“The role of education, human capital, and quality of life in regional development: Evidence from Kazakhstan”

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THE ROLE OF EDUCATION, HUMAN CAPITAL, AND QUALITY OF LIFE IN REGIONAL DEVELOPMENT: EVIDENCE FROM KAZAKHSTAN

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Abstract

This study aims to assess the impact of key components of quality of life, including human capital, social accessibility, and industrial development, on effective territorial development management in Kazakhstan. The study uses an index approach, cluster and correlation analysis, and Markov transition models. The empirical dataset covers 17 regions of Kazakhstan over the period 2013–2023 and is based on official annual statistics, including indicators of education (number of students and teaching staff), employment, income, digital infrastructure, and industrial development. The Quality of Life Index (QLI) was calculated using normalized variables, followed by regional grouping and dynamic modeling. Results indicate that the highest QLI values in 2023 were recorded in Astana city (0.837), Mangystau (0.790), and Shymkent city (0.771), where educational coverage and academic staffing are significantly higher than in other regions. Correlation analysis reveals that industrial development (r = 0.493, p = 0.052) and educational potential (ρ = 0.491, p = 0.045) are positively associated with regional upward transitions in quality of life. Cluster analysis identified three stable groups of regions: with active social transformation (e.g., Mangystau, Kyzylorda), balanced growth (Karaganda, Pavlodar), and limited dynamics (Turkistan, East-Kazakhstan). Thus, regions with strong educational infrastructure and dynamic labor markets, such as the Mangystau region, Astana and Shymkent cities, consistently outperform in QLI. In contrast, structurally lagging regions, such as Turkistan and East Kazakhstan, exhibit limited social mobility and weak institutional support. Consequently, investment in human capital is essential for reducing regional disparities and promoting sustainable territorial development.

Keywords quality of life, human capital, education management, social policy, regional inequality, regional governance

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INTRODUCTION

A modern interpretation of quality of life increasingly goes beyond traditional approaches, focusing on the understanding of social processes and structural factors of economic development. The relationship between social conditions, human capital, and the level of economic activity is becoming a key area of analysis, especially in the context of increasing spatial heterogeneity. Therefore, assessing the quality of life is considered a tool for analyzing the sustainability and balance of regional growth. The study of the quality of life in countries with pronounced regional differences is of particular importance, due to multidirectional and uncoordinated dynamics in social and economic indicators. Kazakhstan, which is in the phase of structural modernization, is a striking example of such a territorial contrast. Despite the presence of large-scale infrastructure initiatives, industrialization strategies, and digitalization programs, persistent differences between

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regions in terms of access to opportunities, employment conditions, institutional support, and the quality of social services remain. At the same time, assessments and perceptions of the quality of life are increasingly shaped not only by macroeconomic indicators but also through everyday experience, access to opportunities, participation in society, and trust in institutions. It is important to take into account that a qualitative transformation of the environment in which a person lives can occur even at moderate rates of economic growth, provided that human capital and institutional infrastructure are effectively used.

1. LITERATURE REVIEW

The modern concept of well-being has passed through the evolution process from economic-centric models to human-oriented theories. The focus was shifted from material indicators to a more comprehensive understanding, including human needs, justice, freedoms, and opportunities. There was a shift from the resource approach to the concept of capabilities, which is essential for assessing the quality of life and designing management-oriented social programs.

In the academic literature, human capital is defined as the totality of knowledge, skills, health, and educational resources that enable participation in productive and social activities. In Becker's (1964) definition, human capital is presented as a form of investment in future development, with education and training playing a central role in this process. Strober (1990) views human capital through the lens of institutional conditions, emphasizing the need for equal access to resources that shape educational and professional opportunities. The concept of human capital, as proposed by Sen (1990, 1994), is interpreted as the basis for expanding life opportunities that depend on the quality of basic institutions – education, healthcare, and social protection. Further, Nafukho et al. (2004) viewed human capital as a resource that determines the development of organizations, and its formation is associated with the education system, vocational training programs, and the structure of personnel training.

The formation of human capital requires the presence of institutional conditions that ensure equal access to education, health care, and other key social resources. According to Rawls (1963), justice is interpreted as the presence of systemic guarantees that ensure access to freedom, self-esteem, and opportunities. In contrast, the basic needs model of Doyal and Gough (1984) specifies that autonomy is possible only if intermediate conditions are met, including education, security, and physiological support. This forms the idea of human capital not only as a result of investments but also as a reflection of the structural availability of basic goods. According to Sen (1994), the level of education and health status are interpreted not as development goals but as indicators of the ability to make decisions and participate in social life, which makes them applicable both to assessing individual potential and to analyzing aggregate well-being. Moreover, Klugman et al. (2011), Alkire and Foster (2011), and Hirai (2017) have emphasized the high sensitivity of the Human Development Index to educational differences and the dependence of macroeconomic indicators on the quality and accessibility of education.

Some studies focus on the structural characteristics of employment and their impact on quality of life and human capital development. In precarious or part-time employment, the standard of living exhibits significant volatility (Paramio & Zofío, 2008). At the same time, income level, employment stability, availability of social protection, and working conditions are key dimensions of employment quality (Sehnbruch et al., 2020). Income within the "living wage range," which covers values sufficient not only to meet basic needs but also to ensure decent living conditions, has a direct impact on the perception of justice, job satisfaction, and a sense of professional security, becoming the basis for a sustainable quality of life (Yao et al., 2017).

In addition, the sector of employment also affects self-assessment of work capacity and life satisfaction: entrepreneurs and farmers demonstrate higher rates compared to employees despite a higher level of uncertainty and responsibility (Saarni et al., 2008). Access to advanced training programs is viewed as a positive factor that enhances the potential of human capital and yields sustainable effects on income and employment, particularly for socially vulnerable groups (Shah & Steinberg, 2021; Attanasio et al., 2022). The role of education in the reproduction of human capital is manifested through the formation and development of key competencies necessary for sustainable socio-economic development. The educational environment acts as a structural element that determines the quality of human capital in the long term. Kireyeva et al. (2019) and Pedro et al. (2020) showed that academic infrastructure, the qualifications of teaching staff, and the effectiveness of management practices affect the reproduction of professional knowledge and applied skills. At the same time, Cui et al. (2024) and Bekbossinova et al. (2023) emphasize that educational level affects not only cognitive resources but also components of human capital, such as financial literacy, the ability to make strategic decisions, and orientation toward long-term economic behavior. Consequently, education serves as a multi-level mechanism that ensures the development of human capital in both institutional and behavioral dimensions.

