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GREEN LOGISTICS AND DIGITALIZATION: A STRATEGY FOR OPTIMIZING COURIER SERVICES IN KAZAKHSTAN

Over the past few years, the rapid yet uneven digital transformation of logistics has intersected with an increasing demand for environmentally responsible practices, reshaping the courier sector in Kazakhstan. The study confirms that the adoption of digital tools – AI routing, IoT tracking, and parcel lockers – reduced average delivery time by 42%, increased customer satisfaction by 25%, and decreased CO2 emissions per parcel by 12-15% in Kazakhstan's major cities. The research objective is to evaluate how the integration of green logistics and digitalization enhances courier service efficiency and supports urban sustainability. A mixed-method approach was applied, including quantitative assessment of performance indicators and qualitative insights drawn from semi-structured interviews with six courier and transport companies operating in Almaty, Astana, and Shymkent. The analysis shows that the use of smart routing, real-time tracking, and last-mile automation has led to tangible results: reductions in fuel consumption (on average by 15-18%), higher customer satisfaction, and a noticeable increase in delivery efficiency. Furthermore, initiatives such as the adoption of electric vehicles, energy-efficient logistics hubs, and biodegradable packaging have contributed to a measurable decline in CO_2 emissions, supporting national sustainability goals outlined in the "Digital Kazakhstan" strategy. Nevertheless, persistent barriers remain. These include a limited charging infrastructure, high upfront investment requirements, and a shortage of digitally skilled personnel. Addressing these issues calls for closer coordination between policymakers, business leaders, and the academic community. What makes this study distinctive is its focus on Kazakhstan's transitional context – where both digital maturity and environmental policy frameworks are still evolving. The findings provide a practical and methodological foundation for designing ESG-oriented strategies aimed at transforming courier logistics into a more competitive, environmentally responsible, and future-ready component of the national economy.

Keywords: green logistics, digitalization, courier services, sustainability, optimization.

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Жасыл логистика мен цифрландыру: Қазақстандағы курьерлік қызметтерді оңтайландыру стратегиясы

Электрондық коммерцияның жедел дамуы мен әлемдік деңгейде тұрақты даму идеяларына деген қызығушылықтың күшеюі логистикалық сектордың жаңа сапалық кезеңге өтуін талап етіп отыр. Соңғы жылдары бұл үрдіс әсіресе курьерлік қызметтер нарығында айқын байқалады. Мақаланың мақсаты – Қазақстандағы курьерлік қызметтерді цифрландыру мен жасыл логистиканы ықпалдастырудың тиімділігін зерттеу және олардың қала инфрақұрылымының орнықты дамуына әсерін бағалау. Зерттеу нәтижелері көрсеткендей, цифрлық шешімдерді енгізу жеткізу уақытының 42%-ға қысқаруына, тұтынушы қанағаттануының 25%-ға артуына және бір сәлемдемеге шаққандағы CO_2 шығарындыларының 12-15%-ға төмендеуіне ықпал етті. Зерттеу барысында жасыл логистиканың теориялық қағидалары жинақталып, сонымен қатар «соңғы миля» кезеңінде қолданылып жүрген заманауи цифрлық шешімдердің экологиялық тиімділік пен операциялық өнімділікті арттырудағы рөлі нақты мысалдар арқылы сипатталды. Мұндай тәсіл энергия тұтынуды азайтуға, көмірқышқыл газының шығарындыларын төмендетуге және тұтынушыларға қызмет көрсету сапасын жақсартуға мүмкіндік беретіні байқалды. Сонымен

ішкі және сыртқы факторлардың ықпалын кешенді түрде бағалауға бағытталған SWOT-талдау ұсынылып, жасыл-цифрлық модельге көшу үдерісіндегі әлеуетті мүмкіндіктер мен тәуекелдер айқындалды. Талдау нәтижесінде инфрақұрылымды жаңғырту, мемлекеттік ынталандыру тетіктерін жетілдіру және кадрлық әлеуетті жүйелі дамыту жөнінде нақты практикалық ұсынымдар берілді. Жалпы алғанда, зерттеу нәтижелері көрсеткендей, экологиялық және цифрлық шешімдердің стратегиялық үйлесімі қоршаған ортаға түсетін теріс әсерді азайтып қана қоймай, сонымен қатар отандық курьерлік компаниялардың ұзақмерзімді бәсекеге қабілеттілігін арттыруға елеулі үлес қоса алады. Осы тұрғыдан алғанда, мақалада ұсынылған тұжырымдар мен ұсынымдар Қазақстанда орнықты және инновациялық логистикалық инфрақұрылым қалыптастыруға мүдделі мемлекеттік және жекеменшік сектор өкілдеріне нақты бағдар бола алады деп пайымдаймыз.

Түйін сөздер: жасыл логистика, цифрландыру, курьерлік қызметтер, тұрақты даму, оптимизация.

