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A MULTI-LEVEL SYSTEM OF STATISTICAL INDICATORS FOR REGIONAL TRANSPORT INFRASTRUCTURE ASSESSMENT: METHODOLOGY AND APPROBATION

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Abstract: This article presents the methodology and approbation results of an original multi-level system of statistical indicators for assessing regional transport infrastructure. The study addresses the limitations of existing one-dimensional approaches that fail to simultaneously account for road surface quality, demographic characteristics, and spatial features of territories. The research object is the transport infrastructure of the Republic of Karakalpakstan — the largest region of the Republic of Uzbekistan by area (166,600 sq. km). The proposed system comprises five indicator blocks: quantitative, qualitative, demographic, spatial, and economic. Based on these blocks, an integrated Infrastructure Transport Index (ITI) is calculated, enabling inter-district comparisons. The system was tested using data for 2000–2025 across 16 administrative units of the republic. The ITI values range from 0.14 (Qo'ng'iro't district) to 0.95 (Takhiatash district), indicating significant intra-regional disparities in transport provision. The results can be applied by government authorities in developing regional transport programmes.

Key words: transport infrastructure; statistical indicators; integrated index; transport provision; Republic of Karakalpakstan; regional statistics; road network.

INTRODUCTION

Transport infrastructure is one of the key factors determining the spatial development of the economy and ensuring the territorial connectivity of regions. The degree of its development largely determines the investment attractiveness of a territory, the quality of life of the population, and the competitiveness of the regional economy [1, 2]. At the same time, existing statistical accounting practices for transport infrastructure are generally limited to a narrow set of aggregated indicators—primarily total road length and road network density per unit area. Such an approach does not provide a comprehensive picture of the actual level of transport provision in a territory, especially in regions characterized by pronounced spatial heterogeneity.

The Republic of Karakalpakstan represents a clear example of such heterogeneity. With an area of 166,600 sq. km (37% of the territory of the Republic of Uzbekistan), population density ranges from less than 2 persons per sq. km in the northern districts to more than 1,500 persons per sq. km in urban agglomerations [3]. Under these conditions, the application of a single aggregated indicator of road provision is methodologically insufficient and may lead to inaccurate conclusions regarding the state of the regional transport system.

The scientific literature offers a variety of approaches to measuring transport provision, including the Engel coefficient [4], the transport accessibility index [5], and spatial connectivity indicators [6]. However, most of these approaches focus on individual aspects of infrastructure or are not adapted to regions with significant variation in population density and road surface quality. Therefore, the development of a comprehensive multi-level system of indicators that addresses these limitations represents a relevant and important scientific task.

The aim of this article is to present an original methodology for constructing a multi-level system of statistical indicators for the assessment of regional transport infrastructure and to test it using data from the Republic of Karakalpakstan for 2000–2025.

LITERATURE REVIEW

The theoretical foundations of the statistical assessment of transport infrastructure were established in the works of several domestic and international scholars. The classical works of Engel (1880) and subsequent studies introduced a coefficient that normalises road length with respect to territorial area and population size [4]. This indicator became widely used in Soviet and post-Soviet statistical practice; however, it does not fully account for variations in road surface quality.

Aschauer [7] empirically demonstrated that public investment in transport infrastructure has a significant positive effect on aggregate economic productivity. Canning and Pedroni [8] further developed this finding by establishing the existence of long-run cointegrating relationships between infrastructure indicators and GDP. Within the framework of the “new economic geography,” Krugman [9] substantiated the role of transport costs in shaping the spatial structure of the economy.

Among contemporary approaches to the multidimensional assessment of transport infrastructure, the works of Rodrigue et al. [10] are particularly noteworthy, as they propose a system of transport connectivity indicators covering physical, functional, and economic dimensions. Kumar and Barrett [11] developed a system of transport indicators for developing countries that encompasses both quantitative and qualitative road characteristics.

In the domestic scientific literature, issues related to the statistical analysis of transport infrastructure have been examined by Danilov [13] and Nosov [14], while in the context of the Central Asian region, relevant contributions have been made by Usmonov [15] and Rahimov [16]. Nevertheless, comprehensive methodologies that integrate qualitative, demographic, spatial, and economic indicators, particularly those adapted to arid regions with low population density, remain insufficiently developed in the existing literature.

The literature review highlights the following research gap: existing indicator systems tend to be either highly aggregated (limited to one or two indicators) or primarily designed for highly urbanised regions, which limits their applicability to large, sparsely populated territories. The present study aims to address this gap.

