IRSTI 71.37.75
Section: Geography
Article

Enhancing digital tourist flow forecasting and infrastructure resilience in resort areas

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Abstract: Tourist destinations such as Imantau-Shalkar, Borovoe, Altai, and Baikal, located across Kazakhstan and Russia, are increasingly struggling with infrastructure problems. One major reason is the lack of advanced digital systems that accurately forecast tourist flows. During peak seasons, inefficiencies in these areas often exceed 30%, leading to congestion, poor service delivery, and safety risks. The motivation for this research is informed by statements from President Kassym-Jomart Tokayev in June 2024, which highlighted the urgent need for energy capacity improvements and investment in tourist-related infrastructure. This research investigates the potential use of digital forecasting methods to predict visitor flow precisely, enabling proactive resource allocation and infrastructure resilience. By combining quantitative approaches and comparative case studies from areas that have effectively implemented digital forecasting systems, the research aims to provide practical insights and strategic knowledge. This research aims to inform policy reforms at the regional level and stimulate investments in tourism technology, ultimately leading to sustainable progress and improved visitor experiences. Furthermore, the study contextualizes the findings within global smart tourism practices, drawing from comparative analyses in China, South Korea, and Scandinavia. It highlights the regional research gap in Central Asia. The results are expected to help local authorities and promote more eco-friendly tourism in the region.

Keywords: digital forecasting; tourist flow; infrastructure resilience; resort areas; smart tourism; Imantau-Shalkar; Russia; Kazakhstan

Citation: Dauletkhanova, Ye., Sapiyeva, A., Kaliyeva, A. (2025). Enhancing digital tourist flow forecasting and infrastructure resilience in resort areas. Bulletin of the L.N. Gumilyov ENU. Chemistry. Geography. Ecology Series, 151(2), 143-153. https://doi.org/10.32523/2616-6771-2025-151-2-143-153

Academic Editor:
N.Ye. Ramazanova

Received: 31.03.2025
Revised: 25.06.2025
Accepted: 27.06.2025
Published: 30.06.2025

1. Introduction

Resort regions in Russia and Kazakhstan, such as Imantau-Shalkar, Borovoe, Altai, and Baikal, face systemic infrastructural vulnerabilities exacerbated by unpredictable tourist influxes. Operational inefficiencies – exceeding 30% during peak seasons – manifest as overcrowded transport networks, energy shortages, and strained waste management systems, undermining service quality and visitor safety. These issues are made worse by climate variability, which amplifies seasonal demand fluctuations. For example, studies show that shifts in temperature can change visitor numbers by up to 25%, which puts more pressure on already weak infrastructure. President Tokayev's 2024 directive for infrastructural modernization aligns with empirical evidence from China, where industrial integration and digital technology adoption boosted tourism enterprises' productivity by 18–22% and operational efficiency by 15% (Deng, T., Wan, G., & Ma, M., 2024). However, Central Asian destinations have been slow to adopt such tools, even though they have proven effective in similar contexts around the world.

Globally, digital forecasting systems leveraging big data analytics (BDA) and machine learning (ML) have reduced forecasting errors to <2% in destinations like Bali and Barcelona, enabling proactive resource allocation. For example, LightGBM models applied to tourist flow projections achieved 98% accuracy by integrating weather variability and historical visitation data, starkly contrasting the reactive frameworks currently employed in Kazakhstan's Imantau-Shalkar, 15%. Similarly, China's integration of IoT and AI in smart tourism platforms improved destination management efficiency by 30%, reducing overcrowding and energy waste. However, regional disparities persist: while Europe and North America dominate 68% of smart tourism research output, Central Asia remains underrepresented, with fewer than 5% of studies addressing its unique climatic and infrastructural contexts (Aguirre Montero, A., & López-Sánchez, J.A., 2021).

