UDC: 316.334.55:332.14(574)
doi: 10.5379/urbani-izziv-en-2025-36-02-01

Received: 17 August 2025
Accepted: 2 November 2025

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A comprehensive assessment of social sustainability in the North Kazakhstan Region of Kazakhstan

With increasing territorial disparities in Kazakhstan, there is a growing need for a systematic assessment of social sustainability at the subregional level. This study develops and pilots an integrated social sustainability index for the districts of the North Kazakhstan Region based on fifteen indicators grouped into five key components: demography, healthcare, education, quality of life, and social integration. The methodology includes data normalization, indicator aggregation, and spatial analysis using GIS tools. The analysis reveals a stable yet markedly asymmetric territorial structure of social sustainability: although the regional centre (Petropavl) has relatively high values across most components, the majority of rural districts show persistent signs of demographic decline, social vulnerability, and insufficient access to basic services and infrastructure. A sensitivity analysis confirms the model's applicability under conditions of incomplete statistical reporting. Based on the results, a typology of districts is developed, and directions for territorially oriented social policy are proposed. The proposed methodology can be applied for interregional monitoring, social risk assessment, and justification of sustainable development priorities in regions with transitional demographic structures.

Keywords: social sustainability, demographic structure, spatial differentiation, North Kazakhstan Region, GIS, sustainability index, sustainable development goals

1 Introduction

Regional social sustainability is gaining relevance amid the implementation of the UN sustainable development goals (SDGs) and current socioeconomic challenges. Research highlights that social sustainability extends beyond basic needs, encompassing equity, inclusiveness, adaptability, and spatial justice. Accordingly, regional-level analysis is crucial because subnational territories often reveal the most acute disparities in access to services and development opportunities. The North Kazakhstan Region illustrates these challenges, marked by population decline, infrastructure gaps, and migration dependence. Despite national efforts to promote sustainable development, spatial differences in social sustainability across Kazakhstan's regions remain underexplored.

This study quantitatively assesses social sustainability across the North Kazakhstan Region's districts using a composite index. Emphasis is placed on selecting relevant indicators aligned with the SDGs and regional conditions, applying normalization techniques and using cartographic analysis. Spatial disparities are highlighted, and an evidence base is provided for a differentiated regional policy aimed at promoting sustainable territorial development.

The concept of social sustainability has undergone significant evolution in academic discourse, gaining increasing analytical significance within the context of regional sustainable development strategies. Studies emphasize that social sustainability goes beyond the simple provision of basic needs, encompassing aspects of inclusivity, equality, participation, and the capacity of communities to adapt to transformations. Eizenberg and Jabareen (2017) proposed a conceptual framework for social sustainability as a hybrid category combining the values of justice, safety, recognition, and participation, with a strong emphasis on spatial and social structures. Their work laid the foundation for integrating social sustainability into urban and regional planning, particularly in peripheral territories.

A significant theoretical contribution was made by Vallance et al. (2011), who distinguished three dimensions of social sustainability: development, maintenance, and adaptation. They argue that underestimating cultural and symbolic aspects leads to simplified models incapable of explaining sustainability in complex local contexts. Shirazi and Keivani (2020) analyse social sustainability in the context of urbanization, emphasizing social inclusion, housing justice, and access to opportunities. Their approach is applicable for assessing spatial inequality in urban environments and can be used to analyse the disparities between Petropavl and the rural districts of the North Kazakhstan Region.

At the international level, significant progress has been made in formalizing composite index systems. Geniaux et al. (2009) classify sustainable development indicator systems based on degree of aggregation, spatial coverage, and analytical purpose. Their classification is useful for comparing approaches used in Kazakhstan. Lacmanović and Tijanić (2025) explore the progress of social policy in the EU by applying the Social Progress Index (SPI), and Wang and Chen (2022) apply principal component analysis to assess social sustainability, demonstrating its effectiveness in reducing multidimensional data. The annual report of the Social Progress Imperative (2025) offers updated data and methodologies for assessing social progress, focusing on rights, health, and opportunities. The World Social Report by the United Nations (2025) provides a framework for assessing social sustainability through the lenses of equity and solidarity. The Sustainable Development Report by SDSN (2024) justifies the metrics for achieving the SDGs and provides a foundation for constructing comparable subnational indices. Examples of regional differentiation in social sustainability highlight the potential for using GIS and remote sensing technologies.

Kazakh researchers have made a substantial contribution to the advancement of sustainable development assessment methodologies. Nyussupova et al. (2021) demonstrated the potential of using GIS to monitor SDG indicators, which is particularly relevant for spatial assessments of social infrastructure in the North Kazakhstan Region. Kuanova et al. (2023) developed a regional sustainability index for Kazakhstan based on national statistical data and normalization methods. Aidarkhanova et al. (2025) constructed a predictive model of sociodemographic processes using business intelligence systems. Studies by Bektemyssova et al. (2025) and Satybaldin et al. (2025) proposed methodological approaches to clustering and adaptive evaluation of regional sustainability, emphasizing multidimensional indices and comparative spatial assessment. ESCAP reports (United Nations, 2023) emphasize the importance of spatial analytics in sustainable governance and advance the integration of geoinformation platforms into regional sustainable development policies. Thus, a review of existing approaches to assessing social sustainability underscores the need to develop a regionally adapted model that takes into account the specific demographic, infrastructure, and socioeconomic features of the North Kazakhstan Region.

This research makes a new contribution because, for the first time, a long-term district-level assessment of social sustainability has been conducted for a region of Kazakhstan. Unlike previous studies limited to interregional comparisons, the methodology allows for the identification of hidden intra-regional disparities and their correlation with the SDGs. The findings complement international research on transitional economies

and offer a reproducible platform for regular monitoring at the level of local governance. The hypothesis of the study is that regional differentiation in social sustainability in the North Kazakhstan Region necessitates implementing targeted sustainable development programmes aimed at reducing territorial disparities and improving the quality of life of the population. To test this hypothesis, a composite social sustainability index was calculated, followed by a spatial analysis of its distribution across the region.

2 Materials and methods

This study is based on a quantitative assessment of social sustainability across the administrative districts of the North Kazakhstan Region, using a composite index specifically developed for this purpose. The empirical foundation of the analysis is official statistical data from the Bureau of National Statistics of the Republic of Kazakhstan (BNS). Regional-level data were collected for thirteen districts and the city of Petropavl over a thirteen-year period (2011–2023) from the Taldau information and analytical system (BNS Taldau, no date) and the Sustainable Development Goals National Reporting Platform of Kazakhstan (no date).

To construct the composite social sustainability index, fifteen indicators were carefully selected and grouped into five thematic domains: demography, healthcare, education, quality of life and basic infrastructure, and social integration and safety. This structure was designed to capture the multidimensional nature of social sustainability by encompassing key factors that affect the quality of life in the region. Among the selected fifteen indicators, four fully correspond to official SDG target indicators: the unemployment rate (SDG 8.5.2), the availability of medical doctors (SDG 3.c.1), the proportion of households with access to water (SDG 6.1.1), and the crime rate per 100,000 population (approximating SDG 16.1.4). An additional nine indicators were classified as alternative or proxy indicators. These include, for example, the crude birth rate, which corresponds to reproductive health metrics, and the digital literacy rate, which reflects adult ICT competence. Two further indicators – overall mortality and age structure – while not directly included in the SDG framework, are widely used in international assessments of demographic resilience, including those by UNDP and OECD (Table 1). The principal criteria for indicator selection were 1) data availability for all districts of the North Kazakhstan Region and 2) official validation of the indicators in Kazakhstan's national statistical systems.