Social accessibility in the context of quality of life is interpreted as a set of conditions that ensure equal access to basic resources, services, and opportunities for participation in public life. In contrast to approaches limited to income measurement, the modern understanding covers a wide range of factors, including housing and communal conditions, digital infrastructure, and opportunities for obtaining key social benefits. Wilkinson and Pickett (2006) emphasize that even at high incomes, institutional inequality can reduce indicators of health, education, mobility, and general well-being, which requires the inclusion of infrastructural and institutional variables in the assessment system. Social indicators are interpreted as a reflection of the uneven distribution of vital resources and conditions that determine the quality of life. Institutional differences in access to energy, water, and waste disposal parameters are considered factors that form the basic level of life support and increase the manifestations of social vulnerability (Collison et al., 2010; Maggino & Zumbo, 2011). Access to infrastructure resources determines the level of provision of basic living conditions. Estoque et al. (2019) emphasized that water supply, energy supply, and other utilities form the basis for sustainable livelihoods and directly affect the quality of life. Some studies consider Internet access as an element of social accessibility that affects the overall quality of life. Cuihong and Chengzhi (2019) and Ma et al. (2020) demonstrated that the presence of an Internet connection has a positive impact on well-being indicators, particularly in areas with limited physical infrastructure. Thus, Adam and Alhassan (2021), Alhassan and Adam (2021), Hasan et al. (2022), and Mohan and Lyons (2024) found that mobile communications and Internet access, and the availability of broadband Internet access contribute to improving conditions in rural areas, where traditional forms of access to social services are complex. The Internet infrastructure acts as an intermediary, providing educational, medical, and administrative services, which expands the potential for utilizing key social resources. Several studies have focused on the impact of industrial development on the quality of life. Industrial development is accompanied by an uneven territorial distribution of resources, changes in the employment structure, and an increased risk of social inequality (Huang et al., 2013). The lack of safety standards and institutional control mechanisms in sectors such as extractive industries leads to an increase in social and labor risks (Amponsah-Tawiah et al., 2014; Yu et al., 2024; Antonaci et al., 2024). Mourtzis et al. (2022) emphasize the importance of technological transformation in creating sustainable working conditions and promoting territorial stability. Regarding the agricultural sector, Lubag et al. (2023) demonstrated that integrating digital platforms into supply chains contributes to price stability and enhances living conditions in rural areas.

A systemic analysis of quality of life requires the integration of diverse socio-economic variables into generalized indicators that reflect the combined effect of education, employment, and infrastructure. The thematic grouping of variables using factor analysis enables cross-regional comparisons (Grasso & Canova, 2008; Uskelenova & Nikiforova, 2024). Additionally, studies note that the dynamics of quality of life are also described using transition matrices, which enable the assessment of the evolution of economic ties and the identification of the stability of structural configurations in the distribution of resources and production flows (Moosavi & Isacchini, 2017; Xia et al., 2020). Zeini et al. (2023) and Zhiyenbayev et al. (2024) suggest-

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ed a complex methodology that includes selecting relevant variables, data standardization, management, and aggregation using multi-criteria analysis. Thus, normalization methods and the choice of weighting coefficients are key when constructing complex well-being indices (Rijpma et al., 2025). Despite the relative stability of the dynamics, the absolute values of the index significantly depend on methodological decisions, including adapting the weights depending on the objectives of the analysis. Within the framework of intra-national comparison of regions, it is justified to use a categorical approach, in which indicators are aggregated by individual areas (education, employment, access to infrastructure), which allows identifying not only the general situation of a region but also its relative advantages and limitations in specific components of quality of life.

Despite the wide range of studies devoted to assessing the quality of life, most of them do not take into account the simultaneous influence of educational, social, and digital factors in regional dynamics, limited by static approaches. Also, they do not reflect the sustainability of territorial development and the probabilistic nature of transitions between levels of well-being.

Given these limitations, this study aims to assess the impact of key components of quality of life – human capital, social accessibility, and industrial development – on effective territorial development management in Kazakhstan.

2. METHODS

The research methodology includes analysis of the contribution of educational indicators – as a key component of the Social Capital category – to the dynamics of quality of life. Comparison of changes in the number of teachers, undergraduate and doctoral students, with the growth rates of the integral index will allow a preliminary assessment of whether the development of human capital contributes to the transition of regions to higher Quality of Life Index (QLI) levels.

At the first stage, a database was formed and indicators were structured, grouped into three key categories: social capital, social accessibility, and industrial advancement. Each category includes a set of specific variables reflecting the main aspects of regional development and the quality of life of the population.

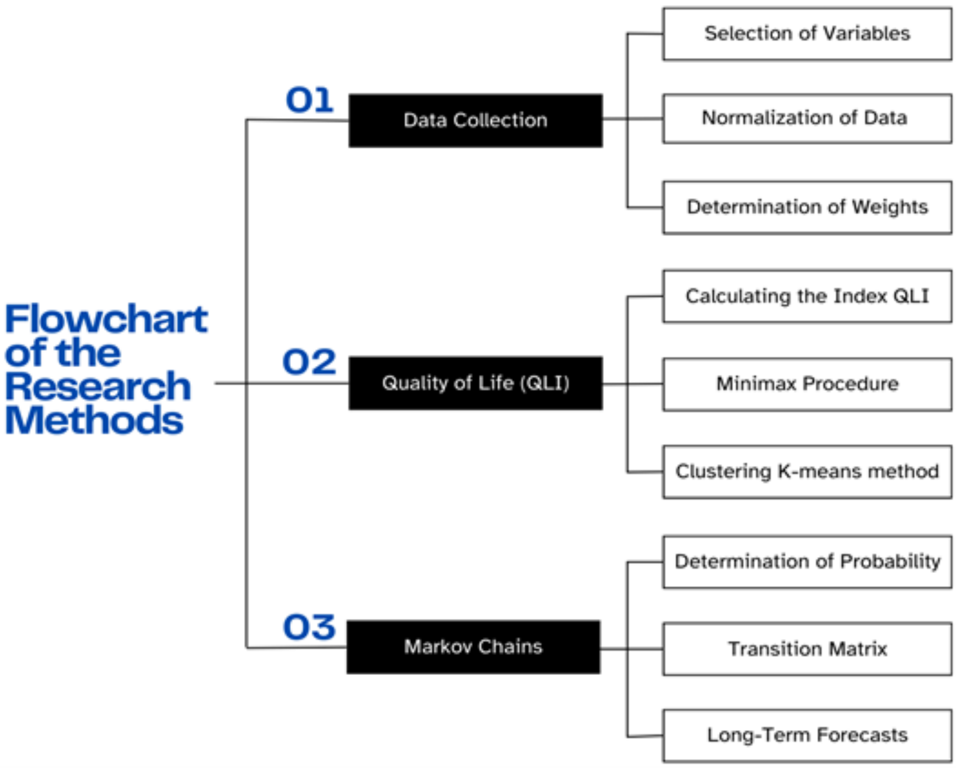

Figure 1. Research stages in the form of a block diagram

The second stage was devoted to the quantitative assessment of the quality of life at the regional level using the integral index. To ensure data comparability, minimax normalization was applied, bringing all indicators to a single scale. The obtained normalized values were used to conduct cluster analysis (using the *k*-means method and the Ward hierarchical method) in order to identify regional groups with homogeneous socio-economic characteristics and to test the stability of the identified clusters.