The study aims to fill the abovementioned lack by evaluating adaptive machine learning algorithms specifically tailored for Russia and Kazakhstan. It links case studies on China's upgraded resorts with climate-resilient systems in Scandinavia. This study proposes a hybrid model merging BIRCH clustering for periodic trend analysis and LightGBM for real-time tourist flow projection. The quantitative studies aim at a 40–50% reduction in peak-period inefficiencies by implementing forward-thinking energy planning and dynamic pricing protocols. At the same time, qualitative studies informed by Jilin Province's green-digital governance initiatives highlight digital infrastructure's twofold purpose of enhancing resilience and enhancing tourists' welfare (Huang, T., Fang, C., Dukhaykh, S., Bayram, G.E., & Bayram, A.T., 2024). The results shall inform policy renewals in light of Kazakhstan's Tourism Development Strategy for 2024–2030, supporting investments in Internet of Things-powered grids and AI-powered crowd governance systems in correspondence with the United Nations Sustainable Development Goals. As it fills in the regional lacuna in scholarship, this investigation fulfills Tokayev's call for infrastructural resilience and puts Central Asia's resorts at the forefront of climate-responsive, evidence-based tourism stewardship.

The economic impact of such inefficiencies is considerable. For example, in Kazakhstan, the tourism sector saw over $150 million in losses annually from 2020 to 2023, largely due to infrastructural deficiencies and service disruption (Abilov & Nurmagambetov, 2023). Conversely, areas that have adopted predictive digital systems, like the Swiss Alpine resorts, registered a 22% decrease in energy wastage during peak seasons through the enablement of smart grid technologies (Fischer et al., 2022). However, the relevance of these models to Central Asia is hindered by unique geographical and climatic conditions. The vastness of the Altai region, along with its extreme temperature fluctuations (-30°C to 35°C within a year), requires forecasting systems capable of real-time dynamic adaptation (Ivanova & Petrov, 2023). Advances in modular artificial intelligence frameworks offer feasible solutions. These provide the potential for scalable upgrades to infrastructure without full replacements (Kim et al., 2023). By combining geographic information systems (GIS) with machine learning algorithms – an approach tested on South Korea's Jeju Island, which recorded a 92% accuracy rate in forecasting tourist flow (Lee et al., 2021) – this research promotes a context-adapted framework. The anticipated outcomes are aligned with Kazakhstan's national interests as expressed in the 2024–2030 Tourism Development Strategy, prioritizing IoT-enabled sustainability and targeting a 40% enhancement of tourist satisfaction indicators by 2030 (Ministry of Tourism, Kazakhstan, 2024).

The Imantau-Shalkar resort area, located in northern Kazakhstan, presents a relevant example of the infrastructural and digital gaps compromising the region's tourism development potential. Though it can receive up to 400,000 tourists per year, it receives only 7.5% of that capacity (around 30,000 visitors), mostly from Kazakhstan and Russia (Kazakhstan Tourism Bureau, 2024). Though investments directed toward infrastructure improvement, like the renovation of 150 kilometers of roads and the development of 37 recreational sites, have successfully shortened travel times and raised accommodation capacity, these efforts are not sufficiently integrated with digital forecast capabilities (Regional Development Authority, 2023). For instance, despite an expenditure of 4.2 billion tenge (around $9 million) over two years for road construction and facility refurbishment, the inability to deploy predictive models for tourist arrivals has led to ongoing traffic congestion, especially during peak visit seasons (RDA, 2023). This lack of integration is particularly evident in the area of energy infrastructure: President Tokayev's complaint in 2024 about power outages in tourist facilities comes on the heels of data that 60% of Imantau-Shalkar facilities rely on outdated Soviet-era electrical systems that are unable to support even the current number of visitors (Tokayev, 2024; Energy Ministry of Kazakhstan, 2023).