In the set "social integration and safety", objective indicators were used: unemployment rate, ratio of average wage to the subsistence minimum, and crime rate. These indicators reflect the formal conditions of economic inclusion and public safety, available in official district-level statistics for 2011 to 2023. Admittedly, subjective dimensions such as life satisfaction, perceived social connectedness, trust, and sense of security are important components of social sustainability. However, due to the lack of representative data at the district level, they were not included in the social sustainability index calculations.

Due to the lack of regional data on enrolment in higher and vocational education, the digital literacy rate was used as a proxy, reflecting basic ICT skills and serving as an approximate indicator of educational capital. To fill temporal gaps, an average was calculated for 2018, 2020, and 2021. The selected indicators reflect both global SDG principles and the practical limitations of regional statistics, balancing analytical rigor with data availability and ensuring the index's relevance for monitoring and spatial comparison.

Normalization was conducted via linear scaling (0 to 1), allowing comparability across indicators and ensuring that higher values indicate stronger social sustainability. Aggregation occurred in two steps: first, sub-indices were calculated for each thematic block; second, the social sustainability index was computed as the mean of these sub-indices, yielding a comprehensive score for each district and the regional seat. To assess the robustness of the final results, a sensitivity analysis of sub-index weights was conducted to examine how the ranking of districts would change under alternative weighting schemes. In addition to the baseline model with equal weights (20% assigned to each sub-index), two alternative configurations were tested: a) weights proportional to the factor loadings of the first principal component, reflecting statistical variance explained by each thematic dimension, and b) expert-assigned weights, reflecting the perceived priority of each sub-index in light of regional development challenges: 30% for healthcare, 25% for education, 20% for quality of life, 15% for demography, and 10% for social integration and safety.

The expert weights were determined through a consensus-based consultation with five academic specialists in demography, regional development, and social geography from Al-Farabi Kazakh National University. All experts have extensive experience in human capital assessment and regional sustainability studies in Kazakhstan, and their input was used to balance statistical and contextual relevance when assigning thematic priorities.

This weighting scheme is consistent with approaches used in previous sustainability studies that apply expert-based calibration (Gan et al., 2017; Mikulić et al., 2015; Abreu et al., 2022; OECD, 2008). A comparison of district rankings calculated under the three weighting schemes demonstrated high robust-

Table 1: Key indicators of the social sustainability index for the North Kazakhstan Region.

Indicator	SDG	Alignment with global SDG framework	Function within sustainability framework
A. Demography			
a1: Crude birth rate	3.1	Alternative to SDG 3.7.2 (adolescent birth rate)	Reflects level of population reproduction; aligned with international demographic practice
a2: Crude death rate	3.2	—	Fundamental indicator for assessing health risks and population ageing
a3: Net international migration balance	10.7	—	Indicates scale of population "outflow" due to labour and educational migration
a4: Share of children 0–14 and elderly 65+	3.c	—	Characterizes age structure and dependency burden on working-age population
B. Healthcare			
b1: Infant mortality rate (< 1 year)	3.2.1	Alternative to SDG 3.2.2 (neonatal mortality rate)	Key indicator of child health, sensitive to quality of healthcare and living conditions
b2: Availability of medical doctors	3.c.1	Full correspondence with SDG 3.c.1 (health workforce density)	Reflects access to healthcare services and capacity of health system
C. Education			
c1: Number of preschool institutions	4.2	Alternative to SDG 4.2.2 (participation in organized learning)	Early childhood development indicator that provides the foundation for further learning
c2: Digital literacy rate of population	4.4	Alternative to SDG 4.4 (ICT skills among adult population)	Reflects level of core competencies and cognitive capital
D. Quality of life and basic infrastructure			
d1: Housing provision	11.1	—	Reflecting comfort of housing conditions and degree of overcrowding
d2: Households with access to piped water	6.1.1	Alternative to SDG 6.1.1 (proportion of population using safely managed drinking water services)	Infrastructure-related indicator, but does not guarantee water quality
d3: Households with access to sanitation	6.2.1	Alternative to SDG 6.2.1 (access to adequate sanitation and hygiene)	Reflects basic sanitary and hygiene conditi-ons aligned with decent standard of living and health
E. Social integration and safety			
e1: Unemployment rate	8.5.2	Full correspondence with SDG 8.5.2 (unemployment rate)	Indicator of economic integration of population
e2: Ratio of average wage to subsistence minimum	1.2.1	Alternative to SDG 1.2.1 (national poverty rate)	Reflects level of relative income adequacy and risk of poverty
e3: Crime rate	16.1.4	Alternative to SDG 16.1 (reduction of violence)	Indicator of public safety and social cohesion

ness of the results. The Spearman rank correlation coefficients between the baseline and alternative models were 0.89 (with PCA-based weights) and 0.77 (with expert-assigned weights), confirming the reliability and reproducibility of the index.

For interpretative purposes, three simple diagnostics were used to flag districts with potentially unstable year-to-year social sustainability index dynamics from 2011 to 2023: the coefficient of variation (CV) of annual social sustainability index values; the count of inter-class switches across the five social sustainability index tiers from year to year; and a mean-reversion share, defined as the proportion of years in which the absolute deviation from the district's long-run mean declined relative to the previous year. As a heuristic threshold, districts with $CV > 0.12$ and/or ≥ 4 tier switches over the period were treated as high-volatility cases for discussion. Short-term var-

iations were interpreted as oscillations that are not sustained over time and tend to revert toward the district's long-run average. These diagnostics are intended to guide interpretation and avoid over-generalization from small-number effects in sensitive indicators (e.g., infant mortality or crime), rather than to provide formal statistical testing.

The number of social sustainability levels was determined using Sturges' formula, which is commonly applied for categorizing small samples into statistically meaningful classes. The final range of the composite index values was evenly divided into five intervals. Based on this classification, districts were categorized as having low, below average, average, above average, or high levels of social sustainability. Using the distribution of the final social sustainability index, the following interval thresholds were determined for the North Kazakhstan Region: low (0.000–0.380), below average (0.381–0.490), average (0.491–0.600), above average (0.601–0.710), and high (above 0.711).

This approach ensures consistency and comparability of classification over time, allowing for stable gradation in future monitoring cycles. Spatial analysis was performed using methods of cartographic visualization and geoinformation modelling in ArcGIS 10.8. Spatial data were integrated into the system to produce thematic maps showing the distribution of the composite index and its component sub-indices across administrative-territorial units. The cartographic outputs made it possible to identify geographical patterns that reveal both sustainable and vulnerable district-level positions within the region.