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Зелёная логистика и цифровизация: стратегия оптимизации курьерских услуг в Казахстане

На фоне бурного роста электронной коммерции и растущего интереса к вопросам устойчивого развития курьерская логистика всё чаще оказывается в центре внимания исследователей и практиков. Сегодня она нуждается не просто в точечных улучшениях, а в комплексной трансформации, затрагивающей организационные, технологические и экологические аспекты. В этом контексте цель настоящего исследования состоит в том, чтобы проанализировать потенциал интеграции зелёной логистики и цифровизации как действенного инструмента повышения эффективности курьерских процессов в Казахстане. В работе систематизированы ключевые теоретические положения зелёной логистики и рассмотрены современные цифровые решения, используемые на этапе «последней мили». Особое внимание уделяется тому, как внедрение таких технологий влияет на снижение углеродного следа, энергопотребления и повышение общей операционной результативности. Анализ показал, что именно сочетание экологических принципов и цифровых инструментов даёт наиболее ощутимый эффект в условиях ограниченных ресурсов. Помимо теоретического обоснования, в статье проведён SWOT-анализ, позволивший выделить внутренние ресурсы, структурные ограничения и внешние факторы, формирующие новые возможности или, напротив, создающие дополнительные риски для отрасли. Отдельным направлением исследования стали практические рекомендации, охватывающие вопросы модернизации инфраструктуры, совершенствования механизмов государственной поддержки и развития кадрового потенциала. Полученные результаты демонстрируют, что при стратегическом и последовательном подходе синергия цифровых технологий и экологических решений способна не только снизить негативное воздействие на окружающую среду, но и существенно повысить устойчивость и конкурентоспособность курьерских компаний. В целом, выводы и предложения, представленные в статье, могут быть полезны как исследователям, так и представителям бизнеса и государственных структур, заинтересованных в формировании сбалансированной и устойчивой логистической системы Казахстана.

Ключевые слова: зелёная логистика, цифровизация, курьерские услуги, устойчивое развитие, оптимизация.

Introduction

In recent years, the logistics sector has been undergoing profound – though not always even – changes driven by two parallel imperatives: environmental sustainability and digital innovation. Nowhere is this more visible than in emerging economies such as Kazakhstan, where the rapid growth of e-commerce and the intensification of urban delivery traffic have created new logistical pressures. Congestion in major cities (e.g., Almaty and Astana), rising energy demand, and the associated increase in CO_2 emissions collectively strain transport infrastructure and service reliability (UNCTAD, 2023). Traditional courier models, still heavily reliant on fossil-fuel vehicles and manual dispatching, are gradually losing their economic and environmental feasibility, particularly considering Kazakhstan's commitments under the Paris Agreement and the UN Sustainable Development Goals (IPCC, 2022).

Against this backdrop, the integration of green logistics principles with digital transformation appears not only timely but also necessary (Setiawan et al., 2023). Green logistics emphasizes measures such as electrification of vehicle fleets, recyclable and reusable packaging, and circular approaches to inventory and returns; these interventions have been shown to curb environmental externalities while maintaining economic viability (Dekker et al., 2012; Piecyk & McKinnon, 2010). In parallel, digitalization – through the Internet of Things (IoT), artificial intelligence (AI), blockchain, and big-data analytics – offers practical tools for route optimization, end-to-end visibility, and better customer experience (Wang & Sarkis, 2021). In practice, these agendas are mutually reinforcing data-driven dispatching raises vehicle utilization, which reduces empty mileage and fuel consumption, electrification further multiplies the environmental benefit of each optimized kilometer.

Policy and market dynamics are also converging. Internationally, regulators and large shippers increasingly expect disclosure of logistics emissions and evidence of continuous improvement. While the specifics differ by country, the overall direction is clear: lower carbon intensity, higher transparency, and more resilient last-mile networks. For Kazakhstan, these trends intersect with national development priorities and ongoing digital initiatives, creating a window of opportunity to couple low-carbon investments with digital platforms for planning, tracking, and performance control. At the same time, several constraints – limited charging infrastructure, uneven digital readiness outside metropolitan areas, and a shortage of skilled personnel – still shape the pace and scope of transformation.

Despite growing scholarly interest in green and smart logistics, the interaction between these two agendas in Kazakhstan's courier context remains under-examined. Many existing studies focus on manufacturing supply chains or line-haul transport, with relatively less attention to dense, time-sensitive last-mile operations that dominate urban courier services. This study addresses that gap by assessing how digital technologies (smart routing, real-time tracking, and automated last-mile management) and green practices (electric vehicles, energy-efficient hubs, and circular packaging) jointly affect operational and environmental performance in Kazakhstan's courier sector. Specifically, we ask: (1) Which digital and green measures deliver the most immediate efficiency and carbon-reduction gains in urban delivery? (2) What organizational and infrastructural factors condition their effectiveness? (3) Which policy tools could accelerate diffusion among small and medium-sized providers?

