyl ↔ Turkestan	0.995***	0.997***	0.956**	—
Kyzylorda ↔ Turkestan	—	—	0.980***	-0.838*
Akmola ↔ Karaganda	0.849*	0.875*	0.912*	—
Akmola ↔ Pavlodar	0.947**	0.934**	0.924**	—
Karaganda ↔ Pavlodar	0.931**	0.927**	0.888*	0.891*
East Kazakhstan ↔ Agro_GCP_East Kazakhstan	0.941**	—	—	—
$p < 0.05$ — *****, $p < 0.01$ — ******, $p < 0.001$ — *******				

Note: compiled by authors based on calculations

The significant correlations identified for 2018-2023 highlighted critical trends in Kazakhstan's agricultural sector. The focus was put on the specific correlations due to their strong statistical significance, indicating solid relationships between agricultural outputs, livestock production, and agricultural services across various regions.

The significant correlations identified for the period 2018-2023 highlighted critical trends in Kazakhstan's agricultural sector, reflecting interregional dynamics and opportunities for collaboration. These specific correlations were chosen due to their strong statistical significance, indicating robust relationships between agricultural outputs, livestock production, and agricultural services across various regions. The correlation between Kostanay and North Kazakhstan exemplified a highly integrated agricultural partnership, underscoring the regions' shared strategies and environmental conditions that led to similar production outcomes. Similarly, the pairing of Almaty and South Kazakhstan showed impressive alignment across all indicators, indicating a synergistic agricultural framework that capitalized on complementary strengths. The emerging significance of southern regions was evident in the strong correlation between Zhambyl and Turkestan, showcasing their growing role in agricultural productivity and collaboration. Meanwhile, the notable livestock production correlation between Kyzylorda and Turkestan pointed to integrated livestock value chains. However, the negative correlation in agricultural services highlighted challenges that needed addressing in service delivery. Additionally, the consistent performance of central regions was illustrated by the positive correlations among Akmola, Karaganda, and Pavlodar, suggesting a stable agricultural environment conducive to forming

potential agro-clusters. However, the lack of correlation in agricultural services for specific regional pairs, particularly between Kyzylorda and Turkestan, indicated a pressing need for enhanced agricultural service infrastructure and delivery mechanisms in those areas.

A resilience ranking was developed based on the comprehensive analysis of agricultural correlations across different regions to assess the potential for agricultural development and cluster formation. This ranking considers the strength of correlations in key agricultural indicators such as gross domestic product in agriculture, gross crop production, gross livestock production, and farming services. By identifying regions that demonstrated high resilience across these metrics, we can prioritize areas for investment and development, enabling the formation of agricultural hubs that can enhance regional and national food security and economic growth.

Below is the interpretation of the resilience scores and rankings based on the findings (Figure 2).