3 Results

3.1 Long-term trends (2011–2023)

Between 2011 and 2023, the composite social sustainability index of the North Kazakhstan Region had a complex and uneven trajectory. The initial years of the study period were characterized by relatively low index values across most districts, primarily due to a combination of demographic decline, infrastructure deficits, and economic constraints. However, from the mid-2010s onward, a gradual upward trend in social sustainability scores became evident. This improvement is associated with the implementation of social sector modernization programmes, enhanced access to healthcare and education services, and a degree of stabilization in infrastructure development. The pace of this growth, however, was tempered by ongoing demographic pressure: population loss driven by both natural decline and out-migration remained a persistent structural constraint (UNDP Kazakhstan, 2020). By 2017–2019, index values across districts began to converge, indicating that several territories had reached a relative plateau of sustainability. During this period, further positive changes slowed, and inter-district differentiation stabilized. The COVID-19 pandemic, which peaked in 2020–2021, introduced short-term disruptions to the established dynamics. A decline in index values was observed, primarily due to deteriorating health indicators (increased mortality and a greater burden on healthcare systems) and a temporary reduction in quality of life (World Bank, 2021). Nevertheless, by 2022, conditions had partially stabilized, and key sub-indexes returned to pre-pandemic levels. Despite this recovery, the overall demographic situation continued to worsen, thereby constraining the full rebound of the composite index.

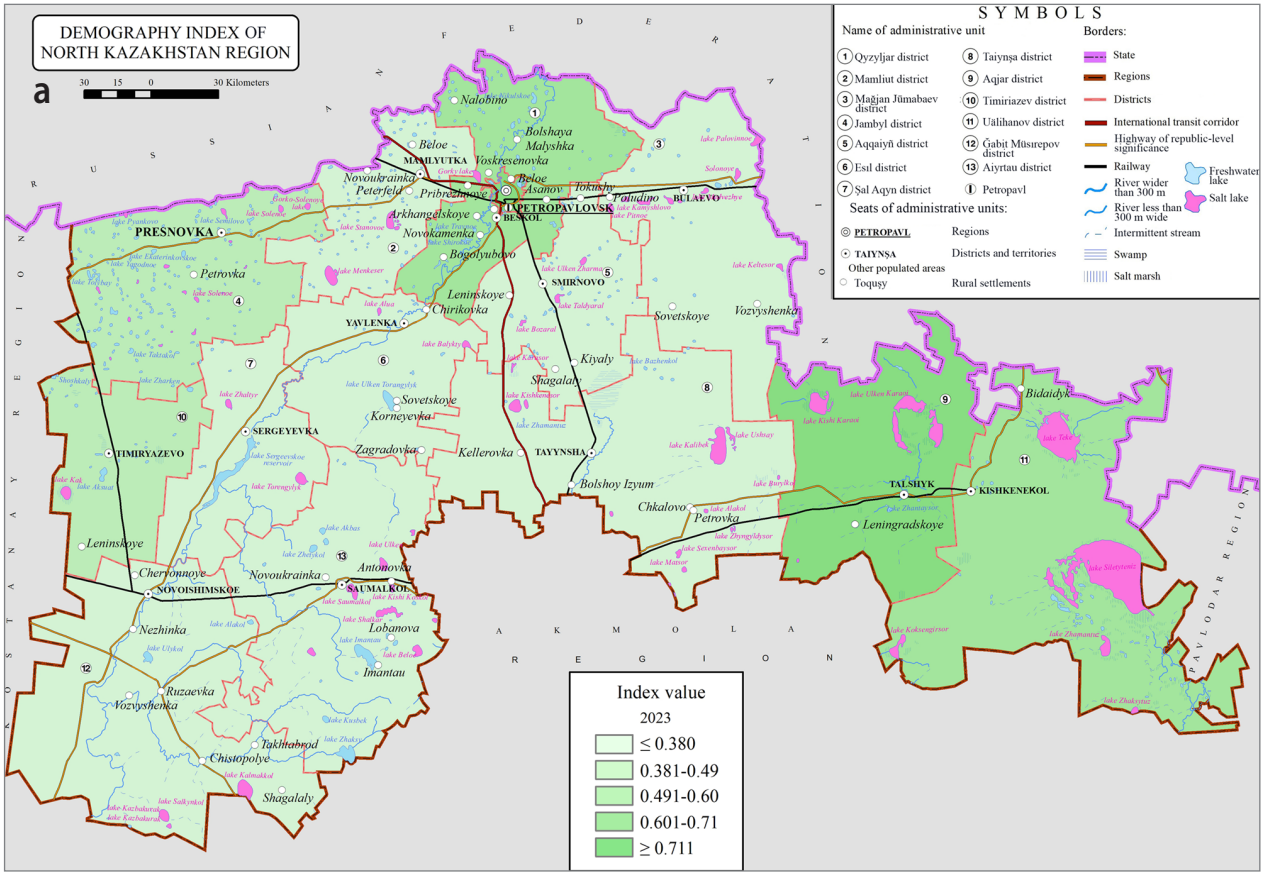
As a result, over the entire study period, the social sustainability index for the North Kazakhstan Region had a moderately positive dynamic, without evidence of a pronounced breakthrough. Improvements in education, healthcare, and quality of life have largely offset the negative effects of ongoing demographic trends. According to official sources, the region's population declined by nearly 9% over the past decade (BNS, no date), which has constrained the potential for sustained growth in the composite index. Thus, the observed trajectory reflects the emergence of a stable yet unevenly distributed positive trend, marked by stagnation in recent years. A significant gap persists between districts with high and low levels of social sustainability, indicating the need for targeted policy and investment efforts aimed at strengthening resilience in the region's most vulnerable territories.

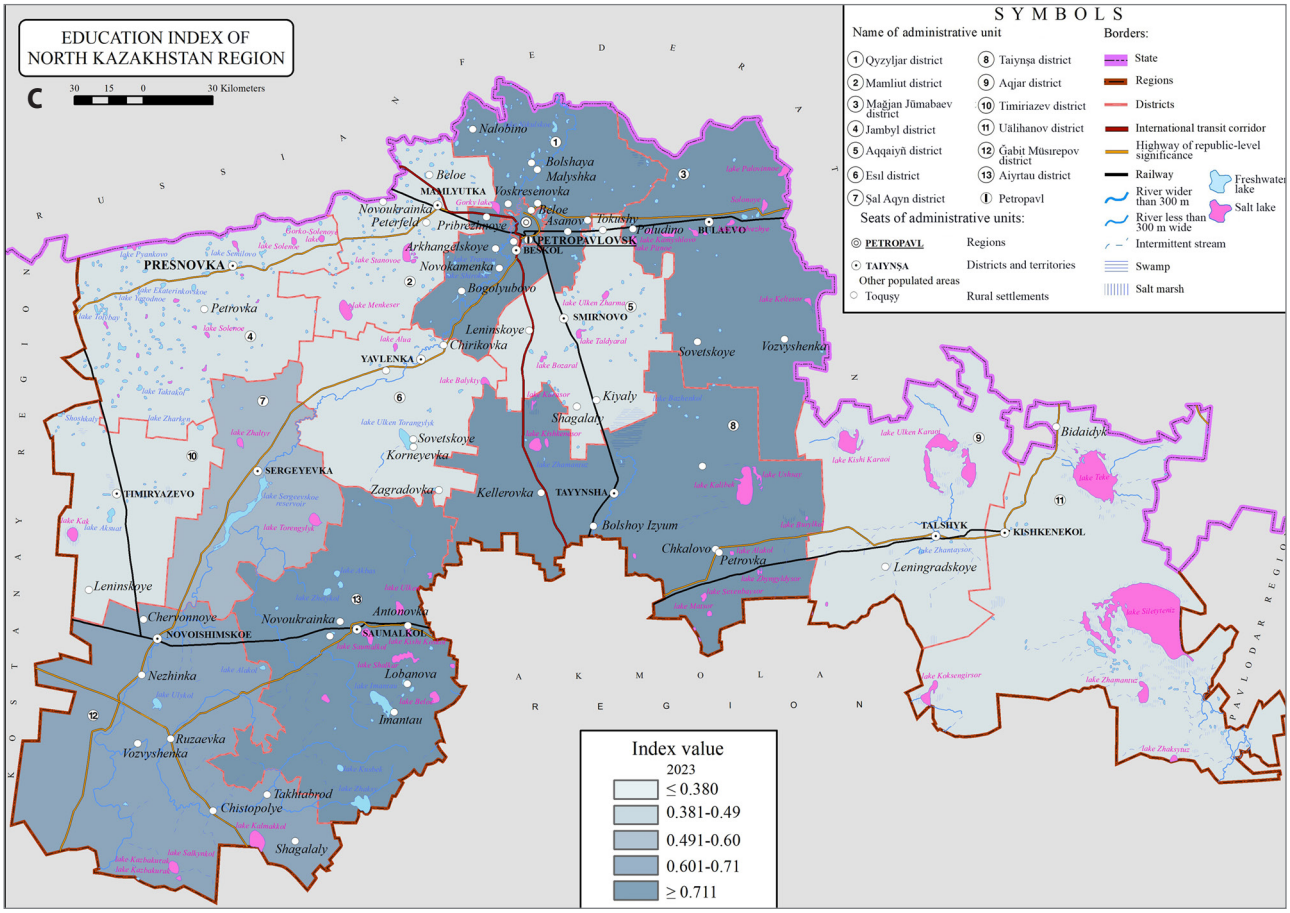
3.2 Regional clustering of sustainability