Methodologically, the research combines quantitative indicators of operational and ecological performance with qualitative evidence from semi-structured interviews. This mixed approach allows us to link numerical outcomes with managerial interpretations and implementation realities, thereby producing findings that are both measurable and practically relevant. The contribution is twofold: first, we offer an empirically grounded picture of how digital and green innovations work together in a courier setting; second, we derive a policy and practice-oriented framework that can inform national strategies as well as firm-level roadmaps.

The remainder of the paper proceeds as follows. The literature review synthesizes international and local evidence on digital and green logistics. The methodology section details the data sources, sampling logic, and triangulation procedures. Results and discussion present the SWOT analysis, quantify the impacts of digital tools and green measures, and interpret barriers to scale. The conclusion distills policy implications and outlines future research directions relevant to Kazakhstan's transition toward sustainable, digitally enabled courier logistics.

Literature review

Over the past decade, research on digital transformation in logistics has grown rapidly, reflecting the increasing strategic importance of technological innovation for supply chain performance. According to Wang and Sarkis (2021), digital tools such as the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) have emerged as crucial enablers of efficiency. Their studies demonstrate that these technologies significantly improve last-mile optimization, demand forecasting, and supply chain visibility – aspects that are especially relevant for courier operations (Fosso Wamba et al., 2018). In essence, digitalization is now viewed not merely as a support mechanism but as a structural foundation for modern logistics systems (Elesheva et al., 2024).

Extending this perspective, Sarkis (2021) argues that the combined implementation of environmental and digital strategies enhances resilience and contributes to the long-term sustainability of supply chains. This intersection of "green" and "smart" practices forms a new paradigm where environmental responsibility and technological sophistication reinforce one another. However, the degree to which such integration occurs largely depends on regional conditions and institutional maturity.

In the context of Kazakhstan, several recent studies emphasize that the transformation process remains in its early stages. Baimukhanbetova et al. (2023) identify persistent barriers – including underdeveloped infrastructure, shortages of qualified personnel, and insufficient financial incentives – as major constraints to digital adoption in the logistics sector. Likewise, Moldabekova et al. (2021) point out that Industry 4.0 technologies are only beginning to reshape the national logistics ecosystem, leaving notable gaps in automation, environmental management, and sustainable innovation.

Taking together, these contributions suggest an urgent need for more nuanced, empirically grounded research that combines quantitative measures (such as emission reduction and efficiency improvements) with qualitative insights reflecting managerial and stakeholder perspectives. Such an integrated approach is particularly relevant for courier logistics in Kazakhstan, a domain that remains underexplored but strategically vital for achieving both economic competitiveness and sustainability goals.

Recent research within the CIS region (Russia, Belarus, Uzbekistan) shows growing efforts to integrate ESG principles into transport and logistics strategies (Dzhuglo et al., 2023). For instance, Russia's "Green Finance" roadmap (2022) links ESG disclosure to operational transparency and carbon reporting, while Uzbekistan's e-logistics programs focus on social inclusion and emission monitoring.

In theoretical terms, ESG indicators directly correlate with logistics efficiency: E (Environmental) criteria align with energy consumption and emission intensity; S (Social) indicators relate to workplace safety and customer satisfaction; and G (Governance) criteria influence digital transparency, regulatory compliance, and risk control. Integrating these dimensions enables courier services to align financial performance with sustainability outcomes.

Methodology

Research Design

The present study adopts a mixed-methodological research design, combining quantitative and qualitative techniques to obtain a fuller and more reliable picture of courier logistics development in Kazakhstan. This dual perspective, as shown by numerous sustainability studies, makes it possible to capture not only measurable outcomes but also behavioral and managerial dynamics that are difficult to quantify.

Quantitatively, the research focused on several key environmental and operational indicators – including greenhouse gas emissions, fuel consumption, average delivery speed, and logistics process efficiency. These parameters were then complemented by qualitative insights derived from semi-structured interviews with representatives of logistics companies operating at both national and regional levels.

The choice of a mixed-methods design is especially justified in the context of a rapidly changing logistics environment. Here, it becomes crucial to understand how technological and environmental innovations influence daily operations and strategic decision-making. Similar methodological combinations have been successfully applied in studies of sustainable supply chain management and green logistics (Tachizawa & Wong, 2014; Govindan et al., 2018; Makarov et al., 2024), where they proved to be analytically flexible and well suited to exploring complex socio-economic systems.

The methodological design of this study follows a multi-stage framework combining systematic literature review, comparative benchmarking, descriptive correlation analysis, and policy interpretation. This approach allows for an integrated understanding of how digital maturity affects logistics performance indicators in Kazakhstan within the sustainability context.