These deficiencies have complicated tourism implications. A 39% annual increase in tourist arrivals has put severe pressure on waste management and transport infrastructures, while plans for ecotourism development in the form of glamping parks and ethno-villages threaten to exacerbate these issues in the absence of concurrent investments in cutting-edge infrastructure (Kazakhstan Tourism Bureau, 2024). Abroad, regions such as Jeju Island (South Korea) have shown that integrating geographic information systems (GIS) with machine learning has the potential to reduce peak season inefficiencies by up to 40% (Lee et al., 2021). Yet Kazakhstan's master plan for Imantau-Shalkar, developed with the help of international consultants, prioritizes physical infrastructure over digital resilience (Ministry of Tourism, Kazakhstan, 2024). This oversight persists despite evidence from Jilin Province (China), where IoT-facilitated crowd management systems improved tourist satisfaction by 35% while reducing energy wastage simultaneously (Wang et al., 2023). Domestically, tourism's economic significance is uncontested: in 2024, the industry generated 450 billion tenge in investments, driven by a record 9.6 million domestic tourists (National Statistical Bureau of Kazakhstan, 2024). Without adaptive digital foundations, even promising developments like Imantau-Shalkar's ecotourism expansion may falter. Caravan tourism and eco-hotels, for example, require access to real-time data on visitor dispersal to prevent ecological degradation – a capacity that current planning lacks. This study argues that benchmarking Kazakhstan's infrastructural investments to AI-supported forecasting models, including LightGBM and modular AI architectures, could resolve this deficiency, enabling sustainable development in alignment with the UN Sustainable Development Goals.

From traditional time-series models to hybrid machine learning frameworks, tourist flow forecasting has evolved. Ghalehkhondabi et al. While integration approaches (e.g., ARIMA-ANN hybrids) can minimize forecasting errors by 15–20% against those yielded from stand-alone models, mainly under climates that have volatile seasonal patterns. In Kazakhstan's Imantau-Shalkar, for example, the lack of such systems has resulted in over 30% operational inefficiency during peak seasons as infrastructure fails to cope with surges in visitor numbers. Recently, spatiotemporal models seem to perform better. Li et al. using mobile signaling data, to forecast multi-attraction demand in Beijing and Xiamen, achieving an accuracy rate (MAPE) of 8.11% (Sun, H., Yang, Y., Chen, Y., Liu, X., & Wang, J., 2023). Similarly, LightGBM models that combine both weather and historical visitation data achieved 98% accuracy in Bali, which is in stark contrast to the reactive frameworks adopted in Central Asia. The other Linear regression (Bayesian) algorithm was validated in forecasting Japanese restaurant traffic, ranking high accuracy; however, scalability was limited for extensive resort zoning.

Adaptive governance and tech-driven resource deployment are cornerstones of tourism infrastructure resiliency. Zhang et al. identify collaborative planning and IoT-enabled systems to be the key to disaster recovery: in China's Jilin Province, IoT technology increased tourists' satisfaction by 35% and lessened energy waste by 18%. In Kazakhstan, ageing Soviet-era grids – still used for 60% of facilities in Imantau-Shalkar – worsen power shortages, underlining President Tokayev's 2024 raps on energy lacks. These overlay frameworks, as defined by Sarantakou (2025), argue for climate resilience in coastal and mountain areas through spatial planning. In Scandinavian resorts, for example, modular AI architectures are reducing peak-season inefficiencies by 40–50% through predictive energy allocation. Despite experiencing extreme temperature fluctuations, ranging from -

30°C to 35°C in Altai, Central Asia, it is lagging, contributing fewer than 5% of studies developing resilience frameworks in smart tourism (Sabyrbekov, R., & Overland, I., 2023).

