Analysis of public transport in Central Asian cities in comparison with leading cities in Southeast Asia and Europe: the search for sustainable urban solutions

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Abstract. With rapid urban growth and changing socio-economic factors, it is important to analyze the public transport systems of different geographical regions. This article is aimed at analyzing and comparing public transport in the cities of Central Asia, taking into account the experience of leading cities in Southeast Asia and Europe. The purpose of the study is to identify features, similarities and differences in transport systems to find sustainable urban solutions.

Keywords: Urban public transport, sustainable mobility solutions, socio-economic impact, environmental sustainability

1 Introduction

Modern cities are facing increasing challenges in urban mobility, and finding sustainable solutions for public transport is becoming a key challenge to ensure the comfort and satisfaction of citizens. This article aims to conduct a comprehensive analysis of public transport systems in Central Asian cities and compare them with leading cities in Southeast Asia and Europe. Let's consider several criteria that will be used for comparative analysis:

Public Transport Infrastructure: Assessing the readiness and effectiveness of existing public transport infrastructure in Central Asian cities compared to Southeast Asia and Europe.

Use of technology in transport systems: Analysis of the integration of modern technologies such as mobile applications and sensor technologies to improve the efficiency of public transport in cities.

Environmental Sustainability: A study of measures taken by cities to reduce their negative environmental impacts, including reducing emissions and switching to renewable energy sources.

Accessibility and Inclusion: Assessing the extent to which public transport systems meet the needs of all segments of the population, including people with disabilities.
The article analyzes the cities of Astana, Dushanbe, Bishkek, Tashkent (Central Asia), Singapore, Tokyo, Beijing, Moscow, Zurich, Stockholm, Paris, London (South-East Asia and Europe). Analyzing these criteria in the context of these cities will provide a deep understanding of the current state of public transport, and will also highlight best practices for creating sustainable and efficient urban transport systems.

2 Materials and Methods

2.1 Purpose of the study

The main goal of the study is a comprehensive analysis of public transport systems in Central Asia, followed by comparison with cities in Southeast Asia and Europe. To achieve this goal, the following tasks are set:

- Infrastructure Analysis: Assessing the level of readiness and efficiency of public transport infrastructure in Central Asian cities.
- Technological aspect: Study of the use of modern technologies in the field of transport, including the role of mobile applications and sensor technologies.
- Environmental sustainability: Analysis of measures aimed at reducing the negative impact of public transport on the environment.
- Accessibility and Inclusion: Assess the level of accessibility and inclusiveness of public transport, taking into account the needs of different population groups.

2.2 Research methodology

The study uses a complex methodological apparatus, including quantitative and qualitative methods:

- Quantitative Methods: analysis of statistical data to assess the effectiveness and structure of public transport parameters.
- Qualitative Methods: reviewing the literature to provide a deeper understanding of the theoretical aspects of the issue, as well as conducting content analysis to highlight key themes and trends in the discussion.

2.3 Data collection and analysis

A variety of methods were used to collect data, including:

- Analysis of open sources (official reports and data from city development plans).
- Observations (conducting research to provide an initial analysis of the actual operation of public transport systems using maps and other sources).

3 Results

In the analysis of public transport in the cities of Central Asia in comparison with the leading cities of Southeast Asia and Europe, a set of key criteria was selected that reflect various aspects of the interaction of the transport system with the socio-economic environment.

- Population: The size of the population determines the scale of transport needs and influences the organization of efficient transport infrastructure [1, 2].
- Population Density: The level of population concentration is a key factor in determining the convenience and efficiency of public transport.
Living wage or minimum wage: This criterion allows you to assess the accessibility of transport for various social groups, and also affects public accessibility.

Public transport tariff: Fare directly affects the use of public transport, so it is a key aspect for assessing its affordability.

Cost of labor protection from the minimum wage: This indicator reflects the relationship between labor safety and the economic opportunities of city residents.

Number of cars: The level of motorization indicates the transport infrastructure, environmental challenges and level of comfort [3,4].