In the third stage, a study of the dynamics of regional changes using the Markov chain approach is planned. The generated matrix of transition probabilities is used to assess the stability of trajectories and the frequency and direction of changes in the quality of life in regions. This tool allows for identifying both stable and unstable development trajectories and analyzing the probability of transitions between different levels recorded on the basis of the integral index.

Next, Figure 1 shows a schematic representation of the three key stages of conducting research in the form of a block diagram.

The flow chart is a methodological framework consisting of three key stages: data collection, calculation of the integral QLI index, and analysis of dynamics using Markov chains. Each stage is detailed with specific analytical procedures and methods reflecting the sequence of implementation of the methodology.

2.1. Formulas and mathematical models

This study uses a comprehensive approach to assessing the QLI of the population by region, based on the integration of indicators of education, employment, income, digital and social accessibility. Based on normalized data, an integral index of quality of life is calculated, allowing for differences in the level of development of social factors. Clustering and analysis of changes in QLI for assessing the sustainability of regional development and the likelihood of transitions between different levels of well-being.

To quantitatively assess the standard of living in the regions, the integral QLI was calculated based on normalized data for five categories using the following formula (1):

$$QLI = \sum_{i=1}^{n} \omega_i \cdot X_i, \tag{1}$$

where: ω_i – weighting factors determined by the normalization method; X_i – normalized indicators for each category.

In order to compare indicators with different dimensions and take into account their relative influence on the overall index, the variables were reduced to a single scale using the minimax normalization method. The obtained results were further divided based on clustering methods to identify groups of regions with similar quality of life characteristics through the *k*-means method. Additionally, the hierarchical clustering method (Ward's method) was used to clarify the boundaries of the clusters and confirm their stability.

To identify the sustainability of regional development and the probabilities of transition between different levels of quality of life, the Markov matrix was used for modeling changes over time and predicting regional development trajectories using the formula (2):

$$P_{ij} = \frac{N_{ij}}{N_i}, \tag{2}$$

where: P_{ij} – the probability of transition from state *i* to state *j*; N_{ij} – the number of transitions from *i* to *j* during the analyzed period; N_i – total number of cases where the region is in state *i*.

2.2. Categories and variables of the QLI

The study is based on the analysis of statistical data on the regions of Kazakhstan for the period 2010–2023. The sources used were the initial data of the Bureau of National Statistics of the Republic of Kazakhstan (data on employment, income level, industrial production), international databases (data on digital infrastructure, social protection), open reports and analytical studies (regional development programs, strategic documents). Further, the indicators were grouped into three main categories reflecting the main aspects

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Table 1. Categories and variables of QLI

Category	Weight, %	Variable
Human Capital		
Education Accessibility	30	1. Number of teachers in higher education institutions 2. Number of undergraduate students 3. Number of doctoral students 4. Number of bachelor students
Employment and Income	25	1. Employed population 2. Labor force 3. Household income 4. Average monthly nominal wage
Social Accessibility		
Internet Access	15	1. Share of households with internet access 2. Number of fixed internet subscribers 3. Number of high-speed broadband internet subscribers
Living Standards	15	1. Water and Waste Services 2. Energy Supply
Industrial Advancement		
Industrial Development	15	1. Industry 2. Information and Communication 3. Wholesale & Retail Trade 4. Transportation and Storage 5. Construction 6. Agriculture, Forestry and Fisheries 7. Mining and Quarrying 8. Manufacturing

of regional development and quality of life of the population (Table 1).

The current analysis proposes a new complex approach for managing and assessing the quality of life by region. The novelty of the current methodology is in the integrated assessment of social factors and dynamic analysis based on the Markov matrix. The developed methodology provides an analysis of the sustainability of regions and the dynamics of their development, and determines regions with stable growth, regions at risk of degradation, and the contribution of each factor. Unlike traditional methods, the proposed methodology allows the recording of the current state of regions and the identification of patterns of long-term changes and management responses. Previously, quality of life studies were limited to comparing indices between regions at a certain point in time without taking into account the probabilities of transitions between different levels of well-being.

3. RESULTS

3.1. Descriptive analysis

The combination of education and employment remains one of the key channels for shaping quality of life, especially in the context of growing socioeconomic differences between regions. The dynamics of the Social Capital indicator by regions of Kazakhstan for 2013–2023 demonstrate significant differences due to the level of development of the higher education system and employment characteristics (see Table 2).

Overall, there is a positive trend in regions such as Astana city, Shymkent city, Mangystau, Kyzylorda, and Aktobe, where the index exceeded 0.40 by 2023, indicating expanded access to education, an increase in the number of students and teachers, and improved employment indicators and management capacity. The increase is especially noticeable in Astana city (from 0.007 in 2013 to 0.550 in 2023) and Shymkent city (from 0.071 to 0.449), reflecting the modernization of university infrastructure and creating jobs in these cities. Regions with high stability in the Education Accessibility indicator include Karaganda, East Kazakhstan, and Almaty city, with stable values noted in 2017–2020. However, despite the strong educational positions, in 2022–2023, East Kazakhstan, Karaganda, and Almaty showed a decline, which may be due to the migration of teaching staff or a decrease in student enrollment.

The Employment and Income component significantly strengthens the overall Social Capital

Table 2. Social Capital Index

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Akmola	0.343	0.248	0.100	0.137	0.160	0.238	0.268	0.228	0.202	0.342	0.317
Aktobe	0.161	0.141	0.089	0.096	0.119	0.237	0.276	0.295	0.347	0.402	0.402
Almaty	0.254	0.253	0.212	0.270	0.304	0.390	0.401	0.417	0.459	0.160	0.213
Atyrau	0.105	0.109	0.109	0.153	0.248	0.308	0.335	0.268	0.263	0.307	0.391
West Kazakhstan	0.123	0.210	0.116	0.170	0.227	0.274	0.301	0.270	0.253	0.279	0.384
Zhambyl	0.345	0.205	0.084	0.082	0.119	0.183	0.199	0.245	0.228	0.333	0.353
Karaganda	0.317	0.234	0.194	0.262	0.317	0.380	0.358	0.287	0.278	0.168	0.198
Kostanay	0.332	0.261	0.178	0.252	0.289	0.343	0.321	0.253	0.225	0.185	0.176
Kyzylorda	0.252	0.141	0.048	0.157	0.175	0.242	0.250	0.271	0.338	0.409	0.456
Mangystau	0.098	0.065	0.122	0.144	0.162	0.281	0.375	0.281	0.333	0.390	0.460
Pavlodar	0.228	0.192	0.140	0.193	0.283	0.317	0.304	0.308	0.287	0.244	0.238
North Kazakhstan	0.234	0.138	0.109	0.129	0.186	0.311	0.337	0.320	0.292	0.234	0.260
East Kazakhstan	0.293	0.283	0.262	0.303	0.364	0.433	0.384	0.388	0.429	0.119	0.153
Astana city	0.007	0.066	0.083	0.148	0.201	0.244	0.304	0.295	0.334	0.427	0.550
Almaty city	0.171	0.149	0.104	0.135	0.125	0.237	0.293	0.276	0.323	0.342	0.438
Shymkent city	0.071	0.086	0.099	0.150	0.208	0.334	0.407	0.380	0.344	0.434	0.449
Turkistan	0.293	0.186	–0.107	–0.083	–0.105	0.032	0.086	0.068	0.030	–0.008	0.001