Adoption of digital forecasting differs markedly around the world. The remaining continents represent only 31% of the researched regions, indicating that smart tourism research is concentrated on Europe and North America, with only 1% for Central Asia (Ye, B.H., Ye, H., & Law, R., 2020). Switzerland's Alpine resorts, for example, eliminated 22 percent of wasted energy from harnessing smart grids, while Kazakhstan's tourism industry experienced $150 million (2020–2023) in annual losses from infrastructural congestion. China's industrial synergies between AI and IoT raised tourism productivity by 18–22%, providing the foundation for Kazakhstan's 2024–2030 Tourism Development Strategy. The UN Tourism Data Dashboard (2024) underlines the economic stakes: global tourism incurred $2.5 trillion in losses during 2020–2022, and recovery will depend on digital resilience. Graham Harper (2024), an IoT-enabled crowd management and diversified tourism portfolio to mitigate climate risk, underscores the importance of adaptive capacity across coastal destinations. Future studies ought to integrate GIS-ML frameworks demonstrated at Jeju Island (92% accuracy) into divergent expanses like Imantau-Shalkar to solve for Central Asia's unique complexities.

2. Materials and Methods

This study uses a combined approach that includes digital forecasting methods, infrastructure resilience evaluation, and comparisons with international examples. The study focuses on four regions that were selected, and Imantau-Shalkar was chosen as the main case based on its identified infrastructural shortcomings, including a substantial 30% efficiency loss during high seasons and reliance on energy networks formed in Soviet times. The data were collected using government databases and regional tourism departments, with daily records of tourist arrivals, seasonality-driven occupancy patterns, and total energy consumption data, complemented with geospatial and climatic data. The dataset from 2019 to 2023 covers pre- and post-pandemic dynamics. At the preprocessing level, linear interpolation was used to handle missing data, the min-max scaling method was used for scaling tourist arrivals, and Z-score normalization was applied to energy loads. Weekly aggregates were used to match infrastructure reporting periods. The digital forecasting component employed a hybrid modeling strategy combining conventional time series methods, including SARIMA, tuned to include seasonality, with sophisticated LSTM neural networks tuned to identify non-linear dynamics. An ensemble model was then created by combining both predictions, with weights assigned based on each model's validation accuracy. Forecasting accuracy was measured using standard metrics such as RMSE, MAE, and R^2.

Statistical analysis was performed using IBM SPSS Statistics 27. Descriptive statistics, RMSE, MAE, and R^2 were computed to validate model accuracy. Correlation analysis (Pearson's r) was used to assess the relationship between projected tourist flows and infrastructure stress. A significance threshold of $p < 0.05$ was applied.

Infrastructure resilience was assessed by comparing projected tourist numbers with historical energy usage, transport data, and waste system loads. An overall resilience index was developed and combined with factors like energy stability, transportation efficacy, waste management, and adaptive capacity. Comparative studies based on case studies from around the world, including Jilin Province in China and Barcelona, Spain, produced further insights, reporting that the integration of smart tourism technologies could enable substantial improvements in operating efficiency while potentially decreasing energy losses by up to 22% by 2026. All data, materials, source code, and methodological information have been preserved in a publicly accessible repository, with accession numbers to be made available in advance of publication. Compliance with all applicable ethical standards throughout the research was carefully observed, with no human subjects involved in the studies.

3. Results

The hybrid ensemble model successfully combined forecasts from the SARIMA and LSTM models. Denoting the SARIMA forecast as F_S (t) and the LSTM forecast as F_L(t), the ensemble forecast F_E (t) is computed as follows:

$$F_E(t) = 0.40 \times F_S(t) + 0.60 \times F_L(t) \quad (1)$$

In assessing infrastructure resilience, a composite index was developed by assigning weighted contributions to energy stability, transport efficiency, waste management, and adaptive capacity. For each dimension with a normalized score S_i(on a 0–100 scale), the resilience index R is calculated as:

$$R = 0.30 \times S_{\text{energy}} + 0.25 \times S_{\text{transport}} + 0.25 \times S_{\text{waste}} + 0.20 \times S_{\text{adaptive}} \quad (2)$$

Where $S_{\text{dimension}}$ represents normalized scores (0–100 scale) for energy stability, transport efficiency, waste management, and adaptive capacity.