RESEARCH METHODOLOGY

3.1. Data Sources

The empirical basis of the study comprises: (1) data from the Statistics Agency of the Republic of Karakalpakstan on the permanent population of districts for 2000–2025; (2) information from the Ministry of Transport of the Republic of Karakalpakstan on the length and structure of public roads as of 1 January 2025; (3) data on the administrative-territorial division and the areas of districts; and (4) official statistics on gross regional product (GRP) for 2016–2024. The total dataset covers 26 time points (2000–2025) across 16 administrative units, forming a panel data structure.

3.2. Structure of the Proposed Indicator System

The developed multi-level system of statistical indicators comprises five interrelated blocks, each reflecting a distinct aspect of the region’s transport infrastructure.

Block I — Quantitative indicators — includes total road length across all categories (km), the length of paved roads (km), and the number of road infrastructure objects (bridges, overpasses, and junctions).

Block II — Qualitative indicators — accounts for the structure of road surfaces by type (cement concrete, asphalt concrete, black surface, gravel/crushed stone, and unpaved) and by road category (international, state, and local).

Block III — Demographic indicators — represented by the transport provision indicator (I_d), defined as the average number of kilometres of paved roads per 1,000 residents.

Block IV — Spatial indicators — includes the traditional road density indicator (I_s , km per thousand sq. km), as well as a transport connectivity indicator characterising the number of administrative centres connected by paved roads.

Block V — Economic indicators — reflects the relationship between transport infrastructure and regional economic development, including the ratio of GRP to paved road length, the growth rate of this ratio, and the correlation coefficient between infrastructure indicators and GRP.

3.3. Calculation of the Infrastructure Transport Index (ITI)

Based on indicators from Blocks III and IV, an integrated Infrastructure Transport Index (ITI) is proposed and calculated according to the following formula:

$$ITI = \alpha \times (I_d / I_d^{\max}) + \beta \times (I_s / I_s^{\max}), \text{ where } \alpha = \beta = 0.5$$

Normalising the indicators by their maximum values in the sample ensures the comparability of components measured in different units. The assignment of equal weights ($\alpha = \beta = 0.5$) is justified by the principle of methodological parity, as both dimensions—demographic and spatial—reflect independent and equally

important aspects of transport accessibility. If additional substantive hypotheses are available, the weights may be refined using principal component analysis or expert assessment methods.

Based on ITI values, all administrative units are classified into four clusters:

- I — high level ($ITI \geq 0.70$);
- II — medium level ($0.50 \leq ITI < 0.70$);
- III — low level ($0.25 \leq ITI < 0.50$);
- IV — critically low level ($ITI < 0.25$).

ANALYSIS AND RESULTS

4.1. Structure of the Road Network of the Republic of Karakalpakstan

As of 1 January 2025, the total length of public roads in the Republic of Karakalpakstan amounts to 4,172 km, including: international roads — 664 km (15.9%); state roads — 966 km (23.1%); and local roads — 2,542 km (60.9%). The structure of the road network by surface type is presented in Table 1.

Table 1. Structure of Roads in the Republic of Karakalpakstan by Category and Surface Type (01-01-2025)¹

Road Category	Length (km)	Cement Concrete (km, %)	Asphalt Concrete (km, %)	Black Surface (km, %)	Gravel (km, %)	Unpaved (km, %)
International	664	269 (40.5%)	342 (51.5%)	53 (8.0%)	0 (0.0%)	0 (0.0%)
State	966	0 (0.0%)	514 (53.2%)	443 (45.9%)	9 (0.9%)	0 (0.0%)
Local	2,542	0 (0.0%)	680 (26.7%)	1,783 (70.1%)	54 (2.1%)	25 (1.0%)
Total	4,172	269 (6.4%)	1,536 (36.8%)	2,279 (54.6%)	63 (1.5%)	25 (0.6%)

Analysis of Table 1 reveals a significant disproportion in road surface quality across different road categories. On international roads, the share of high-quality pavement (cement concrete + asphalt concrete) amounts to 92.0%, whereas on local roads it is only 26.7%. Given that local roads account for 60.9% of the total network, they play a decisive role in determining actual transport accessibility, particularly in rural areas. This finding highlights the importance of incorporating qualitative indicators into the assessment system alongside quantitative ones.

4.2. Calculation of Block III and IV Indicators by Districts

Based on population data for the 16 administrative units of the republic (2025) and the area of each district, the indicators I_d and I_s , as well as the integrated ITI index, were calculated. The results are presented in Table 2.