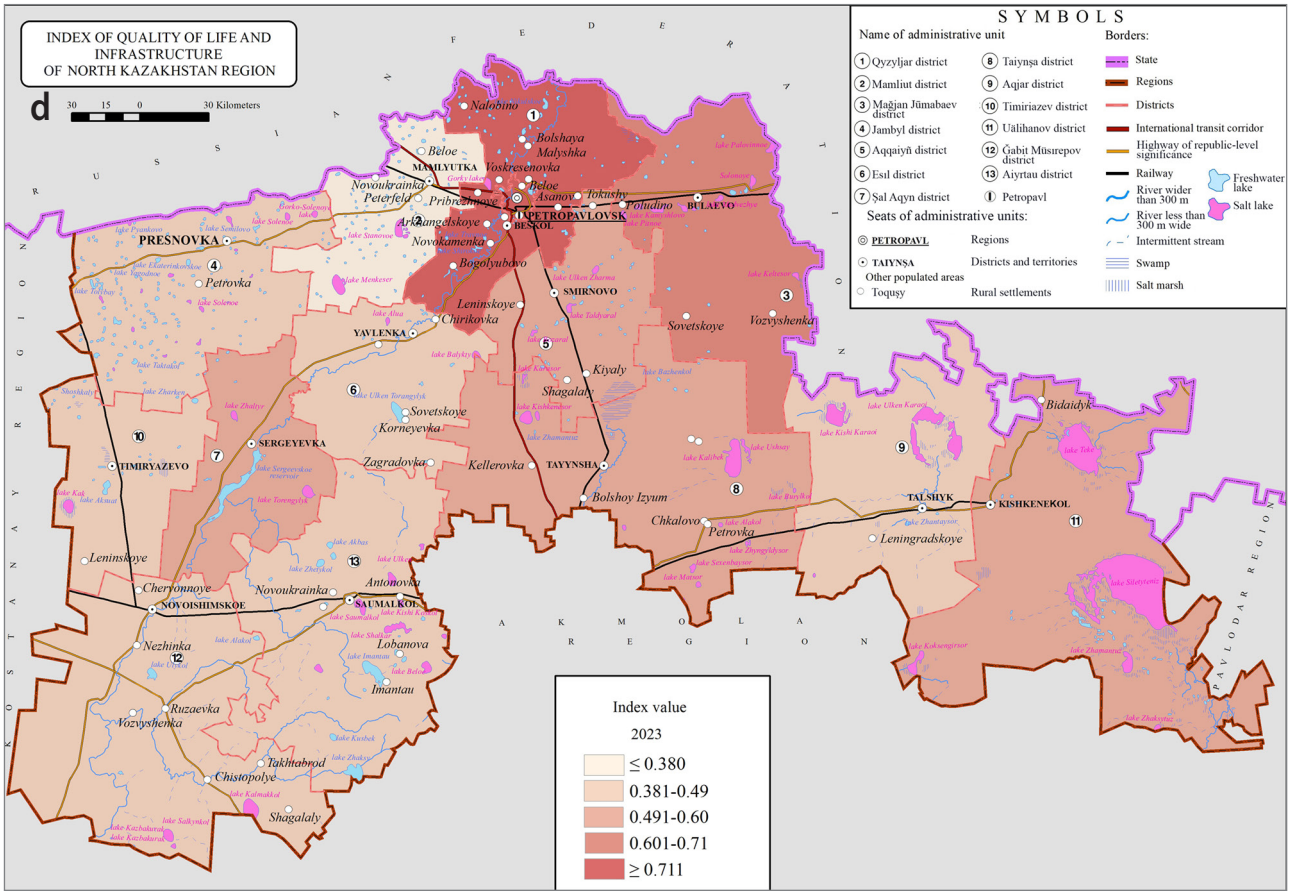
By the end of 2023, all thirteen districts and the city of Petropavl were grouped into five categories based on their social sustainability levels, derived from the composite index. These categories reveal clusters of territories with similar profiles across key sub-indices: demography, healthcare, education, quality of life, and social integration. A high level of social sustainability was recorded only in Petropavl, which outperformed all districts across major components. This is linked to the city's concentration of socioeconomic resources, strong institutional capacity, and developed infrastructure. High access to healthcare and education, reliable gas and water systems, and comparatively low poverty and unemployment contribute to its comprehensive and resilient sustainability profile.

The above-average sustainability group includes the Qyzyljar district and Ğabit Müsırepov district. The former benefits from its geographic proximity to the regional seat, and the latter stands out due to its agro-industrial base and recent improvements in social infrastructure. Both districts consistently demonstrate strong performance in the sub-indices of healthcare, education, and quality of life (Figure 1).

Figure 1: Spatial distribution of social sustainability sub-index values across the districts of the North Kazakhstan Region, 2023: a) demographic index; b) health index; c) education index; d) index of quality of life and infrastructure; e) index of social integration and environmental safety (maps: authors, based on official statistical data).