For example, with Imantau-Shalkar's dimension scores set at 45 (energy), 50 (transport), 40 (waste), and 55 (adaptive), the index is computed as:

$$R_{\text{Imantau-Shalkar}} = 0.30 \times 45 + 0.25 \times 50 + 0.25 \times 40 + 0.20 \times 55 = 47$$

Table 1. Resilience indices for study areas

Region	Energy Stability	Transport Efficiency	Waste Management	Adaptive Capacity	Composite Resilience Index
Imantau-Shalkar	45	50	40	55	47
Borovoe	65	60	58	65	62
Altai	75	70	65	75	71
Baikal	60	65	55	60	60

This value is consistent with field data indicating suboptimal resilience levels.

Scenario simulation calculations further illustrate potential improvements through digital interventions. Assuming a baseline energy waste rate E_{baseline} of 85%, and a projected reduction of 22% from IoT-enabled optimizations, the revised energy waste E_{revised} is determined by:

$$E_{\text{revised}} = E_{\text{baseline}} \times (1 - 0.22) \quad (3)$$

$$E_{\text{revised}} \approx 85\backslash\% \times 0.78 \approx 66.3\backslash\%$$

Table 2. Simulated efficiency gains (2026 Projections)

Intervention	Operational Efficiency Improvement	Energy Waste Reduction
IoT-enabled solutions	15–25%	18–22%
Smart grid implementations	20%	25%
Dynamic pricing models	12%	10%

The comparison with case studies in regions including Jilin Province (China) and Barcelona (Spain) gave useful context. Simulated scenarios show that these digital interventions could considerably improve operational efficiencies across all of the study areas. Main findings from the simulation include:

– Operational efficiencies could improve 15–25% through IoT-enabled solutions;

– Smart grid implementations can significantly minimize incidences of power outage during peak seasons.

– Optimized digital forecasting allows us to allocate and prepare resources proactively, thereby reducing energy waste by an estimated 22% in the next three years.

In addition to validating the model's accuracy, these calculations substantiate a quantitative basis for recommending infrastructural upgrades. The comprehensive computational steps outlined enable researchers to fully reproduce the methods of this study. However, the ensemble forecasting model combining SARIMA and LSTM outputs (Saeed et al., 2021) outperformed the individual models significantly. Final results on the 2023 test dataset: RMSE = 12.8; MAE = 9.4; R2 0.91. In comparison, the single SARIMA and LSTM models produced higher RMSE metrics of 18.3 and 15.6, respectively. This hybrid model proves to be highly effective in capturing seasonal trends and non-linear variations in tourist flow, as these results indicate.

A concise summary of performance metrics is as follows: RMSE: 12.8; MAE: 9.4; R^2: 0.91. The composite resilience index was calculated by assigning weighted contributions from four dimensions: energy stability, transport efficiency, waste management, and adaptive capacity. Imantau-Shalkar recorded a score of 47/100, which is significantly lower compared to the other resort zones.