indicator in the western and southern regions. Mangystau, Atyrau, and Aktobe show consistently high values after 2020, especially in terms of nominal wage growth and total employment, where employment is based mainly on the industrial sector, making the structure of social capital more balanced from a management perspective. In contrast, Turkistan has had low or even negative values for a number of years, especially in the Employment and Income line, indicating structural problems with employment and wages.

Thus, Social Capital as a composite indicator demonstrates a growing contribution to the resilience of regions. However, the pronounced dependence on employment requires additional education support and management, especially in agricultural and remote regions. The leaders in terms of social capital in 2023 are Astana city (0.550), Shymkent city (0.449), Mangystau (0.460), Kyzylorda (0.456), and Aktobe (0.402), characterized by a high number of students, teachers, and stable employment rates. The outsider is Turkistan (0.001), where low or negative values have been observed for access to education and employment for most years. In addition, in 2023, low values were recorded in Kostanay (0.176), East Kazakhstan (0.153), and Karaganda (0.198), i.e., regions that previously demonstrated stable or high positions but lost momentum by the end of the period.

The second block, reflecting social accessibility, recorded a steady increase in indicators in most regions of Kazakhstan between 2013 and 2023 (Table 3).

In 2023, the highest values were recorded in Almaty (0.238), Karaganda (0.218), North Kazakhstan (0.208), Pavlodar (0.205), and East Kazakhstan (0.207). A high level of internet connectivity, development of digital services and management systems, and improvement of public utility conditions characterize these regions. Karaganda and Pavlodar have shown stable growth since 2018, without sharp fluctuations. Astana city (0.186) and Shymkent city (0.168) show high values as well, which were facilitated by investments in urban infrastructure and expanded access to basic services. A significant improvement in the indicator is observed in Turkistan, where the value increased from 0.022 in 2015 to 0.174 in 2023, thanks to the active expansion of the digital and utility environment. The group with average results is Aktobe (0.197), Atyrau (0.191), Kyzylorda (0.186), and West Kazakhstan (0.179), but the pace of improvement was less pronounced here. Among the laggards is Almaty city, with a value of 0.036 in 2023: after an increase in 2014 (0.172), the region faced a sharp decline, and the values have not recovered. Zhambyl also declined from 0.193 in 2022 to 0.165 in 2023. Thus, social accessibility indicators show an overall improvement, but differences remain between regions with stable infrastructure and areas with limited access to basic services.

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Table 3. Social Accessibility Index

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Akmola	0.021	0.052	0.092	0.116	0.131	0.157	0.113	0.155	0.221	0.162	0.228
Aktobe	0.069	0.047	0.058	0.078	0.099	0.149	0.125	0.123	0.208	0.143	0.197
Almaty	0.041	0.050	0.103	0.107	0.101	0.115	0.112	0.159	0.192	0.196	0.238
Atyrau	0.098	0.103	0.096	0.082	0.117	0.142	0.185	0.144	0.201	0.172	0.191
West Kazakhstan	0.094	0.066	0.056	0.094	0.137	0.145	0.127	0.143	0.167	0.164	0.179
Zhambyl	0.035	0.055	0.041	0.058	0.082	0.134	0.143	0.181	0.189	0.193	0.165
Karaganda	0.074	0.090	0.056	0.087	0.116	0.123	0.174	0.163	0.195	0.134	0.218
Kostanay	0.008	0.086	0.053	0.044	0.072	0.094	0.136	0.154	0.201	0.162	0.177
Kyzylorda	0.088	0.053	0.051	0.037	0.119	0.151	0.132	0.190	0.174	0.185	0.186
Mangystau	0.131	0.134	0.066	0.037	0.115	0.141	0.174	0.158	0.197	0.212	0.208
Pavlodar	0.056	0.061	0.064	0.102	0.102	0.164	0.164	0.173	0.223	0.184	0.205
North Kazakhstan	0.054	0.080	0.070	0.102	0.100	0.135	0.144	0.142	0.189	0.147	0.208
East Kazakhstan	0.002	0.065	0.086	0.117	0.070	0.130	0.146	0.152	0.213	0.177	0.207
Astana city	0.010	0.058	0.085	0.102	0.082	0.120	0.165	0.157	0.221	0.183	0.186
Almaty city	0.134	0.172	0.036	0.123	0.149	0.057	0.089	0.050	0.130	0.047	0.036
Shymkent city	0.054	0.045	0.028	0.013	0.045	0.140	0.163	0.156	0.220	0.145	0.168
Turkistan	0.054	0.040	0.022	0.021	0.055	0.113	0.154	0.154	0.220	0.166	0.174

Industrial development of Kazakhstan's regions between 2013 and 2023 demonstrates significant variability, reflecting different models of industry participation in shaping the quality of life (Table 4).

The leading positions are occupied by Turkistan (0.159), Kyzylorda (0.148), West Kazakhstan (0.146) and Almaty city (0.153), where the key role is played not only by production volumes but also by the broad involvement of the population in trade, logistics, construction, manufacturing and management. The assessment approach is based not on the gross volume of industrial production but on the importance of industries – such as construction, logistics, trade, and manufacturing – for the daily quality of life of the population. In Turkistan, an increase in indicators in the construction and processing sectors is recorded, which ensures leadership in the index. In Kyzylorda, logistics chains have stabilized, and the agro-industrial block has strengthened. Almaty city shows balanced development in trade, information technology, and transport infrastructure. Average values are recorded in Pavlodar (0.083), Karaganda (0.072), Atyrau (0.056), and Astana city (0.101), where the basis is formed by traditional industries – metallurgy, mining, and construction. Regions with limited industrial potential and low results include Aktobe (0.075), Akmola (0.115), and Zhambyl (0.102), where the contribu-