Table 2. Transport Provision Indicators and ITI Index by Districts of the Republic of Karakalpakstan (2025)²

District / City	Population (thous.)	Area (thous. sq. km)	I_d (km/ thous. pop.)	I_s (km/thous. sq. km)	ITI	Cluster
Nukus City	349.4	0.22	0.72	1,145.5	0.87	I
Takhiatash District	77.8	0.18	4.37	1,893.3	0.95	I
Qonliko'l District	54.8	0.74	6.20	459.5	0.72	I
Xo'jayli District	131.3	0.55	2.59	508.0	0.76	I
Chimboy District	117.1	1.44	2.90	236.1	0.65	II
Kegeyli District	75.9	0.92	4.48	370.7	0.68	II
Shumanay District	58.7	0.78	5.79	436.5	0.70	II
Nukus District	55.9	0.94	6.08	361.7	0.66	II
Amudarya District	218.7	1.02	1.56	334.3	0.56	II
Bo'zatov District	21.8	2.04	15.60	167.2	0.52	II
Beruniy District	212.6	3.95	1.61	86.3	0.38	III
To'rtko'l District	236.1	7.48	1.44	45.5	0.32	III
Qorao'zak District	54.8	5.89	6.20	57.7	0.29	III
Taxtako'pir District	38.9	21.12	8.74	16.2	0.21	IV
Mo'ynoq District	34.1	37.88	9.97	9.0	0.18	IV
Qo'ng'iro't District	138.4	76.00	2.45	4.5	0.14	IV

¹ Source: Ministry of Transport of the Republic of Karakalpakstan (2025).

² Source: Author's calculations based on data from the Statistics Agency of the Republic of Karakalpakstan.

The calculation results clearly demonstrate a substantial degree of intra-regional differentiation in transport provision. The range of the ITI index is 0.81 (from 0.14 to 0.95), and the coefficient of variation is 38.4%, indicating a high level of heterogeneity. Four districts are classified in Cluster I (high level), six in Cluster II (medium level), three in Cluster III (low level), and three in Cluster IV (critically low level).

It is important to emphasise that the traditional approach, based solely on road density (I_s), would produce a markedly different picture. The proposed two-dimensional ITI index helps to reduce this methodological limitation and provides a more balanced assessment.

4.3. Economic Indicators (Block V)

To assess the relationship between transport infrastructure and regional economic development, a correlation analysis was conducted. The Pearson correlation coefficient between paved road length and the GRP of the Republic of Karakalpakstan for 2016–2024 is $r = 0.981$ ($p < 0.01$), indicating a very strong positive linear relationship. The Spearman rank correlation coefficient confirms this result ($\rho = 0.967$).

The ratio of GRP to paved road length increased from 2.23 billion UZS/km in 2016 to 12.05 billion UZS/km in 2024, i.e. by a factor of 5.4. This trend suggests that economic growth has progressed at a faster pace than the expansion of the road network, which may be interpreted as a characteristic feature of the early stage of infrastructure modernisation.

The obtained results are consistent with a number of theoretical and empirical findings reported in the literature. The strong correlation between transport infrastructure indicators and GRP ($r = 0.981$) is in line with the findings of Aschauer [7] and Canning and Pedroni [8]. However, high correlation values alone do not allow definitive conclusions regarding the direction of causality: economic growth may either precede or follow infrastructure development [17]. Addressing this issue requires the application of Granger causality tests, which may be considered in further research.

The substantial intra-regional differentiation in transport provision identified in this study (coefficient of variation of ITI = 38.4%) supports the argument that aggregated regional indicators may conceal significant disparities in transport infrastructure accessibility across districts [10]. From a policy perspective, the results suggest prioritising investment in the transport infrastructure of the three Cluster IV districts (Qo'ng'iro't, Mo'ynoq, and Taxtako'pir), where ITI does not exceed 0.21, rather than applying a uniform investment distribution approach.

The methodological advantages of the proposed system compared to traditional approaches can be summarised as follows. First, it explicitly distinguishes between the demographic and spatial dimensions of transport accessibility, which is particularly important for regions with uneven settlement patterns. Second, the qualitative indicators block accounts not only for the presence of roads but also for their operational characteristics. Third, the economic block establishes a linkage between physical infrastructure parameters and economic performance.