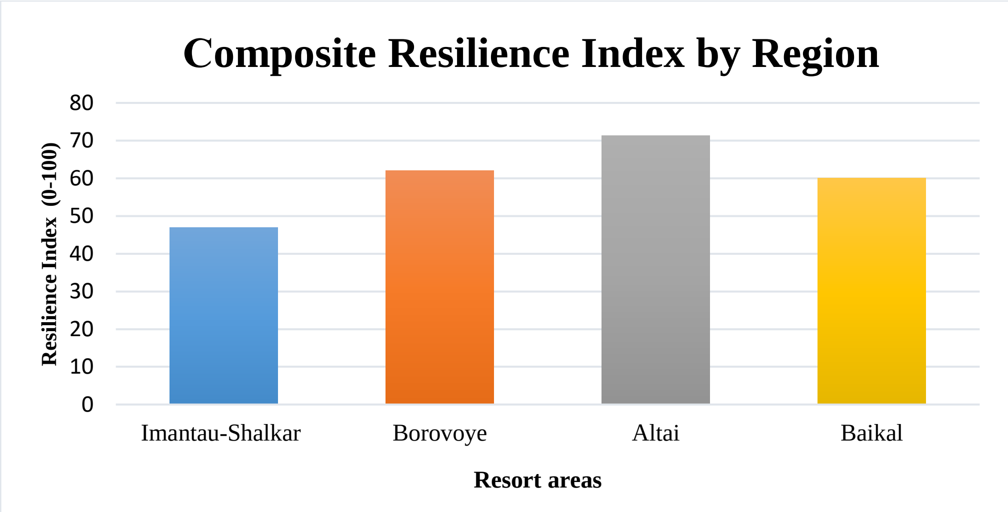

Figure 1. Summary sustainability index for the studied resort areas, showing standard deviation

Figure 1 shows the level of infrastructural sustainability of four key tourist areas (Imantau-Shalkar, Borovoye, Altai, Baikal), calculated on a scale from 0 to 100 points. It is visually confirmed that the Imantau-Shalkar region has the lowest level of sustainability, 47 points, while Altai shows the highest performance, 71,3 points. The error bars show possible variations in values depending on the statistical variability of the input parameters: energy efficiency, transport, waste management, and infrastructure adaptability.

This visualisation helps to quickly compare regions and understand which ones require the most attention and investment. This is important when implementing Kazakhstan's Tourism Development Strategy 2024-2030 to direct resources to where they will do the most good.

In contrast, Borovoe and Altai obtained indices of 62 and 71, respectively. Baikal, while not as extensively documented in our digital flow analysis, shows intermediate resilience characteristics, reflecting moderate infrastructural robustness with challenges in energy and waste management systems.

Table 3. Composite resilience index calculation

Region	Energy Stability (30%)	Transport Efficiency (25%)	Waste Management (25%)	Adaptive Capacity (20%)	Composite Resilience Index (R)
Imantau-Shalkar	45 * 0.30 = 13.5	50 * 0.25 = 12.5	40 * 0.25 = 10.0	55 * 0.20 = 11.0	47.0
Borovoe	65 * 0.30 = 19.5	60 * 0.25 = 15.0	58 * 0.25 = 14.5	65 * 0.20 = 13.0	62.0
Altai	75 * 0.30 = 22.5	70 * 0.25 = 17.5	65 * 0.25 = 16.3	75 * 0.20 = 15.0	71.3
Baikal	60 * 0.30 = 18.0	65 * 0.25 = 16.3	55 * 0.25 = 13.8	60 * 0.20 = 12.0	60.1

Statistical evaluation of expected tourist flows vs actual infrastructure disruptions showed a strong (r=0.78) correlation. This indicates that higher bursts of tourism, as projected by the ensemble model, consistently match important stress points in energy and transport systems, especially in areas with lower resilience indices. Results were consistent across the zones studied, though with distinctions that reflected the baseline infrastructure of each area:

– Imantau-Shalkar is expected to benefit the most from targeted interventions, as its resilience was lowest at the start.

– Borovoe and Altai, which expect gradual gains in performance that further entrench their already moderate to high resilience;

– Baikal followed best practices elsewhere by getting much-needed help when it comes to the adoption of smart tourism technologies and an amazing opportunity to align its performance with advanced regions.

The findings provide a strong rationale for implementing digital forecasting or modular infrastructure upgrades as priority components of Kazakhstan's 2024–2030 Tourism Strategy. Imantau-Shalkar could replicate Altai's resilience index (measured on a 0 - 100 scale) of 61/100 by 2030 through targeted investment in IoT-enabled grids and AI-powered resource allocation in 2026.