Table 4. Industrial Advancement Index

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Akmola	0.086	0.099	0.100	0.075	0.071	0.076	0.086	0.095	0.091	0.169	0.115
Aktobe	0.135	0.107	0.064	0.106	0.149	0.143	0.145	0.105	0.105	0.118	0.075
Almaty	0.085	0.104	0.114	0.070	0.087	0.091	0.105	0.063	0.171	0.088	0.095
Atyrau	0.059	0.052	0.088	0.099	0.104	0.091	0.081	0.021	0.079	0.041	0.056
West Kazakhstan	0.111	0.144	0.054	0.134	0.122	0.085	0.107	0.080	0.062	0.118	0.146
Zhambyl	0.161	0.114	0.050	0.126	0.115	0.108	0.119	0.079	0.119	0.120	0.102
Karaganda	0.126	0.071	0.119	0.105	0.099	0.102	0.110	0.072	0.088	0.086	0.072
Kostanay	0.126	0.105	0.059	0.098	0.123	0.151	0.143	0.121	0.127	0.117	0.125
Kyzylorda	0.130	0.091	0.068	0.065	0.089	0.088	0.095	0.029	0.136	0.116	0.148
Mangystau	0.120	0.133	0.071	0.120	0.102	0.120	0.098	0.047	0.106	0.111	0.121
Pavlodar	0.088	0.052	0.090	0.084	0.124	0.139	0.102	0.074	0.119	0.103	0.083
North Kazakhstan	0.135	0.091	0.093	0.048	0.123	0.096	0.079	0.096	0.114	0.111	0.117
East Kazakhstan	0.148	0.090	0.051	0.112	0.103	0.127	0.129	0.087	0.112	0.078	0.109
Astana city	0.100	0.078	0.076	0.048	0.089	0.078	0.110	0.080	0.133	0.079	0.101
Almaty city	0.172	0.189	0.126	0.142	0.161	0.150	0.158	0.128	0.206	0.143	0.153
Shymkent city	0.009	0.010	0.009	0.008	0.008	0.160	0.144	0.138	0.161	0.150	0.154
Turkistan	0.008	0.009	0.008	0.007	0.007	0.167	0.174	0.155	0.169	0.144	0.159

Table 5. Quality of Life Index

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Akmola	0.451	0.399	0.292	0.327	0.362	0.472	0.467	0.479	0.514	0.674	0.660
Aktobe	0.365	0.295	0.211	0.281	0.368	0.530	0.547	0.524	0.660	0.663	0.674
Almaty	0.380	0.407	0.429	0.446	0.493	0.596	0.618	0.639	0.822	0.445	0.547
Atyrau	0.263	0.264	0.293	0.335	0.470	0.541	0.600	0.433	0.543	0.520	0.639
West Kazakhstan	0.328	0.421	0.225	0.398	0.486	0.504	0.536	0.493	0.481	0.561	0.710
Zhambyl	0.541	0.373	0.175	0.266	0.316	0.425	0.461	0.505	0.536	0.646	0.620
Karaganda	0.518	0.395	0.369	0.454	0.532	0.605	0.642	0.523	0.562	0.388	0.488
Kostanay	0.466	0.452	0.291	0.394	0.484	0.589	0.599	0.528	0.553	0.464	0.478
Kyzylorda	0.471	0.284	0.167	0.259	0.383	0.481	0.476	0.491	0.647	0.710	0.790
Mangystau	0.348	0.332	0.259	0.301	0.379	0.542	0.647	0.486	0.635	0.713	0.790
Pavlodar	0.372	0.305	0.295	0.379	0.509	0.619	0.570	0.554	0.630	0.531	0.526
North Kazakhstan	0.423	0.309	0.272	0.279	0.410	0.542	0.560	0.557	0.595	0.492	0.585
East Kazakhstan	0.442	0.438	0.398	0.532	0.536	0.690	0.659	0.627	0.753	0.374	0.470
Astana city	0.118	0.202	0.244	0.297	0.372	0.442	0.579	0.532	0.688	0.689	0.837
Almaty city	0.478	0.510	0.266	0.399	0.435	0.444	0.539	0.454	0.659	0.531	0.627
Shymkent city	0.134	0.141	0.137	0.171	0.261	0.634	0.714	0.674	0.725	0.729	0.771
Turkistan	0.355	0.235	–0.078	–0.054	–0.043	0.312	0.414	0.376	0.419	0.302	0.335

tion of individual industries to the quality of life remains fragmented. The results emphasize that large enterprises do not always directly affect regions' social and living standards, and the degree of inclusion of key industries in the employment structure and management practices, as well as the local economy, plays an important role.

The integrated QLI results for 2013–2023 by regions demonstrate stable regional differentiation (Table 5).

The leaders in terms of the final indicator by 2023 include Astana city (0.837), Shymkent city (0.771), and Mangystau (0.790), where a gradual improvement is observed in a set of parameters – from institutional modernization to expansion of infrastructural and social accessibility. Strengthening social capital plays a significant role in this context, including developing educational, employment, and income components. In the opposite group are regions with slow dynamics, such as Turkistan, East_KZ, and Zhambyl, where limited investment in the social sphere, including education, is combined with unsustainable industrial growth. In some cases, such as Karaganda or Almaty city, structural discrepancies are observed between a high level of industrial development and stagnation in other areas, including social accessibility and institutional provision, thus determining heterogeneity of regional development models and the complexity of the balance between sectoral components. Given the identified differences, varying trajectories and heterogeneous degree of integration of components, the following analytical step was cluster analysis. Its goal is to identify stable types of regional dynamics and clarify the relationship between the parameters underlying the quality of life.

3.2. Clustering

Next, a cluster analysis was conducted to identify groups of regions of Kazakhstan with similar social characteristics. The main objective of this stage was to determine the patterns of development and structural differences between regions, which allows for a more accurate interpretation of the factors influencing quality of life and economic well-being.

Table 6 presents the centroids of the resulting clusters, providing a basis for a detailed comparison of regional groupings in terms of their relative performance across the selected indicators.

Cluster analysis using the centroid method allowed identifying three stable groups of regions of Kazakhstan by the level of social transformation. The first group includes regions with pronounced positive dynamics – Mangystau (0.752), Kyzylorda (0.750), Aktobe, Akmola, East Kazakhstan, Turkistan, and West Kazakhstan, where the regions have recorded a stable growth of key social indicators: expanding access to infrastructure, increasing the level of employment and developing

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Table 6. Cluster centroids by region

Region	Cluster 1	Cluster 2	Cluster 3
Akmola	0.667	0.483	0.366
Aktobe	0.669	0.565	0.304
Almaty	0.496	0.669	0.431
Atyrau	0.580	0.529	0.325
West Kazakhstan	0.635	0.503	0.372
Zhambyl	0.633	0.482	0.334
Karaganda	0.438	0.583	0.454
Kostanay	0.471	0.567	0.417
Kyzylorda	0.750	0.524	0.313
Mangystau	0.752	0.578	0.324
Pavlodar	0.528	0.593	0.372
North Kazakhstan	0.538	0.564	0.339
Turkistan	0.667	0.483	0.366
East Kazakhstan	0.669	0.565	0.304
Astana city	0.496	0.669	0.431
Almaty city	0.580	0.529	0.325
Shymkent city	0.635	0.503	0.372

social services and management systems. The second group is represented by regions with balanced and stable dynamics – Karaganda (0.583), Pavlodar (0.593), Kostanay (0.567), North Kazakhstan, Almaty (0.580), and Astana (0.496) cities. Here, moderate, uniform growth is observed without sharp jumps, indicating a sustainable social policy and a functioning industrial base. The third group covers territories with fragmented or unstable dynamics – Atyrau, Zhambyl, Almaty city, and partially Mangystau and East Kazakhstan. The absence of comprehensive changes, weak investment