Among the limitations of the study, the following aspects should be noted: (1) the absence of data on the actual technical condition of roads (e.g. potholes and rutting), which are not captured in official statistics; (2) the use of equal weights for ITI components, whereas optimal weights may vary depending on analytical objectives; and (3) the territorial specificity of the Republic of Karakalpakstan, which may limit the direct transferability of the results to other regions without appropriate adaptation.

CONCLUSION AND RECOMMENDATIONS

This article presents an original multi-level system of statistical indicators for the assessment of regional transport infrastructure, comprising five blocks: quantitative, qualitative, demographic, spatial, and economic indicators. Based on the indicators of the two central blocks, an integrated Infrastructure Transport Index (ITI) has been developed, providing a two-dimensional—demographic and spatial—assessment.

The approbation of the system using data from the Republic of Karakalpakstan for 2000–2025 demonstrates that: (1) ITI values across 16 administrative units range from 0.14 to 0.95, with a coefficient of variation of 38.4%; (2) three districts are classified within the critically low transport provision cluster; and (3) the correlation coefficient between paved road length and GRP is $r = 0.981$, confirming a strong relationship between transport development and the regional economy.

The theoretical contribution of this study lies in advancing the methodology of regional transport statistics for large, sparsely populated territories. Its practical significance is reflected in the potential application of the proposed tools by statistical agencies, sectoral authorities, and regional planning bodies to support the justification of investment priorities in transport infrastructure.

Further research may focus on verifying causal relationships using Granger causality tests, developing a methodology for optimising ITI weighting coefficients, and extending the proposed approach to other Central Asian regions with similar spatial characteristics.

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REFERENCES

1. Banerjee, A., Duflo, E., & Qian, N. (2020). On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics*, 145, 102442.
2. Calderón, C., & Servén, L. (2008). Infrastructure and economic development in Sub-Saharan Africa. *World Bank Policy Research Working Paper*, No. 4712.
3. Statistics Agency of the Republic of Karakalpakstan. (2025). *Key socio-economic development indicators of the Republic of Karakalpakstan*. Nukus.
4. Engel, E. (1880). Das Zeitalter des Dampfes in technisch-statistischer Beleuchtung. *Zeitschrift des Königlich Preußischen Statistischen Bureaus*, 20, 121–168.
5. Geurs, K. T., & van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies. *Journal of Transport Geography*, 12(2), 127–140.
6. Ducruet, C., & Notteboom, T. (2012). The worldwide maritime network of container shipping. *Global Networks*, 12(3), 395–423.
7. Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, 23(2), 177–200.
8. Canning, D., & Pedroni, P. (2008). Infrastructure, long-run economic growth, and causality tests for cointegrated panels. *The Manchester School*, 76(5), 504–527.
9. Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3), 483–499.
10. Rodrigue, J.-P., Comtois, C., & Slack, B. (2020). *The geography of transport systems* (5th ed.). Routledge.
11. Kumar, A., & Barrett, F. (2008). *Stuck in traffic: Urban transport in Africa*. World Bank.
12. Rodrigue, J.-P., & Notteboom, T. (2010). Comparative North American and European gateway logistics. *Journal of Transport Geography*, 18(4), 497–507.
13. Danilov, A. I. (2019). Methodology of statistical analysis of regional transport infrastructure. *Issues of Statistics*, 26(5), 43–57.
14. Nosov, S. I. (2021). System of indicators for assessing territorial transport accessibility. *Regional Economics: Theory and Practice*, 19(3), 486–508.
15. Usmonov, B. (2022). Statistical assessment of transport infrastructure in Central Asian regions. *Economics and Statistics*, 4, 78–89.
16. Rahimov, A. (2023). Transport infrastructure as a factor of regional economic development in Uzbekistan. *International Journal of Economics and Finance*, 15(2), 112–125.
17. Straub, S. (2011). Infrastructure and development: A critical appraisal of the macro-level literature. *Journal of Development Studies*, 47(5), 683–708.
18. Keunimzhaev, M. K. (2025). Statistical assessment of the development processes of the transport infrastructure of the region (on the example of the Republic of Karakalpakstan). *World Economics and Finance Bulletin*, 44, 282–285.
19. Keunimzhaev, M. K. (2026). Transport accessibility in Karakalpakstan: Spatial analysis and comparative assessment of districts. *Yashil Iqtisodiyot va Taraqqiyot*, 2, 1339–1343.

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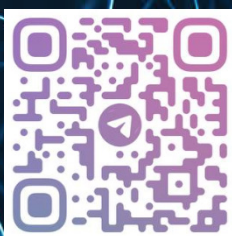
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