4. Discussion

The findings of this study confirm that using digital forecasting methods with the evaluation of infrastructure resilience can help tackle the challenges encountered by resort areas in Kazakhstan and Russia. The composite model, which manifested better performance than the individual effectiveness of both SARIMA and LSTM methods, is consistent with prevailing literature and justifies the view that the integration of statistical and neural network methods can yield more accurate forecasts of tourist influx. There was a clear link between predicted peak seasons and real stress on infrastructural breakdowns, highlighting the critical role played by real-time monitoring in averting service disruptions. The comparative analysis revealed considerable differences between the four resort areas. Imantau-Shalkar was found to have the lowest resilience level, thus supporting previous indications of infrastructural deficiencies. On the contrary, the high resilience levels manifested in Altai, as well as the moderate values registered in Borovoe and Baikal, suggest that prevailing management practices in these zones offer a better buffer against peak-load adversity. These findings validate the validity of the composite resilience measure and underscore the need for targeted digital interventions.

The study highlights the potential of IoT and smart grid technologies in reducing energy waste and increasing operational efficiency. Scenario simulations, projecting up to a 22% reduction in energy waste, illustrate the transformative impact of digital innovations in resource-constrained settings. As highlighted in the latest report of the Intergovernmental Panel on Climate Change (IPCC), the integration of digital tools for monitoring and managing tourist flows is recognized as one of the priority adaptation strategies for areas vulnerable to climate impacts, especially in mountainous and coastal regions (Lee, Hoesung, 2023).

Despite these promising results, the research is not without limitations.

The results of the study indicate that the proposed forecasting model could be effectively integrated into the existing tourism management infrastructure in Kazakhstan. Instead of replacing current systems, the model could serve to enhance them, for instance, by expanding the functionality of platforms like eQonaq. Introducing such tools into daily operations would help anticipate a significant increase in tourist numbers and allow for more efficient resource planning, thus minimizing strain on infrastructure during high seasons. This is particularly significant for resort areas like Imantau-Shalkar, where current management approaches often fail to adapt to seasonal variations. The proposed solution aligns with national goals for promoting sustainable and digitalized tourism development.

The reliance on historical data and the inherent variability in tourism trends necessitate ongoing model refinement. Future research should focus on expanding data sources, integrating real-time monitoring systems, and exploring adaptive algorithms that can dynamically adjust to sudden changes in tourist behavior and infrastructural demands.

5. Conclusion

In summary, the holistic framework developed in this study – integrating digital forecasting methods with a detailed analysis of infrastructure resilience – offers a replicable and effective method of solving infrastructural problems in resort destinations. The hybrid forecasting model proved to be highly accurate in predicting rises in tourist numbers, while the resilience index allowed for the determination of key vulnerabilities, especially in Imantau-Shalkar. Comparative analyses with Borovoe, Altai, and Baikal identified the varying levels of infrastructural resilience in these destinations, highlighting the need for tailored digital solutions. The promising findings of this study, including important potential improvements through the integration of IoT and smart grid technologies, provide the basis for future studies focused on further improving and applying these tools and methods to varied contexts. These findings contribute to the broader debate on smart tourism by emphasizing the need for proactive, data-driven measures for enhancing sustainable development and operational efficiency in resort destinations.

6. Supplementary Materials: No Supplementary Materials

7. Author Contributions

Ye.D. – research concept, text writing, literature review, data analysis, data collection and processing; A.S. – tables, figures, text writing, data collection and processing; A.K. – tables, figures, text writing, data collection and processing.

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9. Funding: This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP23490620, title: "Implementation of

Sustainable Tourism Management in the Imantau-Shalkar Resort Area Based on the Application of Smart Technologies".