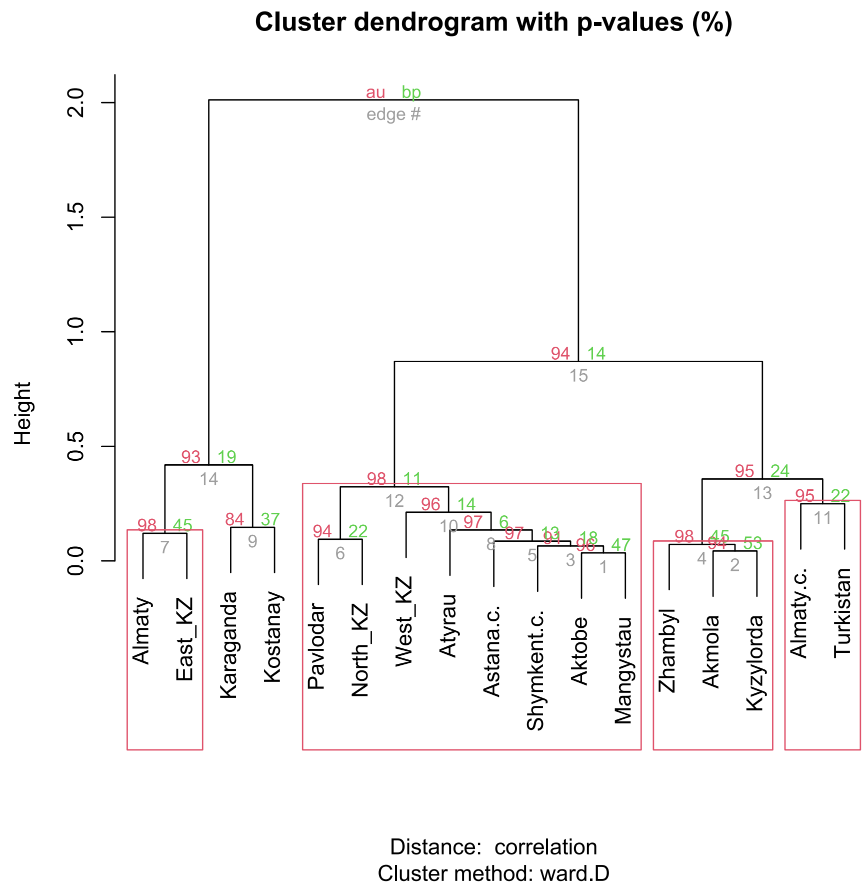

Figure 2. Clustering of Kazakhstan's regions by socio-economic development level

activity, and management inefficiencies limit opportunities for sustainable development. In order to clarify the structure of regional differences, hierarchical clustering was additionally carried out.

In addition to the centroid method, hierarchical clustering was conducted to test the internal consistency of the identified groups and to visualize the structural connections between the regions. The dendrogram reflects the degree of proximity of the regions in terms of the aggregate dynamics of social indicators and traces how the territories form stable groups based on similarities in the change directions. Moreover, the hierarchical approach reveals nested levels, borderline cases, and potential subgroups. The inclusion of a hierarchical structure enhances the interpretative potential of the analysis and confirms the reliability of the identified clusters. The dendrogram results confirmed the heterogeneity of regional development, and the results are presented in Figure 2.

The dendrogram, constructed based on directional changes in key social indicators, made it possible to identify a stable structure of regional groups. The use of agglomerative hierarchical clustering with a bootstrap stability assessment (AU *p*-value) confirmed the statistical reliability of the clusters, with AU values above 95%. The analysis revealed four distinct groups. The first included Astana city, Almaty city, Shymkent city, Mangystau, and Kyzylorda, where the most pronounced positive dynamics regarding quality of life, industrial growth and management, infrastructure, and employment were recorded. The second group – Karaganda, Pavlodar, Aktobe, Kostanay, West Kazakhstan, and Zhambyl – demonstrates balanced development without sharp fluctuations. The third included Turkistan, East Kazakhstan, and North Kazakhstan, with limited progression and low expression of social shifts. The fourth group is represented by the Akmola, Atyrau, and Almaty regions, which form an independent cluster with an intermediate trajectory and distinct management features that do not coincide.

Hierarchical clustering confirmed the segmentation previously identified by the centroid method and expanded the interpretive capabilities of the analysis by displaying levels of similarity and identifying transitional cases.

3.3. Evaluation of the dynamics of changes using Markov chains

An analysis of the relationships between regional transitions in terms of QLI showed that employment, industrial development, and education have the greatest influence on the dynamics of change (Table 7).

Table 7. Correlation matrix of transition quality

Category	Correlation (r) / Sig. (p)	QLI	IA	SC	SA
1. QLI	Pearson's r	–	–	–	–
	p-value	–	–	–	–
	Spearman's rho	–	–	–	–
	p-value	–	–	–	–
2. IA	Pearson's r	0.493	–	–	–
	p-value	0.052	–	–	–
	Spearman's rho	0.489	–	–	–
	p-value	0.054	–	–	–
3. SC	Pearson's r	0.000	0.040	–	–
	p-value	1.000	0.887	–	–
	Spearman's rho	0.000	0.040	–	–
	p-value	1.000	0.887	–	–
4. SA	Pearson's r	–0.036	–0.228	–0.026	–
	p-value	0.895	0.379	0.926	–
	Spearman's rho	–0.023	–0.228	–0.026	–
	p-value	0.933	0.379	0.926	–

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

The development of the industrial sector demonstrates the highest correlation with the quality of regional transitions in the QLI system. The Pearson coefficient between Industrial Advancement and QLI is $r = 0.493$ ($p = 0.052$), which is close to the level of statistical significance. This may indicate partial involvement of industrial development in the positive changes taking place in a number of regions. However, the absence of statistically significant relationships between quality transitions and other social blocks, in particular, education, social capital, and accessibility, indicates an asymmetry in structural growth. Industry, acting as the engine of macroeconomic expansion, does not provide a comprehensive social effect that would be reflected in sustainable institutional and educational improvements and management capacity. Such isolation of industrial growth from the social sphere can give rise to unstable development trajectories, in which the outwardly positive dynamics of QLI are not supported by long-term sustainability factors – primarily through human capital, employment, and institutional involvement. Thus,

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industrialization is recorded as a driver of economic activity, but not as a systemic factor of social transformation.