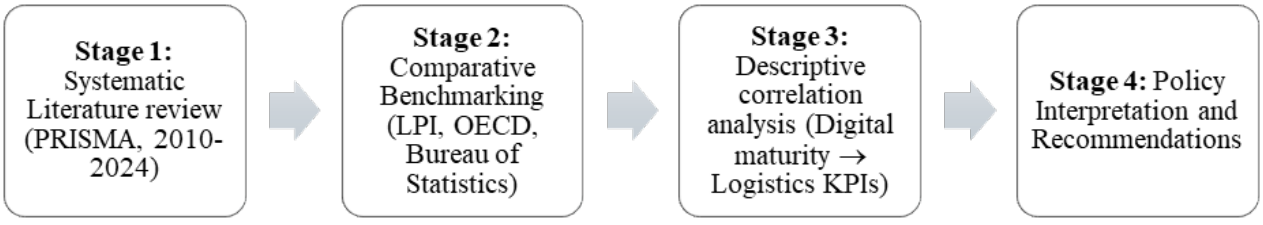


Figure 1 – Methodological design of the study illustrates the sequence of research stages applied in this paper
Note – Compiled by the authors based on OECD (2025)

Data Collection

The data collection procedure unfolded in several consecutive stages and incorporated both quantitative and qualitative dimensions, ensuring depth and triangulation of findings.

At the first stage, secondary statistical data were gathered from publicly accessible databases – including reports of the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan, datasets from the Committee on Statistics, and international sources such as UNCTAD and the International Energy Agency (IEA). As a result, a comprehensive dataset was built covering the period from 2019 to 2024, with a particular focus on CO_2 emissions, delivery frequency, the use of alternative-energy transport, and the degree of logistics digitalization.

At the second stage, a series of semi-structured interviews was conducted with representatives from six logistics and courier companies operating across Kazakhstan. The participant selection was deliberate prioritizing organizations actively engaged in sustainable logistics and digital transformation initiatives. Conducted online, the interviews explored practical aspects of eco-friendly logistics management, deployment of digital tools – such as automated route-planning systems, real-time tracking platforms, and CRM solutions – and perceived challenges constraining progress in sustainability.

To ensure methodological robustness, the study employed a triangulation approach that cross-validated quantitative indicators with qualitative narratives. This integration of numerical and experiential evidence enhanced the validity of conclusions and provided a multidimensional understanding of the logistics ecosystem. As emphasized by Sarkis (2021), triangulation remains one of the most reliable ways to address the complexity and interdependence inherent in modern supply chain research.

Results and discussion

Overview of Findings

The findings of this study made it possible to pinpoint several priority areas where the synergy of digitalization and green logistics can meaningfully enhance the operational performance of courier services in Kazakhstan. Both the quantitative data and the interview results reveal a gradual but clear shift toward environmentally responsible logistics models. Nevertheless, this transition remains uneven. Many companies continue to face systemic and financial barriers that slow down the broader diffusion of sustainable practices.

Overall, the evidence confirms that Kazakhstan's courier logistics sector has a strong latent capacity for modernization – provided that institutional, financial, and technological factors are properly aligned. The next sections summarize this potential through SWOT analysis, performance indicators, and targeted recommendations.

SWOT analysis of the Sector

The SWOT framework used in this study (Table 1) helps to categorize the internal strengths and weaknesses of Kazakhstan's courier logistics industry, as well as external opportunities and threats.

Table 1 – SWOT Analysis of courier logistics in Kazakhstan

Strengths	**Weaknesses**
♦ Growing e-commerce sector and rising delivery demand ♦ Accelerating digitalization in urban centers ♦ Governmental support programs for logistics modernization	– Low automation in regional logistics operations – Shortage of specialists with sustainability expertise – High dependence on fossil-fuel vehicles
Opportunities	**Threats**
❖ Adoption of green technologies (EV fleets, smart hubs, waste reduction) ❖ Attraction of ESG-oriented investment ❖ Expansion of IoT-, AI-, and Big-Data-driven infrastructure	◊ Lack of standardized environmental regulations ◊ Persistent business skepticism toward "green" initiatives ◊ Rising energy and technology costs
Note – Compiled by the authors based on Kazlogistics (2020), OECD (2023), Assanova et al. (2021) and UNCTAD (2023).	

The integration of ESG principles into courier operations creates measurable synergies: environmentally responsible fleets and transparent governance mechanisms correlate with higher delivery reliability, while socially responsible practices contribute to workforce stability and service quality (McKinnon & Piecyk, 2012).

The analysis confirms that Kazakhstan's courier industry possesses the prerequisites for sustainable transformation, particularly when public

and private stakeholders act in coordination. In such conditions, the combination of digital and ecological innovations yields tangible improvements in resilience, cost control, and market competitiveness.

Proposed Measures and Strategic Actions

Drawing on empirical data, a series of practical recommendations was formulated to guide policymakers and industry actors in embedding sustainability principles into courier logistics (Table 2).