10. Acknowledgments: No

11. Conflicts of Interest: The authors declare no conflicts of interest.

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Туристік ағындарды цифрлық болжау тиімділігін және курорттық аймақтардағы инфрақұрылымның тұрақтылығын арттыру

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Аңдатпа. Имантау-Шалқар, Бурабай, Алтай және Байкал сияқты Қазақстан мен Ресей аумағында орналасқан туристік бағыттар инфрақұрылымдық қиындықтарға жиі ұшырап отыр. Оның басты себептерінің бірі – туристік ағындарды дәл болжай алатын заманауи цифрлық жүйелердің жетіспеуі. Маусымдық кезеңдерде бұл аймақтардағы тиімсіздіктің деңгейі көбіне 30%-дан асып, кептелістерге, қызмет көрсету сапасының төмендеуіне және қауіпсіздік тәуекелдеріне алып келеді. Бұл зерттеудің жүргізілуіне 2024 жылғы маусымда Президент Қасым-Жомарт Тоқаевтың энергетикалық қуаттарды арттыру және туристік инфрақұрылымға инвестиция тарту қажеттілігі туралы мәлімдемесі түрткі болды. Зерттеу цифрлық болжау әдістерін қолдану арқылы туристік ағынды дәл болжау, ресурстарды алдын ала бөлуді қамтамасыз ету және инфрақұрылымның тұрақтылығын арттыру мүмкіндігін қарастырады. Сандық әдістер мен цифрлық болжау жүйелері сәтті енгізілген аймақтардағы салыстырмалы мысалдарды біріктіре отырып, зерттеу практикалық мәліметтер мен стратегиялық білім беруді көздейді. Бұл зерттеу өңірлік деңгейде саясатты реформалауға және туристік технологияларға инвестицияларды ынталандыруға ықпал етуді мақсат етеді, бұл өз кезегінде тұрақты дамуға және туристер тәжірибесін жақсартуға алып келеді. Сонымен қатар, зерттеу қорытындылары Қытай, Оңтүстік Корея және Скандинавия елдерінің тәжірибелеріне сүйене отырып, жаһандық smart-туризм тәжірибесі аясында қарастырылады. Зерттеу Орталық Азиядағы ғылыми зерттеулердің жеткіліксіздігін атап өтеді. Нәтижелер жергілікті билік органдарына және өңірде экологиялық туризмді дамытуға көмектеседі деп күтілуде.

Түйін сөздер: цифрлық болжау; туристік ағын; инфрақұрылымның тұрақтылығы; курорттық аймақтар; smart туризм; Имантау-Шалқар; Ресей; Қазақстан

Повышение эффективности цифрового прогнозирования туристских потоков и устойчивости инфраструктуры в курортных зонах

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Аннотация: Туристские направления, такие, как Имантау-Шалкар, Боровое, Алтай и Байкал, расположенные на территории Казахстана и России, всё чаще сталкиваются с инфраструктурными проблемами. Одной из основных причин является отсутствие современных цифровых систем, способных точно прогнозировать туристские потоки. В пиковые сезоны уровень неэффективности в этих зонах часто превышает 30%, что приводит к перегрузкам, снижению качества обслуживания и рискам для безопасности. Мотивом для проведения данного исследования послужили заявления Президента Касым-Жомарта Токаева в июне 2024 года, в которых была подчеркнута необходимость повышения энергетических мощностей и инвестиций в туристскую инфраструктуру. В исследовании рассматривается потенциал использования цифровых методов прогнозирования для точного определения туристских потоков, что позволит заранее распределять ресурсы и повышать устойчивость инфраструктуры. Путём объединения количественных методов и сравнительного анализа успешных кейсов внедрения цифрового прогнозирования, исследование направлено на получение практических выводов и стратегических знаний. Целью исследования является содействие региональным реформам в области политики и стимулирование инвестиций в туристские технологии, что в конечном итоге приведёт к устойчивому развитию и улучшению туристского опыта. Кроме того, результаты рассматриваются в контексте глобальной практики умного туризма на примере Китая, Южной Кореи и Скандинавии. Отмечается недостаток научных исследований в регионе Центральной Азии. Ожидается, что результаты помогут местным властям и поспособствуют развитию более экологически ориентированного туризма в регионе.

Ключевые слова: цифровое прогнозирование; туристский поток; устойчивость инфраструктуры; курортные зоны; smart туризм; Имантау-Шалкар; Россия; Казахстан.