The absence of statistically significant relationships between the quality of social transitions and key components, especially education and social infrastructure, while the industrial factor dominates in the first correlation model, points to a structural gap between economic growth and social transformation. This disproportion creates risks of imitation development, in which regions demonstrate formal improvements in quality of life indicators without profound institutional changes and management reforms. In this regard, it becomes necessary to move from analyzing qualitative characteristics to assessing the quantity of transitions to identify how actively regions participate in social shifts. Quantitative transitions allowed recoding the intensity of changes, which is especially noticeable in education and employment, and becomes critically important for assessing the sustainability and reproducibility of the achieved effects. The second correlation model focused on the dynamics of regions' participation in the transformation process, specifying which factors contribute to their inclusion in social development (Table 8).

Table 8. Correlation matrix of transition quantity

Category	Correlation (r) / Sig. (p)	QLI	IA	SC	SA
1. QLI	Pearson's r	–	–	–	–
	p-value	–	–	–	–
	Spearman's rho	–	–	–	–
	p-value	–	–	–	–
2. IA	Pearson's r	0.210	–	–	–
	p-value	0.418	–	–	–
	Spearman's rho	0.316	–	–	–
	p-value	0.217	–	–	–
3. SC	Pearson's r	0.420	0.184	–	–
	p-value	0.094	0.479	–	–
	Spearman's rho	0.491	0.218	–	–
	p-value	0.045	0.401	–	–
4. SA	Pearson's r	–0.393	–0.073	–0.411	–
	p-value	0.119	0.781	0.101	–
	Spearman's rho	–0.485	–0.195	–0.410	–
	p-value	0.048	0.454	0.102	–

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

Analyzing the correlation dependence between the number of social transitions and integral indices revealed more pronounced interrelations than in the quality model. The statistically confirmed connection between the number of transitions and the level of Social Capital (Spearman's ρ = 0.491, p = 0.045), the main component of which is education, is especially significant. Consequently, in regions with a higher level of accumulated educational potential, there is a higher activity in changing social trajectories, which indicates the inclusion of human capital in the development process. Unlike the first model, where the industrial component had the primary influence, the educational base plays a key role in this model, providing conditions for transitions between development levels. There is also a negative connection between the number of transitions and the Social Accessibility indicator (Spearman's ρ = –0.485, p = 0.048), which may reflect a deficit of infrastructural opportunities in peripheral regions despite growth potential. The identified combination of active participation in transformation with limited access to social benefits points to the need to balance educational expansion and infrastructural support. Thus, the results of the second correlation model of quantitative transitions support the importance of education as a driver of social change and simultaneously reveal the limitations associated with the availability of social resources.

Due to the recorded discrepancy between the results of the two correlation matrices, by quality and quantity of transitions, a Markov chain matrix was constructed based on two matrices by region, formed by the QLI_Qual and QLI_Quant indicators. The goal of this stage was to identify the stability of trajectories, frequency, and direction of transitions of regions between different levels of quality of life. The resulting distance matrix, visualized as a heat map, complemented the results of cluster and index analysis, revealing stable differences in the nature and intensity of changes.

Figure 3 shows the results of the analysis of regional transitions by QLI.

The analysis of the distance matrix between the regions of Kazakhstan, based on the QLI_Qual and QLI_Quant indicators, revealed stable differences in the nature and intensity of changes in the quality of life. The minimum values of the Euclidean distance (0.0–1.0) are observed between Akmola, Aktobe, Almaty, Kyzylorda, and Almaty

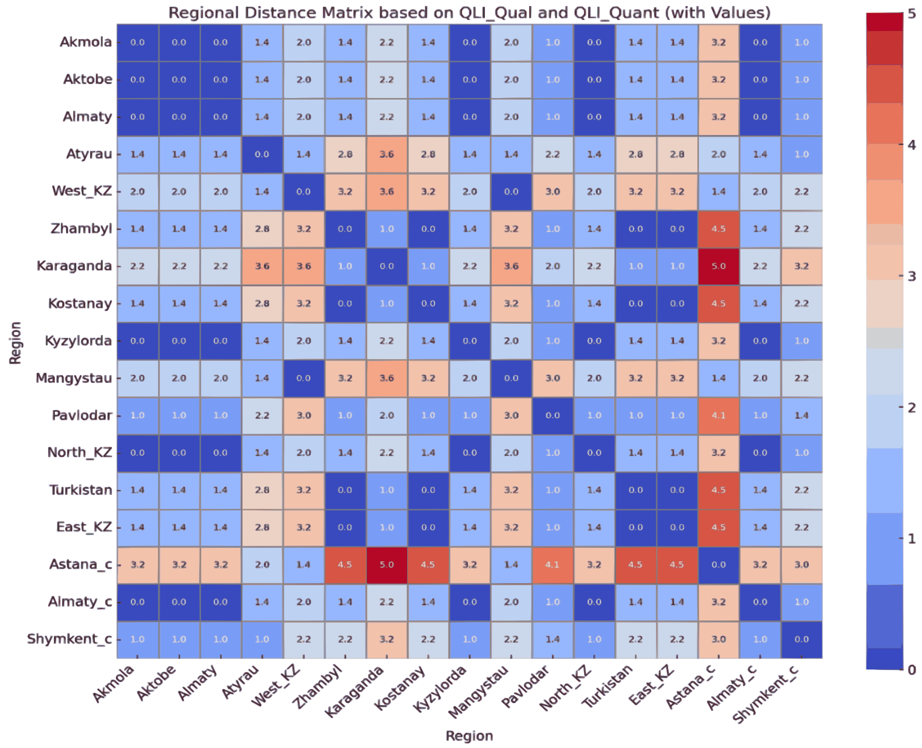

Figure 3. QLI transition matrix

city, where positive shifts are observed both in the quality and quantity of transitions, indicating a stable and consistent improvement in living conditions. One of the key factors contributing to such sustainable development is education: data on the education index indicate a balanced accumulation of academic potential, especially in terms of the level of training (BA, Master, Ph.D.) and management involvement, and the number of teaching staff. The similarity of the direction and accumulated effect of transformations is confirmed by the previously conducted clustering and stable positions in the structure of the integral index. At the same time, the group of regions of Turkistan, East_KZ, North_KZ, and Zhambyl is characterized by weak dynamics and low-intensity transitions. Despite individual fluctuations, structural changes in education, infrastructure, social accessibility, and management systems are limited. Insufficient investment in the education sector, low values for higher and postgraduate education indicators, and a shortage of qualified academic resources form signs of institutional stagnation. Such specificity is reflected in the heat map and the results of calculating generalized social indicators.