EDUCATION INDEX OF
NORTH KAZAKHSTAN REGION
c
30 15 0 30 Kilometers
SYMBOLS
Name of administrative unit
1 Qyzyljar district
2 Mamliut district
3 Mağjan Jümabaev district
4 Jambyl district
5 Aqqaiyñ district
6 Esil district
7 Şal Aqyn district
8 Taiynşa district
9 Aqjar district
10 Timiriazev district
11 Ualihanov district
12 Ğabit Müsirepov district
13 Aiyrtau district
Petropavl
Seats of administrative units:
PETROPAVL Regions
TAIYNŞA Districts and territories
Other populated areas
Toquşy Rural settlements
Borders:
State
Regions
Districts
International transit corridor
Highway of republic-level significance
Railway
River wider than 300 m
River less than 300 m wide
Intermittent stream
Swamp
Salt marsh
Freshwater lake
Salt lake
Index value
2023
≤ 0.380
0.381-0.49
0.491-0.60
0.601-0.71
≥ 0.711
PRESNOVKA
PETROPAVLOVSK
BESKOL
BULAEVO
SMIRNOVO
YAVLENKA
SERGEYEVKA
TIMIRYAZEVO
NOVOISHIMSKOE
SAUMALKOL
TAYYNSHA
TALSHYK
KISHKENEKOL
Nalobino
Bolshaya Malyshka
Beloe
MAMLYUTKA
Voskresenovka
Novoukrainka
Peterfeld
Pribrezhnoye
Asanov
Tokushy
Poludino
Arkhangelskoye
Novokamenka
Bogolyubovo
Petrovka
Leninskoye
Chirikovka
Sovetskoye
Vozvyshenka
Kiyaly
Shagalaly
Korneyevka
Zagradovka
Kellerovka
Bolshoy Izyum
Chkalovo
Petrovka
Leningradskoye
Bidaidyk
Lobanovo
Imantau
Ruzaevka
Takhtabrod
Chistopolye
Shagalaly
Antonovka
Cheryomnoye
Nezhinka
KOSTANAY REGION
AKMOLA REGION
PAVLODAR REGION


INDEX OF QUALITY OF LIFE AND
INFRASTRUCTURE
OF NORTH KAZAKHSTAN REGION
d
30 15 0 30 Kilometers
SYMBOLS
Name of administrative unit
1 Qyzyljar district
2 Mamliut district
3 Mağjan Jümabaev district
4 Jambyl district
5 Aqqaiyñ district
6 Esil district
7 Şal Aqyn district
8 Taiynşa district
9 Aqjar district
10 Timiriazev district
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SAUMALKOL
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TALSHYK
KISHKENEKOL
Nalobino
Bolshaya Malyshka
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Voskresenovka
Novoukrainka
Peterfeld
Pribrezhnoye
Asanov
Tokushy
Poludino
Arkhangelskoye
Novokamenka
Bogolyubovo
Petrovka
Leninskoye
Chirikovka
Sovetskoye
Vozvyshenka
Kiyaly
Shagalaly
Korneyevka
Zagradovka
Kellerovka
Bolshoy Izyum
Chkalovo
Petrovka
Leningradskoye
Bidaidyk
Lobanovo
Imantau
Ruzaevka
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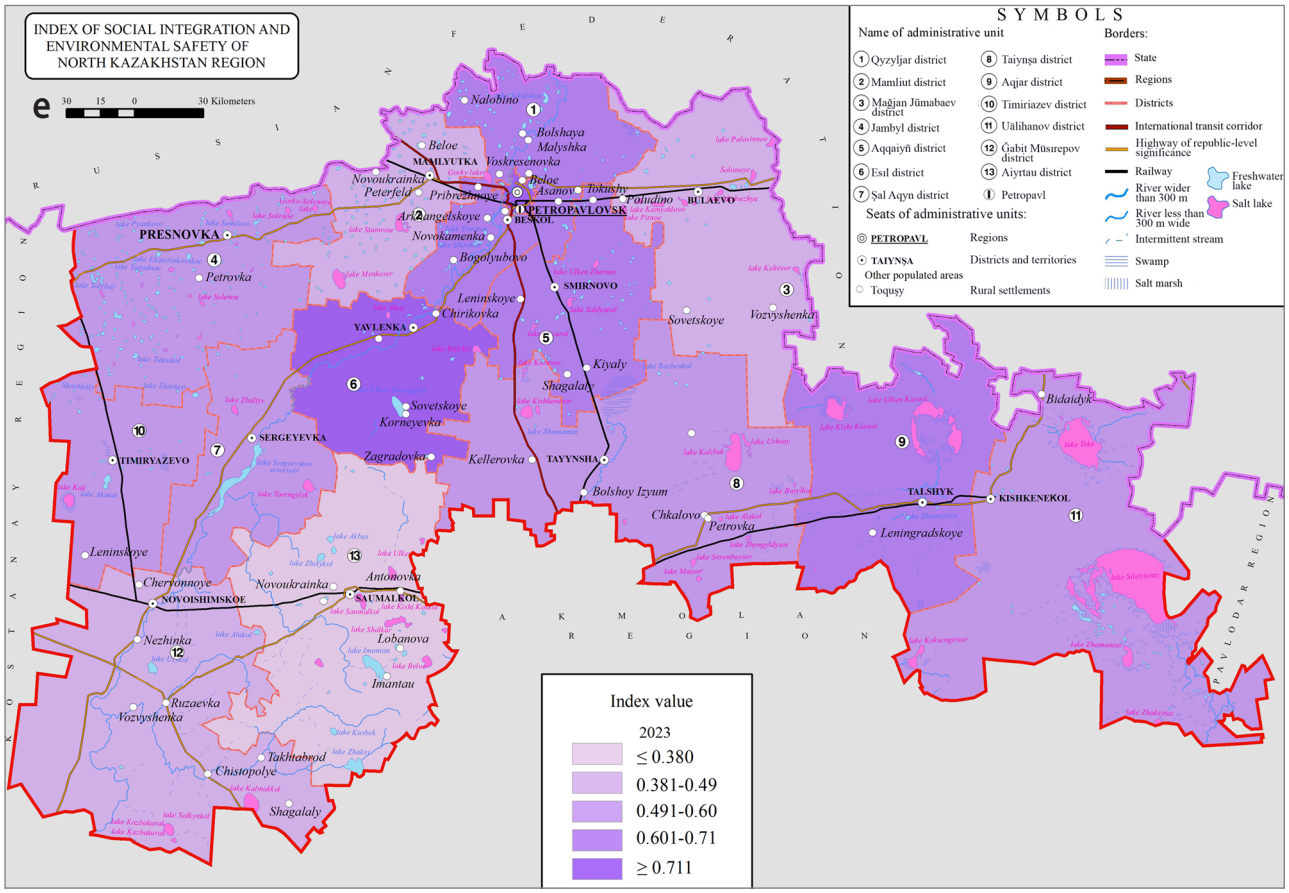

A medium level of social sustainability was recorded in the Taiynşa, Aiyrtau, Jambyl, and Mamliut districts. These territories are characterized by balanced performance across all components, without notable achievements or severe deficiencies. Their sub-index values fluctuate near the regional average, reflecting a relatively stable, though unspectacular, sociodemographic profile. The below-average group includes the Aqqaiyñ district and Mağjan Jūmabaev district. These areas are constrained by relatively weak demographic indicators, limited access to quality healthcare, and insufficient basic infrastructure. The accumulation of social challenges in these districts has resulted in lower composite index values (Institute of Economic Research, 2021). The low sustainability group comprises the districts of Aqjar, Uälihanov, and Şal Aqyn. These remote and sparsely populated rural areas exhibit critically low values across all components. Their profile is shaped by infrastructure isolation, demographic decline, and limited employment opportunities – factors that collectively contribute to chronic social vulnerability. Access to education, healthcare, and essential living conditions in these districts remains significantly below the regional average.