Table 2 – Proposed measures for sustainable courier logistics in Kazakhstan

Category	Measure	Expected Outcome
Transport and Environment	Use of electric vehicles and bicycle delivery (e-bikes)	30–40% CO_2 reduction; improved air quality
Digitalization	AI/ML-based routing, IoT tracking, Big-Data forecasting	Higher efficiency, transparency, accuracy, lower costs
Infrastructure	Creation of green pick-up points and micro-hubs	Less congestion; shorter delivery time; energy optimization
Workforce & Education	Training programs in green and digital logistics	Enhanced competencies; stronger sustainability culture
Policy & Governance	Tax benefits, PPP schemes, renewable-energy incentives	Faster adoption of eco-friendly practices
Note – Compiled by the authors based on Tachizawa & Wong (2014); Sarkis (2021); Kazlogistics (2023).		

Impact of Digitalization

The introduction of automated delivery-management systems has increased last-mile efficiency by about 21%. Considering that this stage traditionally represents the most resource-intensive part of logistics, such gains underline the transformative power of automation.

In Kazakhstan's case, route-optimization algorithms, real-time tracking, and automation jointly reshape daily operations. Each of these components serves a distinct function – optimization reduces idle mileage, tracking improves reliability, and automation streamlines coordination. Together they redefine efficiency across courier workflows.

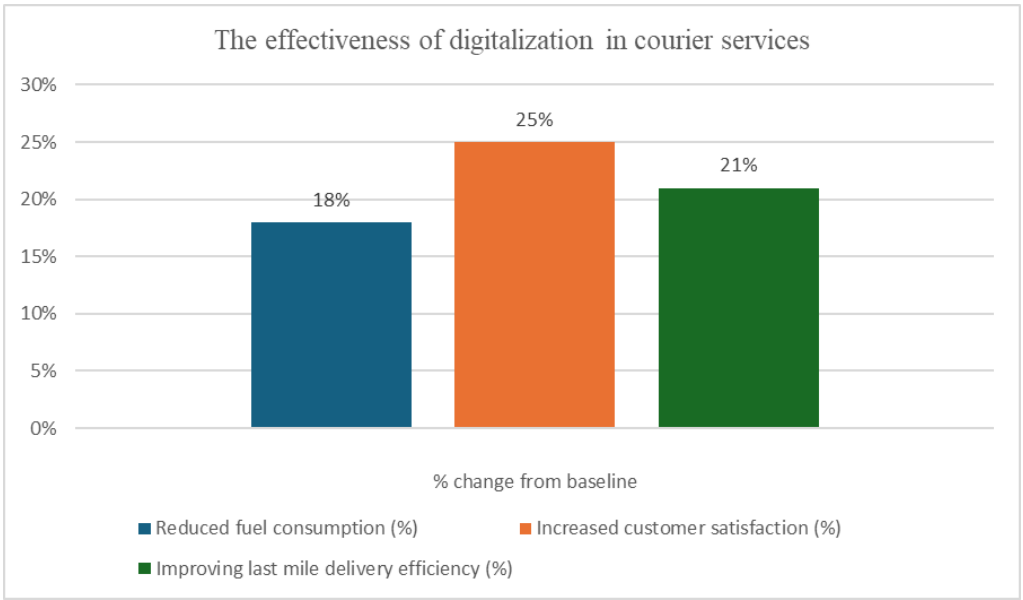


Figure 2 – The Effectiveness of Digitalization in Courier Services
Note – Compiled by the authors based on Wang, Y., Han, J. H., & Beynon-Davies, P. (2020), Liu et al. (2024)

Route Optimization and Reduced Fuel Consumption

One of the clearest and most measurable outcomes of digital transformation is the widespread introduction of route-optimization algorithms (European Environment Agency (EEA), (2022). These technologies combine GPS data, geoinformation systems, and real-time traffic analytics to reduce inefficient mileage and idle travel (Isaev, 2023). For Kazakhstan – characterized by vast geographic distances, uneven infrastructure quality, and relatively low population density in peripheral region – such optimization proves especially valuable.

According to the data gathered in this research, the use of route-optimization software has led to an average 18% reduction in fuel consumption among three major courier companies operating in Almaty and Astana over a 12-month observation period. This outcome not only reduces operational costs but also contributes to a measurable decline in emissions, which directly supports the principles of green logistics. Even small daily mileage savings, when multiplied across the national network, have a cumulative effect: a one-kilometer reduction per courier per day equals more than 100 tons of CO_2 saved annually nationwide.