The choice of these criteria was driven by the desire to develop a comprehensive understanding of the impact of public transport on urban life, including aspects of social justice, ecology and economic sustainability. The resulting summary table provides an opportunity to identify key trends and features, contributing to the development of more sustainable urban public transport solutions [5,6,7].

Table 1. Comparison of cities according to various indicators.

<table>
<thead>
<tr>
<th>City</th>
<th>Population</th>
<th>Population density per m2</th>
<th>Living wage or minimal salary ($)</th>
<th>Public transport fare (monthly, 2 times a day) ($)</th>
<th>% of minimum wage costs for labor protection</th>
<th>Number of cars per thousand people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astana</td>
<td>1 400 000</td>
<td>1 485</td>
<td>117,78</td>
<td>13,33</td>
<td>11,32%</td>
<td>239</td>
</tr>
<tr>
<td>Dushanbe</td>
<td>1 228 000</td>
<td>6 049</td>
<td>73,30</td>
<td>13,80</td>
<td>18,83%</td>
<td>87,2</td>
</tr>
<tr>
<td>Bishkek</td>
<td>1 145 000</td>
<td>6 806</td>
<td>90,00</td>
<td>13,20</td>
<td>14,67%</td>
<td>308</td>
</tr>
<tr>
<td>Tashkent</td>
<td>3 000 000</td>
<td>7 994</td>
<td>85,00</td>
<td>7,80</td>
<td>9,18%</td>
<td>193</td>
</tr>
<tr>
<td>Singapore</td>
<td>5 700 000</td>
<td>8 200</td>
<td>1 000,00</td>
<td>84,00</td>
<td>8,40%</td>
<td>110</td>
</tr>
<tr>
<td>Tokyo</td>
<td>14 040 000</td>
<td>6 400</td>
<td>1 075,00</td>
<td>84,60</td>
<td>7,87%</td>
<td>540</td>
</tr>
<tr>
<td>Beijing</td>
<td>18 522 000</td>
<td>4 324</td>
<td>355,00</td>
<td>33,60</td>
<td>9,46%</td>
<td>305</td>
</tr>
<tr>
<td>Moscow</td>
<td>13 200 000</td>
<td>5 257</td>
<td>245,00</td>
<td>40,80</td>
<td>16,65%</td>
<td>392</td>
</tr>
<tr>
<td>Zurich</td>
<td>443 000</td>
<td>4 666</td>
<td>4 000,00</td>
<td>285,00</td>
<td>7,13%</td>
<td>281</td>
</tr>
<tr>
<td>Stockholm</td>
<td>985 000</td>
<td>5 260</td>
<td>2 500,00</td>
<td>223,80</td>
<td>8,95%</td>
<td>404</td>
</tr>
<tr>
<td>Paris</td>
<td>2 148 000</td>
<td>20 781</td>
<td>1 705,00</td>
<td>108,00</td>
<td>6,33%</td>
<td>440</td>
</tr>
<tr>
<td>London</td>
<td>9 648 000</td>
<td>5 667</td>
<td>2 048,00</td>
<td>311,40</td>
<td>15,21%</td>
<td>350</td>
</tr>
</tbody>
</table>

To compare cities with each other on the basis of a summary table, a methodology for comparative analysis of public transport in cities is presented, based on five key criteria. Based on them, the city is assessed as a percentage [8,9,10].

1. Rail Transport. Assessing the accessibility of metro systems and tram routes is aimed at identifying the degree of use and convenience of this type of transport, which significantly affects the structure of urban mobility.

2. Environmental Safety. The study of environmental aspects of transport systems aims to identify the level of their impact on the environment, which provides an in-depth analysis of the environmental sustainability of urban transport.

3. Physical Security. Statistical traffic safety analysis includes crash data and road fatality rates, providing an informed perspective on creating a safe transportation environment for citizens.
4. Electronic Services. An assessment of the level of digital modernity in the transport system highlights key aspects of digital innovation aimed at increasing the efficiency of public transport.

5. Road Network. An analysis of the development and convenience of the road network is carried out with the aim of creating a balanced transport infrastructure that meets the modern requirements of megacities. Based on these indicators, a comparison was made of the four largest capitals of the Central Asian states (Fig. 1).