This spatial distribution of social sustainability confirms the city-centric nature of regional development: Petropavl forms a distinct core of social resilience, and the more remote districts remain in a zone of persistent vulnerability. Most rural territories occupy intermediate positions, underscoring the need for a territorially differentiated regional policy aimed at addressing spatial disparities and enhancing local capacities.

3.3 Structural decomposition of the index

An analysis of the structure of the composite index reveals the territorial specificity in the formation of social sustainability. The five sub-indices collectively determine the overall assessment; however, their relative contributions vary significantly between leading and lagging districts.

Petropavl has a balanced and uniformly high profile, with all five sub-indices exceeding the regional average (Figure 2). Three of them – education, healthcare, and quality of life – reach the highest values across the entire region. Petropavl holds a leading position in the education component due to its high rates of preschool and higher education coverage, supported by the presence of universities and vocational colleges.

The city also ranks first in the healthcare sub-index, benefiting from a high density of medical personnel, the presence of specialized facilities, and favourable demographic health indicators, including infant mortality and life expectancy (Sus-

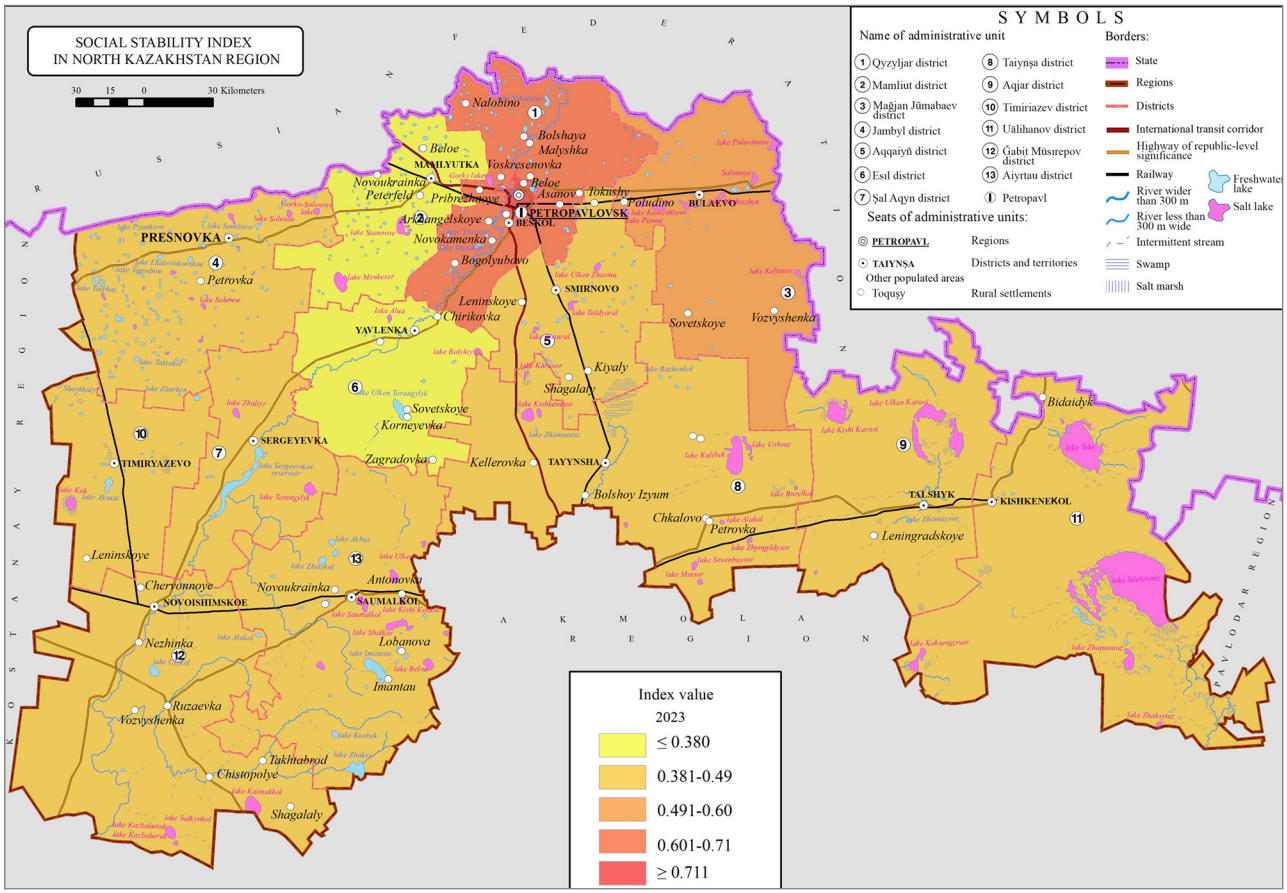

Figure 2: Spatial distribution of the social sustainability index across districts of the North Kazakhstan Region, 2023 (map: authors, based on official statistical data).

tainable, no date). The quality of life sub-index in Petropavl is driven by its extensive coverage with utility services: more than 95% of households are connected to centralized water supply and heating, and a significant portion have access to gas. Active residential construction and the availability of apartment housing further contribute to strong infrastructure performance.

In the social integration sub-index, the city has moderately high values supported by low unemployment and a relatively small proportion of the population living below the subsistence minimum. The only relatively weaker dimension is safety because the level of registered crime in the city is traditionally higher than in rural areas, which slightly reduces the final value of the social integration sub-index (BNS, no date).

In contrast, districts such as Ualihanov and Aqjar have what may be described as a "declining profile": the values across all five sub-indices remain low, without any significant compensatory advantages (Figure 2). The demographic component pulls down the composite index due to persistently high mortality rates, which exceed birthrates, and active out-migration. The healthcare sub-index is negatively affected by personnel shortages, remoteness from medical institutions, and less favourable health outcomes. The education component in these remote districts is largely limited to primary and secondary education, and the share of the population with higher education is significantly lower than in the regional seat. Infrastructure provision is chronically underdeveloped: many villages lack a reliable water supply and centralized heating, road quality remains poor, and gasification levels are minimal. Social integration is further weakened by a high share of the population living below the poverty line, restricted access to labour markets, and general economic stagnation. Under such conditions, even a relatively low crime rate has little impact on improving the overall index score.

Consequently, leading districts benefit from multi-component reinforcement, in which each sub-index amplifies the effects of the others, producing a synergistic effect. In contrast, lagging districts experience a cumulative weakening, in which negative factors across multiple domains undermine the structure of sustainability as a whole. This imbalance calls for a territorially differentiated policy approach. In the case of Petropavl, the key task is to maintain the level of sustainability achieved and to enhance resilience to future shocks. In contrast, peripheral districts require targeted interventions in their most vulnerable components – primarily infrastructure, healthcare, and demographic stability – to overcome structural disadvantages and close the sustainability gap.