The most significant distance values (4.5–5.0) are recorded between Karaganda and Astana_c, as well as Zhambyl and Almaty_c, showing multidirectional dynamics: Karaganda demonstrates a steady decline in QLI_Qual with low transition activity, while Astana_c is characterized by a high frequency of transitions and a predominance of positive changes. A similar dichotomy is observed in the case of Zhambyl and Almaty_c. Such a contrast indicates a pronounced structural gap between regions in which transformation processes are accompanied by regression and territories demonstrating steady growth in social quality, including due to the systemic modernization of the educational sector.

4. DISCUSSION

The results confirmed the validity of the transition from economy-centric models to multidimensional approaches focused on institutional capabilities, management functions, and quality of life. The importance of components such as education, employment, digital infrastructure, and social accessibility reflects the capabilities proposed by Sen (1990), according to which capabilities are realized through education, health care, and institutional conditions, and supports the findings of Klugman et al. (2011) on the index sensitivity to

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education-related variables across regions. The increased values of the Social Capital index in regions such as Astana city, Shymkent city, and Kyzylorda confirm the approach of Sen (1994), which recognizes education and participation in social life as necessary conditions for human well-being. The results aligned with modern studies, including Pedro et al. (2020) and Cui et al. (2024), who regarded the educational environment as a key factor in regional development. The correlation analysis showed the absence of statistically significant relationships between the quality of social transformations and the level of education, which calls into question the universality of the conclusions of Rawls (1963) and Doyal and Gough (1984) regarding the decisive role of fair access to social institutions. The dominant influence of Industrial Advancement ($r = 0.493$, $p = 0.052$) confirms the observations of Toimbek (2022), who associated industrial growth with the general increase in macroeconomic performance. In contrast, regional disparity is observed in Atyrau, where industrial growth is not accompanied by corresponding improvements in education or institutional support, whereas in Astana city, industrial development coincides with sustained social advancement.

The second correlation block revealed a statistically significant relationship between the number of social transitions and the level of Social Capital ($\rho = 0.491$, $p = 0.045$), which aligns with the structure proposed by Alkire and Foster (2011) and Hirai (2017): education, social integration, and institutional mechanisms jointly shape sustainable development. In both frameworks, the institutional embedding of educational capacity is considered a necessary condition, but in the Kazakhstani regional context, the observed effect becomes measurable only when the educational potential is reinforced by broader social infrastructure – indicating a shift from theoretical sufficiency to structural dependency.

The negative association with Social Accessibility ($\rho = -0.485$, $p = 0.048$) contrasts with the claims of Hasan et al. (2022) and Mohan and Lyons (2024), who associated ICT availability with greater inclusion. In the current setting, the indicator of infrastructure access does not produce expected social effects in the absence of digital literacy and institutional facilitation. According to Alhassan and Adam (2021), in regions with weak institutional environments, the presence of ICT infrastructure does not translate into functional participation. Therefore, the same structural inputs may result in differentiated regional outcomes, depending on the presence or absence of reinforcing institutional and cognitive components.

In Turkistan and Almaty city, the coexistence of industrial growth with persistent social constraints mirrors the pattern described by Wilkinson and Pickett (2006) and Collison et al. (2010), where manufacturing expansion does not eliminate structural inequalities. In both Karaganda and East Kazakhstan, a similar misalignment was observed between sectoral development and the functioning of social and administrative systems. These cases correspond to the framework proposed by Bekbossinova et al. (2023), which models macroeconomic progress and social institutional lag as parallel yet insufficiently coordinated processes. However, the results of the current study reveal that the magnitude and persistence of identified mismatches are more regionally entrenched, particularly where governance systems lack integrative capacity across sectors.

The cluster and hierarchical analysis results demonstrate consistency with Noll's (2018) theoretical approaches, emphasizing the importance of institutional sustainability and transparency. Moderately developing regions such as Pavlodar, Karaganda, and Kostanay demonstrate balanced development with different sectoral specialization, which confirms the effectiveness of the multidimensional index approach proposed by Grasso and Canova (2008).

The steady increase in QLI values in Astana city, Mangystau, and Shymkent city confirms the findings of Zhiyenbayev et al. (2024) on the importance of integrated approaches combining environmental, social, and infrastructural aspects, and management practices. The coincidence between positive index values and multifactorial progress is consistent with the arguments of Estoque et al. (2019), who emphasize the role of vulnerability, infrastructure, and resource potential in assessing the quality of life. The simultaneous decrease in values in previously stable Karaganda, East Kazakhstan, and Almaty city and improvements in Turkistan and Shymkent city reflect the gap between planned and actual development results identified by Uskelenova and Nikiforova (2024). This highlights the importance of assessing dynamics through change trajectories, as shown by Rijpma et al. (2025), where the choice of indicators and the normalization method significantly impact the final results of the analysis.

Thus, the patterns identified in the study confirm the theoretical provisions on the relationship between education, industrial growth, and infrastructure accessibility and quality of life. At the same time, the discovered structural gaps between economic activity and social development indicate the need to strengthen the role of education, digital inclusion, and institutional regulation in the policy of sustainable regional development.

CONCLUSION

The goal of the current analysis was to evaluate key components of quality of life, focusing on human capital, social accessibility, and industrial development impact on effective territorial development management in Kazakhstan. The conducted analysis enabled the assessment of the dynamics of changes in the quality of life in Kazakhstan's regions. The paper revealed the importance of education, employment, and industrial development in shaping regional differences.

The employment indicator demonstrated the most stable and pronounced connection with the standard of living and the stability of socio-economic management. The impact of industrial development also proved to be significant, but the level of training of the workforce determines its effectiveness. In regions such as Atyrau and Mangistau, a high level of industrialization is accompanied by limited educational potential, which reduces the likelihood of moving to a higher quality of life cluster. At the same time, in the cities of Almaty, Astana, and Karaganda region, a higher level of educational infrastructure enhances the effect of industrial growth, providing qualified labor resources and a sustainable level of employment.

The results confirmed the mediating role of education in the relationship between industrial development and job creation, as well as its importance in ensuring sustainable territorial management. Regions with a developed educational system have a higher chance of improving their positions in quality of life clusters, while regions with a low level of personnel training more often remain in their current state or demonstrate slow growth. The formation of a skilled workforce and the ability to adapt to changes in the labor market, modernization processes, and institutional transformations largely depend on the level of education.

Social development and infrastructure showed less significance, which indicates their auxiliary nature in forming living conditions, but not their determining influence on long-term growth. Access to basic social services and public utilities remains an essential element of well-being, but it does not act as the primary factor in inter-cluster transitions.

Based on the findings, it is recommended to concentrate management efforts on the development of human capital in regions with industrial potential but limited educational infrastructure. Expanding access to vocational training, higher education, and advanced training programs will help to activate the socio-economic effects of industrial growth. The integration of the educational component into regional development management strategies will ensure a more sustainable and balanced improvement in quality of life.

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