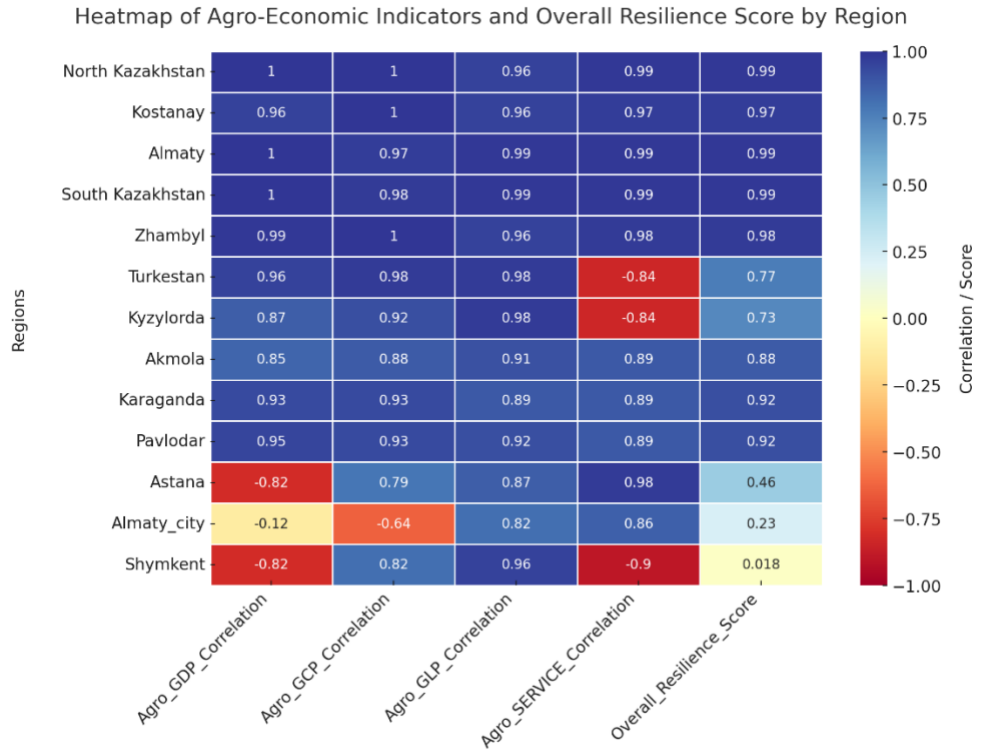

FIGURE 2. Regional ranking

Note: compiled by authors based on calculations

The ranking table offers a comprehensive assessment of agricultural resilience and economic stability across Kazakhstan's regions from 2013 to 2023 and regions' capacity for maintaining agricultural output stability over the decade for developing agro-hubs. Almaty and South Kazakhstan also rank prominently, excelling in production indicators and agricultural services, further enhancing their contribution to the agricultural sector.

As key agricultural contributors, these regions maintain a robust balance between production and service infrastructure, affirming their readiness for potential cluster development within the national agricultural framework. Regions such as Zhambyl and

Turkestan excel in crop and livestock production but perform more moderately in agricultural services. While their production strengths position them favorably for agrarian growth, enhancing service infrastructure is essential for increasing overall economic stability.

In the middle range, regions like Akmola, Karaganda, and Pavlodar maintain consistent agricultural production performance, though a gap in service infrastructure slightly lowers their overall resilience ranking. A continued focus on strengthening agrarian services could elevate their contribution to the national agricultural economy.

Kyzylorda stands out for its strong livestock production performance, though weaker agricultural service results suggest a need for focused improvements to enhance resilience. Strengthening service-related infrastructure could reinforce its agricultural and economic contributions.

Urban centers, including Astana, Almaty and Shymkent cities, present lower rankings in agricultural resilience due to weaker production correlations. However, their role in agricultural services is more pronounced, especially for Astana, which demonstrates significant strength in this domain. While these cities may not lead in production, their service-related infrastructure is essential in supporting agricultural activities in surrounding rural areas. Astana excels in agricultural services, while Almaty City shows mixed performance, with negative correlations in crop production but a stronger focus on service infrastructure. With its strengths in livestock production, Shymkent faces challenges in agricultural services, highlighting a need for further infrastructure development.

The assessment of agricultural resilience reveals that a region with balanced performance across both production and service infrastructure leads Kazakhstan's agricultural development. North Kazakhstan, Kostanay, Almaty, and South Kazakhstan consistently perform across multiple agricultural metrics, confirming their role as prime candidates for agro-hub formation. In contrast, regions such as Kyzylorda and Turkestan, where production capacity is strong but service infrastructure lags, demonstrate the potential for improvement through targeted investment in agricultural services. With their distinct contributions through service-oriented infrastructure, urban centers remain pivotal in supporting rural agricultural productivity, ensuring a well-rounded agrarian system across the country.

5. CONCLUSION

This analysis aimed to assess agricultural trends in Kazakhstan across two distinct periods, 2013–2017 and 2018–2023, focusing on crucial agrarian indicators such as gross agricultural output, gross crop production, gross livestock production, and agricultural services. The results revealed significant correlations among various regions, highlighting emerging trends, weak points, and opportunities for collaboration within the agricultural sector.

Key findings indicated strengthened partnerships between regions such as Kostanay and North Kazakhstan and Almaty and South Kazakhstan, underscoring the potential for collaborative agricultural initiatives. The emerging role of southern areas, particularly Zhambyl and Turkestan, further emphasized their growing importance in enhancing agricultural productivity. Additionally, integrated livestock value chains were noted, especially between Kyzylorda and Turkestan, suggesting avenues for improved competitiveness.

However, challenges were also identified. The negative correlation in agricultural services between Kyzylorda and Zhambyl revealed discrepancies that could hinder effective collaboration. The inconsistent performance of newly established regions, such as Turkestan and Shymkent, highlighted the need for targeted strategies to foster alignment and cohesion. To capitalize on the identified trends and address the challenges, it is recommended that policymakers focus on fostering collaboration among high-

performing regions. Investments in agricultural service infrastructure are crucial, particularly in areas demonstrating weaknesses. Strengthening regional cooperation can enhance productivity, streamline service delivery, and promote sustainable agricultural practices.

AUTHOR CONTRIBUTION

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