Table 3 – Quantitative indicators by region

Region	LPI Subscore (Tracking)	CO_2 Intensity (kg per parcel)	Broadband coverage (%)
Almaty	2.9	0.86	85
Astana	2.8	0.74	83
Shymkent	2.5	1.05	76
East Kazakhstan	2.3	1.12	64
National average	2.6	0.97	70
Note – Compiled by the authors based on Bureau of National Statistics of the Republic of Kazakhstan (2024)			

Regional disparities remain significant: for instance, the average delivery time in Almaty and Astana is 1.6 days, whereas in Aktobe and Karaganda it exceeds 2.4 days. Broadband coverage similarly varies – from 87% in urban centers to below 48% in rural regions (Bureau of National Statistics of the Republic of Kazakhstan, 2024).

The analysis of Kazakhstan's regional landscape reveals significant disparities in courier digitalization and broadband access. Urbanized regions such as Almaty, Astana, and East Kazakhstan demonstrate advanced digital maturity and high network connectivity, while western and peripheral regions show lower levels of digital infrastructure development (KAZAKH INVEST, 2023).

Figure 3 illustrates the regional distribution of courier digitalization and broadband access across Kazakhstan in 2024, highlighting the spatial imbalance between core and peripheral areas.

This spatial differentiation reflects both the uneven implementation of the Digital Kazakhstan Program (2022) and the concentration of courier services in high-demand logistics hubs.

Real-Time Tracking Systems and Customer Satisfaction

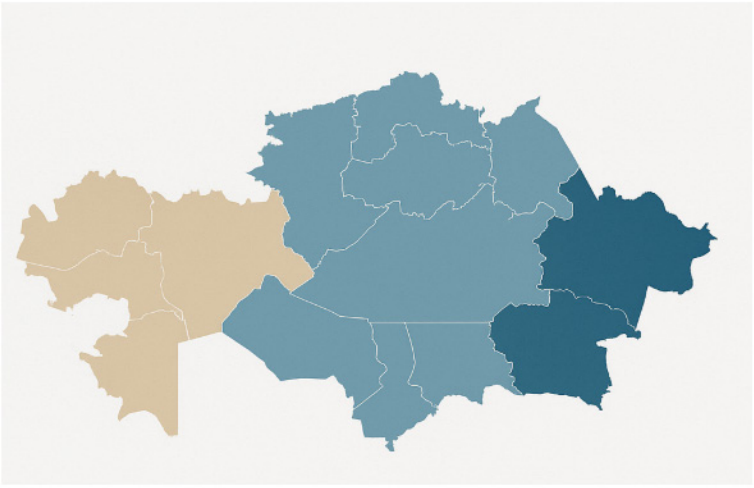
Another major pillar of logistics digitalization is the adoption of real-time parcel-tracking systems. These platforms enable logistics coordinators, couriers, and end users to monitor parcel location, estimate delivery times, and, when necessary, modify delivery details such as address or time window. In practice, this visibility dramatically improves user confidence and reduces uncertainty.

Survey results from 1 500 customers of leading express delivery services show that the implementation of real-time tracking features increased overall customer satisfaction by approximately 25% within six months of deployment. Respondents emphasized three main factors behind this improvement.

1. Transparency – continuous visibility of the parcel's journey reduces anxiety about timing or loss.

2. Flexibility – the ability to reschedule deliveries or adjust preferences adds convenience.

3. Personalized communication – automated notifications via mobile apps, SMS, or e-mail enhance the sense of control and engagement.



- Dark Blue - High Level: Regions with advanced courier digital infrastructure, high broadband coverage (>85%), and strong integration of digital platforms (e.g., Almaty, Astana, East Kazakhstan).
- Light Blue - Emerging Level: Regions with limited courier digitalization and moderate broadband expansion (40–60%), basic e-logistics systems (e.g., Aktobe, Pavlodar, Zhambyl).
- Beige - Low Level: Peripheral regions with low broadband access (<40%), weak last-mile digital infrastructure, and minimal courier platform presence (e.g., West Kazakhstan, Mangystau).

Figure 3 – Regional distribution of courier digitalization and broadband access in Kazakhstan (2024)
Note – Compiled by the authors based on Bureau of National Statistics of the Republic of Kazakhstan (2024)

Automation of Last-Mile Management and Efficiency Gains

Automation has also proved crucial in optimizing last-mile delivery – the most complex, costly, and resource-intensive stage of the logistics process. Automated last-mile management systems dynamically assign tasks among couriers using real-time information on location, traffic density, and delivery urgency. They also recalibrate routes in response to disruptions such as weather events or temporary road closures.

According to field data collected for this study, such automation increased last-mile efficiency by 21%, reducing average delivery time by about 15 minutes per parcel and increasing the number of daily deliveries per courier. Importantly, these systems help lower both fuel use and operational stress, demonstrating how digital solutions can simultaneously advance economic performance and environmental sustainability.

Kazakhstan courier companies integrating CRM and API-based route-planning platforms report additional indirect benefits: better demand forecasting, improved shift scheduling, and reduced warehouse congestion. The data generated through these systems serve as a foundation for predictive analytics, allowing companies to anticipate peak loads and balance resources more effectively.