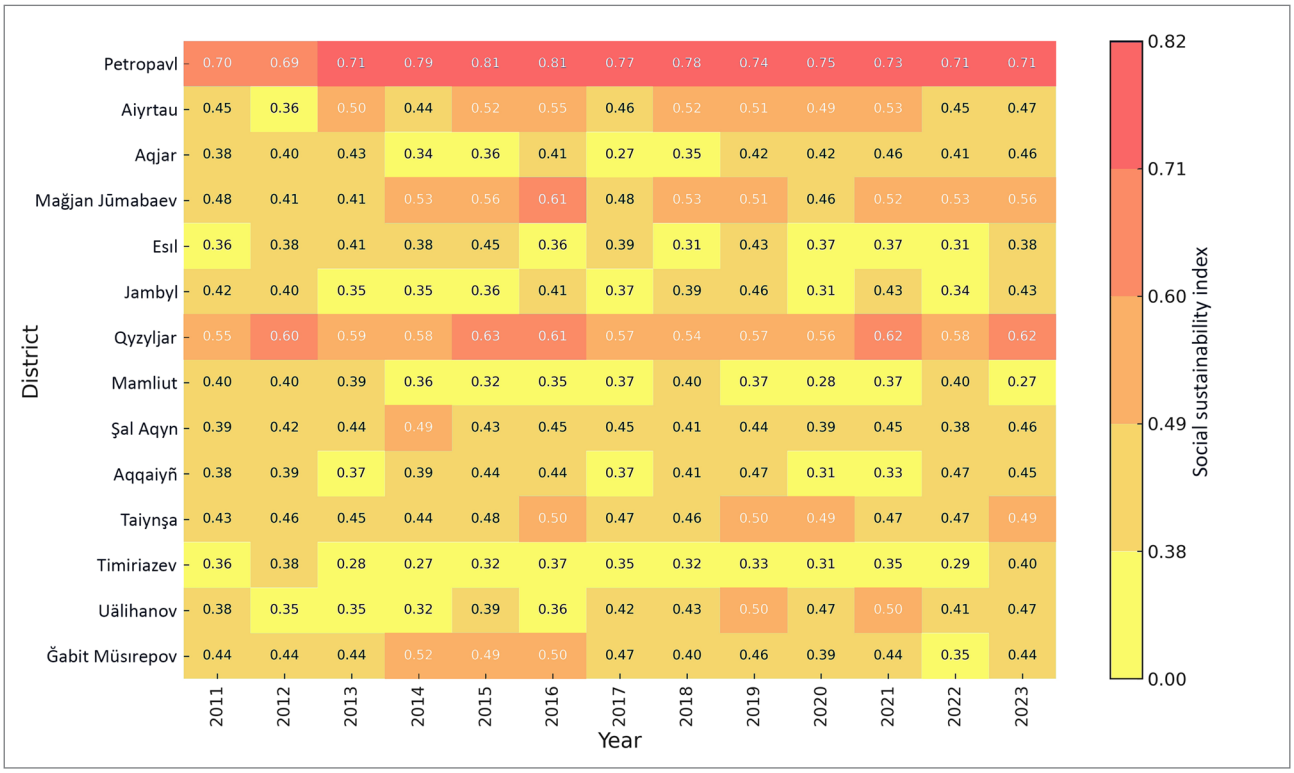

Figure 3: Dynamics of the social sustainability index across the districts of the North Kazakhstan Region, 2011–2023 (illustration: authors, based on official statistical data).

3.4 Typology of districts in the North Kazakhstan Region by level of social stability

An analysis of the dynamics of the social sustainability index across the administrative districts of the North Kazakhstan Region from 2011 to 2023 reveals both consistently stable and highly volatile territories. Stability is observed at both the high and low ends of the sustainability spectrum. For example, Petropavl consistently held a leading position in the composite index throughout the entire study period. At the opposite end, chronically low-performing districts were also identified. The Uälihanov and Şal Aqyn districts remained in the bottom quintile of the regional ranking over the entire period. Minor year-to-year fluctuations did not affect their overall standing, indicating entrenched socioeconomic disparities and the absence of effective mechanisms for adaptation to demographic and infrastructure challenges.

In addition to persistently high- and low-performing districts, several areas in the region exhibited considerable variability in sustainability performance. For instance, the Taiynşa district was initially classified at a medium level of sustainability but, due to investments in the social sector, the modernization of educational and transport infrastructure, and the launch of new industrial facilities, it improved its standing in the 2020s and entered the above-average category (Prime Minister, 2020). A reverse trend was observed in the Mağjan Jūmabaev district. The district performed near the regional average during the first half of the period, but a marked decline was recorded after 2017. Increased out-migration, the downsizing of the social service network, and the deterioration of basic infrastructure led to falling sub-index values, placing the district in the below-average sustainability category (MTRK, 2021; Figure 3).

Sparsely populated districts tend to exhibit higher year-to-year volatility of the social sustainability index. Using the screening definitions introduced in Section 2 (CV and tier-switch counts, complemented by a simple mean-reversion share), several districts are flagged as high-volatility cases, in which small absolute changes in sensitive components (e.g., infant mortality or crime) can produce visible swings in normalized values. In most such cases, the direction of change is not persistent beyond one to two years, and the index reverts toward its long-run average, which is termed *short-term variation* here. With regard to policy, this pattern supports a distinction between maintenance and incremental improvement in consistently high-sustainability districts, and stabilization measures in high-volatility districts – multiyear funding cycles, protected staffing for physicians and teachers, and territorially targeted governance instruments – to dampen acute swings and reduce exposure to shocks.

4 Discussion

4.1 Interpretation of findings

The integrated assessment of social sustainability in the districts of the North Kazakhstan Region (2011–2023) reveals persistent spatial polarization, with marked differences between urban and rural areas. The highest index values are concentrated in Petropavl, confirming an urban-centric sustainability model, in which population density, resources, and institutional capacity support high levels of social provision. The balanced performance across all sub-indices indicates integrated urban development, despite a slightly elevated crime rate. Rural districts display considerable variation. Although some central and southern districts (e.g., Qyzyljar and Ğabit Müsırepov) show positive trends, aided by proximity to the regional seat and investment, northeastern and border areas remain at consistently low levels. This reflects not only current socioeconomic conditions but also structural legacies: demographic decline, weak infrastructure, and poor connectivity.

Sub-index analysis reveals that underperformance in lagging districts stems from systemic deficits: demographic shrinkage, limited service access, infrastructure gaps, and persistent poverty. These factors reinforce each other, producing cumulative vulnerability. In terms of temporal dynamics, although urban centres and selected districts have improved, others – such as Aqjar, Uälihanov, and Şal Aqyn – remain chronically low-performing. This inertia suggests structural resistance to change and a lack of adaptive policy measures. The overall stability of rankings confirms both the model's robustness and the entrenched nature of territorial inequality.

4.2 Comparison with previous studies

The findings of this study are consistent with the conclusions drawn in earlier research on territorial resilience and regional differentiation in post-Soviet and developing countries. As noted by Gan et al. (2017) and Abreu et al. (2022), the resilience of territories is shaped not only by formal macroeconomic indicators, but also by structural balance in access to basic social services, demographic potential, and the quality of the environment. From this perspective, the observed dominance of the regional seat and the vulnerability of remote districts align with global trends in asymmetric regional development, as documented in Central Asia, eastern Europe, and Latin America.