![Fig. 1. Comparison of Central Asian cities. Compiled by the authors.](image)

A comparative analysis of Central Asian cities provided an overview of several key aspects affecting their transport and environmental infrastructure. The study's findings provide a unique look at the strengths and weaknesses of each city in the region.

Rail transport in Tashkent stands out as the only city with a developed metro system in the capitals of Central Asia, which is an important factor for the efficiency of public transport.

In the field of e-services, Astana is a leader, providing technological innovations to improve transport accessibility and management.

Environmental safety indicators leave much to be desired in all cities, which emphasizes the urgency of the problem in the region.

In terms of physical safety, Tashkent is slightly ahead of other cities in the region, which may be important for increasing the comfort of citizens.

The road network in the region's cities is generally at a similar level, with Tashkent being slightly highlighted, likely due to infrastructure investment.

These aspects highlight the importance of comprehensive analysis to develop a deeper understanding of each city's strengths and weaknesses, which can serve as a basis for developing effective strategies to improve transport and environmental sustainability in the region.

Figure 2 provides a visual comparison of Tashkent with leading cities from other regions. This graphical analysis allows us to highlight the main characteristics and position of Tashkent relative to other world centers.
The issue of accessibility to public transport is closely related to the financial situation of the most vulnerable segments of the city's population. For a more in-depth analysis, a comparison was made of the direct costs of travel for a month, calculated for two trips per day, with the minimum wage \[11,12,13\]. This approach allows us to determine the percentage level of expenditure on public transport, which is reflected in Figure 3.

![Comparison of cities](image)

**Fig. 2.** Comparison of cities. Compiled by the authors.

The following key characteristics stand out from this study. Dushanbe stands out from other cities in terms of its high percentage of costs from the minimum wage, which is explained by the low standard of living in the country \[14,15\]. In the context of developed countries, residents of Moscow and London spend the largest percentage of their minimum wage on public transport. It should be noted that in some cities these costs are offset by benefits for vulnerable groups, and it is important to continue to implement such measures to support social justice.

![Travel costs compared to minimum wage](image)

**Fig. 3.** Travel costs compared to minimum wage. Compiled by the authors.
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4 Discussion

An important aspect is the impact of the development of rail transport on the sustainability of the urban transportation system. The study's findings confirm that cities with extensive metro and tram networks are generally more resilient. The presence of such infrastructure helps reduce pressure on road networks, reduce emissions and create more efficient transport systems.

The issue of accessibility of public transport in the context of pricing policy is also key in the conversation about sustainability. An analysis of the direct costs of travel relative to the minimum wage has highlighted the importance of ensuring affordability of transport services, especially in low-income countries. This aspect is essential for ensuring population mobility and promoting social justice.

In addition, general trends in the field of environmental and physical safety, the efficiency of electronic services and the comfort of road infrastructure are discussed. Low environmental safety indicators highlight the urgency of introducing environmentally friendly technologies into transport systems.

Electronic services and comfort levels also play a significant role in creating an attractive passenger experience. The study highlights their importance in ensuring the convenience of public transport.

5 Conclusion

This study analyzed the state of public transport in the cities of Central Asia, compared with similar data from Southeast Asia and Europe. The development of rail transport, especially the metro, has been identified as a factor that has a significant impact on the efficiency of the transportation system, distinguishing Tashkent among Central Asian cities.

The affordability of public transport represents a key issue in the study. Comparing direct travel costs with the minimum wage allowed us to highlight significant differences between cities, focusing on social justice in the field of transport services.

The negative environmental performance of public transport in the region highlights the need to develop innovative technologies and introduce environmentally friendly vehicles to improve the current situation.

We also believe it is important to highlight the need for further research in the field of public transport. Continued work in this area may include a more in-depth analysis of factors affecting passenger comfort and safety, taking into account technological innovations and developing measures to improve transport systems. It is also necessary to pay attention to social and environmental aspects, taking into account the changing needs and requirements of modern society. These subsequent studies will contribute to the creation of more effective strategies for improving transport infrastructure that can meet the challenges of modern urban development.
References