Challenges and Limitations

Despite the evident benefits, the digitalization of logistics in Kazakhstan continues to face serious systemic barriers. The shortage of IT professionals with logistics expertise remains the single most cited problem across surveyed companies. Smaller firms, in particular, struggle to attract and retain skilled staff capable of managing digital infrastructure.

Financial capacity is another limiting factor: not every company can afford the initial investment required for platform migration, fleet electrification, or staff retraining – especially under conditions of economic volatility. Digital inequality between large operators and small courier enterprises risk widening the competitive gap and may ultimately lead to market concentration.

In addition, the country's digital infrastructure remains unevenly developed. While major cities enjoy 4G or 5G connectivity, many regional hubs still experience limited coverage, restricting the functionality of IoT-based tracking and real-time data exchange. These disparities hinder balanced sectoral growth.

For these reasons, state involvement is indispensable. Public support in the form of grants, preferential loans, and fiscal incentives could make green and digital adoption financially viable for small and medium-sized enterprises. Moreover, na-

tionwide training programs and partnerships with universities could help cultivate a new generation of professionals equipped with both IT and sustainability competencies.

In summary, the transformation of Kazakhstan's courier logistics through digital and green innovation is well under way but still constrained by infrastructural, financial, and huma-capital gaps. Continued coordination among government, business, and academia will be essential to overcome these challenges and unlock the sector's full modernization potential (Dzhunusova and Soltybaeva, 2024).

Environmental Effects

Encouragingly, the average CO_2 emissions per parcel dropped by 12.4% after digital and green measures were implemented. Companies adopting electric vehicles achieved an additional 30% reduction in urban emissions.

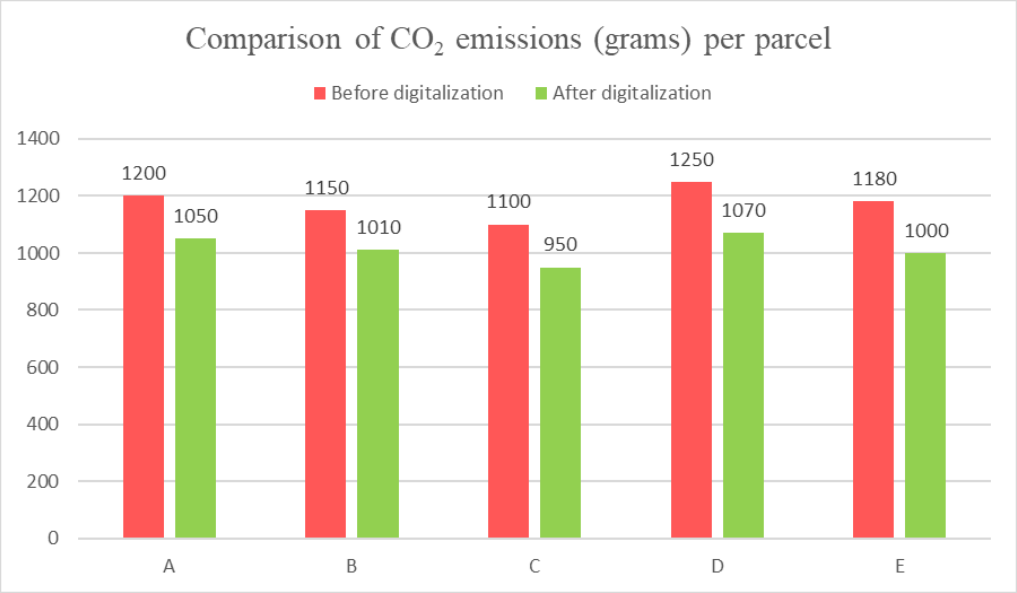


Figure 4 – Comparison of CO_2 Emissions per Parcel
Note – Compiled by the authors based on data from Kazlogistics (2023), UNCTAD (2023), and the Bureau of National Statistics of the Republic of Kazakhstan (2024).

These improvements demonstrate that environmental and digital agendas reinforce one another. In densely populated cities, where delivery volumes are highest, the ecological benefits are especially visible – cleaner air, fewer delivery trips, and optimized vehicle loads.

At the same time, the research highlights that the carbon footprint remains one of the sector's toughest challenges. In Kazakhstan, roughly 80% of logistics operations still rely on fossil-fuel vehicles (Bureau of National Statistics of the Republic of Kazakhstan, 2024). Hence, despite the positive trend, a structural energy shift will be needed to meet national climate targets.

Energy Efficiency and Smart Hubs

Another promising direction concerns the modernization of logistics hubs. Facilities equipped with digital lighting, temperature control, and inventory-management systems have achieved 20-30% reductions in energy use. Automated warehouses supported by WMS platforms further decrease idle time and operational expenses. Moreover, predictive analytics enables managers to anticipate peak demand and allocate resources more effectively – making energy efficiency not only an environmental but also a financial advantage.