In the case of Kazakhstan, these results corroborate and expand upon findings by UNDP Kazakhstan (2020), the Institute of Economic Research (2021), and Zhanibayeva (2022), which emphasize the structural inequality between urban and rural areas. In particular, issues such as limited access to basic services, a shortage of labour resources, and low income levels in rural districts of the northern regions have previously been identified as key barriers to achieving sustainable regional development (OECD, 2008). Unlike more aggregated approaches as part of which analysis is conducted at the oblast or macroregional level, this study offers a micro-level perspective by mapping social sustainability at the district level. This approach makes it possible to identify not only general development patterns but also intra-group disparities that are often obscured by aggregated indicators. Furthermore, the use of an integrated index with sensitivity analysis of weights helps mitigate methodological bias, enhancing the reliability of inter-territorial comparisons. Similar models have been applied in studies in India, Turkey, and Latin America, where district- or municipal-level assessments have proven highly effective in identifying local hotspots of social vulnerability (CEEW, 2020; DST-GoI, 2024; Tanır et al., 2022; IPEA, 2015; Menezes et al., 2018; León-Cruz et al., 2024). Thus, the results obtained are in line with and confirm international trends while making a significant contribution to the understanding of Kazakhstan by providing high spatial resolution and a comprehensive calculation model. This enhances their relevance for integration into policy-making and regional governance practices.

4.3 Strengths and limitations of the approach

The proposed approach to assessing social sustainability has several important methodological and practical strengths. By integrating five interrelated sub-indices it provides a comprehensive assessment of the social sphere at the district level, moving beyond fragmented analyses toward a holistic understanding of sustainability. A major advantage lies in transparent data normalization and the use of multiple weighting schemes. Sensitivity analysis confirmed the consistency of district rankings across these models, enhancing the robustness of results and reducing potential bias, in line with international guidelines (Gan et al., 2017; OECD, 2008). The use of GIS tools, particularly ArcGIS, allowed the visualization of index values and dynamics, revealing spatial patterns and areas of elevated risk. These visual outputs improve the accessibility of results for both experts and decision-makers.

However, several limitations should be noted. The reliance on official district-level statistics constrains the ability to capture intra-district disparities, especially between urban centres and remote villages, potentially leading to aggregation bias. In addition, some dimensions – such as informal institutions, perceptions of justice, or governance quality – remain beyond the scope of available data and would benefit from complementary qualitative research. The timeframe (2011–2023) is

adequate for short- and medium-term analysis, but it limits insight into the long-term impacts of structural reforms. Future studies should consider extending the temporal horizon and integrating scenario-based forecasts. In sum, despite these constraints, the methodology proves effective in data-limited contexts and offers a sound basis for monitoring social sustainability and informing regional policy.

The absence of comparable subjective indicators at the district level – such as life satisfaction, social cohesion, and trust – limits the completeness of the "social integration" dimension. For future monitoring rounds, the following is proposed 1) introducing a survey module of eight to ten questions with an annual stratified sample of three hundred to four hundred respondents; 2) hybridizing the index through a latent variable "social engagement" (confirmatory factor analysis) calibrated against unemployment, income, and crime indicators; and 3) regularly incorporating municipal administrative data (participation in volunteering) as indirect proxies.

4.4 Policy and planning implications

The results obtained directly link the initial research hypothesis with the need for targeted sustainable development programmes at the subregional level. The social sustainability index mapping revealed a stable core (Petropavl and adjacent municipalities) and a perimeter of chronic vulnerability (remote, sparsely populated districts). This indicates that universal equalization measures will be insufficient: differentiated intervention packages are required, combining infrastructure investments (water supply, gasification, roads, and digital connectivity), strengthening of human capital in healthcare and education, and economic incentives to retain young people and qualified specialists. In practical terms, this implies a transition toward district-level "sustainability roadmaps", in which goals and funding are aligned with subindex profiles, and monitoring is conducted based on the annual updating of social sustainability index indicators.

To align the findings with local policy implementation, it is advisable to cluster policy measures as follows:

- A high-sustainability core (Petropavl): maintaining achieved levels through preventive health programmes, urban safety initiatives, fine-tuning of education and ICT competencies, and effective management of migration and housing.
- Medium and above-average sustainability (the Qyzyljar and Ğabit Müsırepov districts): implementing "growth accelerators" such as upgrading infrastructure to urban standards, expanding access to specialized medical services, vocational colleges and IT courses, and developing local employment programmes.
- Below-average and low sustainability (Uälihanov, Aqjar, Şal Aqyn, and others): ensuring stabilization through basic infrastructure improvements (water, sanitation, roads, communications), targeted medical staffing and incentive contracts for teachers and doctors, creation of local economic activity hubs (small-scale processing and logistics), and prioritized targeted support for households.

The findings have strong practical relevance for regional policy, particularly regarding the sustainable development goals – reducing inequality (SDG 10) and promoting health (SDG 3), education (SDG 4), infrastructure access (SDG 11), and institutional capacity (SDG 16). The concentration of high social sustainability in Petropavl and nearby suburbs underscores the need to revise uniform infrastructure policies. Structural disparities in rural areas require adaptive planning and targeted support for districts with persistently low sub-index values – especially in healthcare, infrastructure, and demography. The clustering of districts by sustainability levels supports a differentiated policy approach. Lagging areas such as Aqjar and Uälihanov require integrated strategies: upgrading medical and educational facilities, improving transport and digital connectivity, and fostering employment through local enterprise development. Social support must be closely linked to economic and infrastructure interventions.

Another priority is the institutionalization of monitoring mechanisms. The composite index developed can be incorporated into regional development tools, allowing regular data updates, dashboard visualizations, and integration with funding programmes. This would facilitate more effective needs-based investment planning. Promising districts such as Taiynşa and Qyzyljar, which show upward trends, can serve as pilots for innovation in social services and the digital economy. Scaling successful models while adapting them to local contexts may foster a more balanced and resilient regional system. In conclusion, this study offers not only a snapshot of current territorial disparities but also a policy framework to reduce spatial inequality and enhance the adaptive capacity of vulnerable districts.

5 Conclusion

Using an integrated social sustainability index, persistent territorial disparities and long-term spatial inequality trends were identified in the North Kazakhstan Region. Urbanized and resource-concentrated areas, such as the city of Petropavl and its surrounding suburbs, are the most sustainable areas in this region. In contrast, remote and sparsely populated districts exhibit structural vulnerability, characterized by demographic depopulation, limited access to basic services, and a weak economic base. This confirms the existence of a spatial divide

that cannot be addressed through universal policy measures and instead requires territorially sensitive strategies. Priority areas should include the stabilization of demographic processes, improvement in the accessibility and quality of healthcare and education, infrastructure modernization, and human capital support in peripheral districts. Moreover, the integration of spatial planning tools and digital technologies is essential to improve the targeting and effectiveness of decision-making.

Thus, the hypothesis that territorial differentiation of social sustainability in the North Kazakhstan Region necessitates targeted programs to reduce disparities and improve quality of life is confirmed. The results presented in this study can serve as a foundation for monitoring regional disparities, guiding territorial development planning, and shaping equitable social policy within Kazakhstan's sustainable development agenda. The composite index developed can be adapted for application in other regions of the country, integrated into the monitoring system of territorial development programmes, and used to justify the priority allocation of resources. The proposed typology of districts and the operationalized subindices make it possible to directly translate the results into the design of district-level sustainable development programmes, results-based budgeting, and annual monitoring of target indicators.

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Acknowledgements

This research was funded by the Science Committee of the Ministry of Science and Higher Education of Kazakhstan (grant no. BR24993222).

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