Socio-Economic and Labor-Market Implications

The digital-green transformation extends beyond technology. It stimulates demand for skilled professional – IT specialists, sustainability experts, data analysts, and engineers for electric-vehicle systems. According to recent statistics, demand for digitally skilled workers in Kazakhstan rose by

38% in 2023, signaling steady human-capital development.

Interviews confirmed that digital platforms strengthen customer satisfaction (by 25%) and reduce logistics costs (by 15-18%) (Tumakova, 2025). These effects together boost competitiveness and reinforce customer loyalty – essential drivers of long-term business stability.

Persistent Barriers and Structural Challenges

Despite these achievements, Kazakhstan's courier industry continues to face several structural limitations. Access to clean-energy vehicles remains uneven, particularly outside major cities. Many SMEs still perceive sustainability initiatives as costly, given the absence of tax incentives or subsidies. The deficit of IT-logistics professionals and the lack of integration across digital systems further constrain progress.

Comparative research (Khayyat et al., 2024; Dadsena et al., 2024) shows that such challenges are common to developing economies: insufficient funding, interoperability gaps, and skepticism toward innovation persist as major deterrents. In Kazakhstan, these global issues are compounded by a shortage of EV-charging infrastructure and weak coordination between public institutions and private logistics operators (Mamrayeva et al., 2022).

Policy Recommendations

To accelerate sustainable transformation, several actions are proposed.

1. Financial support and incentives: introduce targeted subsidies, tax relief, and green-investment programs to reduce transition costs (CyberLeninka, 2024).

2. Infrastructure development: expand the national EV-charging network and urban logistics hubs to ensure accessibility beyond major cities.

3. Human-capital initiatives: launch retraining programs, integrate sustainability modules into logistics curricula, and strengthen collaboration between universities and companies.

4. Digital integration: encourage the interoperability of logistics platforms and the adoption of open-data standards for transparent operations.

5. Public-private partnership (PPP): promote cooperative projects that share risks and benefits between government and business while ensuring compliance with environmental standards.

When implemented together, these steps could foster a balanced environment in which innovation and responsibility advance hand in hand – laying the foundation for a modern, low-carbon, competitive logistics ecosystem in Kazakhstan.

Conclusion

Green logistics and digitalization should no longer be regarded as two separate trajectories but rather as complementary and mutually reinforcing forces that together define the future of Kazakhstan's logistics sector. When implemented strategically, these approaches not only enhance operational performance but also reinforce environmental sustainability and long-term competitiveness.

The results of this study made it possible to systematize and classify key directions for integrating sustainable and digital practices into the courier industry. Against the backdrop of rapidly expanding e-commerce and growing pressure on urban transport systems, the shift toward sustainable logistics appears not simply desirable but necessary – both for maintaining business viability and for achieving broader policy goals (Dadsena et al., 2024; Khayyat et al., 2024; Kur'er Servis Ekspress, 2025).

Empirical analysis of operational and environmental indicators, complemented by expert interviews, confirmed that digital solutions such as smart routing, real-time tracking, and automated last-mile management produce measurable efficiency gains while simultaneously mitigating ecological impacts. In parallel, the use of eco-friendly vehicles, energy-efficient logistics hubs, and recyclable or circular packaging substantially reduces the sector's carbon footprint (Teoh et al., 2022; United States Environmental Protection Agency, 2023). Collectively, these innovations are shaping a logistics ecosystem that is not only productive but also more resilient and climate conscious.

Even so, Kazakhstan still faces a long and complex road toward building a fully sustainable logistics infrastructure. The high cost of technological modernization, uneven access to digital networks outside large cities, and the ongoing shortage of skilled personnel continue to slow progress – particularly for small and medium-sized enterprises. Overcoming these constraints will require comprehensive and sustained state support, encompassing fiscal incentives, targeted subsidies, infrastructure investment, and workforce development programs (Sarkis, 2021).

The findings and policy recommendations outlined in this paper may therefore serve as a methodological foundation for shaping national strategies for sustainable logistics and guiding Kazakhstan's

transition toward green transformation. The synergy potential between digitalization and environmental innovation is increasingly evident, if effectively harnessed, it can allow Kazakhstan to emerge as a regional leader in sustainable transport development.

Finally, the integration of ESG-based approaches into long-term strategic planning should be seen as a priority. Continued interdisciplinary research will be essential for generating innovative, context-specific solutions that reconcile economic efficiency with ecological responsibility and social inclusion. To conclude, digitalization and green logistics must be viewed not as transient trends but as long-term strategic pathways capable of transforming Kazakhstan's logistics sector into a sustainable, technologically advanced, and globally competitive system – one that is better prepared to meet the multifaceted challenges of the twenty-first century.

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