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SUSTAINABILITY OF TRANSPORT SYSTEMS: THE CASE OF LARGE RUSSIAN CITIES

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Abstract
The article describes a study devoted to the assessment and analysis of the state of transport systems in Russian cities. The relevance of this topic is due to the fact that the transport system significantly affects the comfort of living in the city, its economic condition, the environmental situation in it, that is, it predetermines the sustainable development of the city. In this regard, the aim of the study was to study the sustainability of transport systems in large Russian cities. The study was based on such methods as scoring indicators and calculating the integral index on its basis, which demonstrated the degree of sustainability of urban transport systems. In the integrated assessment, various indicators were used that reflect three basic aspects of sustainable development: social, economic and environmental. Also, to compare cities, the method of ranking and analysis of the dynamics of individual indicators of transport development was used. The study found that while urban transport systems need to be improved. The key problem can be considered a decrease in the interest of residents of Russian cities in public transport. This negatively affects all aspects of the sustainability of transport systems. At the same time, the study of foreign experience has shown that to overcome this problem, it is necessary to reorganize and form a single intermodal transport system of the city, which is also relevant for modern Russian cities.
Keywords: city; transport; transport system; intermodal; sustainable development.

1. INTRODUCTION

In the modern urbanized world, large cities are becoming the main centers of development of society and states. In this regard, the issue of organizing a comfortable urban environment, in which a large number of residents can harmoniously exist, is becoming increasingly important. One of the basic questions of comfort in the conditions of motorization of society is the question of the development of transport systems in large cities. They must ensure that the different needs of a huge number of townspeople are met. They should also lay the foundation for the economic development of the city. In addition, modern transport must strictly comply with environmental standards, which are inextricably linked to the health of the

population and the comfort of life in the city. That is why the creation of sustainable urban transport systems is now becoming so urgent. (Kumar A., Anbanandam R., 2019)

A sustainable urban transport system can be considered an interconnected combination of vehicles, routes, subjects of transportation and management of transport infrastructure, capable of meeting the growing needs of the city population in transport and not having a negative impact on the environment. This concept originates in the concept of sustainable development, which implies a balance of social, economic and environmental aspects in the development of modern society. (Tian N., Tang S., Che A., Wu P., 2020)

One of the basic conditions for creating a sustainable urban transport system is its organization as an intermodal system, that is, a system that allows the use of different types of transport not as duplicating, but as complementary to each other. With such an organization of transport, it is possible to maximally satisfy the needs of citizens (social effect), relieve traffic arteries, speed up traffic in the city (economic effect) and reduce the amount of polluting emissions into the atmosphere (environmental effect). At the same time, the basis of such a system is not private transport, but specifically public transport, since its work is much easier to coordinate in order to form an intermodal system. (Lin H., Wei J., 2019; Goldman T., Gorham R., 2006).

In this regard, we can say that the practice of organizing transport in large cities and its compliance with the concept of sustainable intermodal transport systems is now interesting and promising. That is why, within the framework of this study, the practice of organizing transport systems of some of the largest Russian cities with a population of more than 1 million people was studied: Kazan, Yekaterinburg, UFA, Chelyabinsk, Voronezh. The main purpose of the study was to analyze and assess the state of transport systems of these cities in order to formulate recommendations for their development and improvement as sustainable transport systems.

2. MATERIALS AND METHODS

The aim of our study is to assess and analyze the state and sustainability of transport systems in Russian cities. To achieve this goal in the course of the study, we solved some problems, namely, we assessed the integral indices of the stability of transport systems in the largest cities of Russia, and also carried out a comparative analysis of the development of transport systems.

As already noted, the concept of sustainable transport systems involves the study of three main aspects: social, economic and environmental. Each of them includes many different characteristics and indicators that differ from each other in many ways. In this regard, the most convenient research method is the index

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method, which reflects the change in the aggregate of various values over a certain period. It was this method that was used as the main one in this study.

The methodology for calculating the integral index of the stability of transport systems included many indicators, divided into three basic thematic blocks:

- Social aspect – reflects the need of citizens for transport and ease of use;
- Economic aspect – reflects the economic costs of organizing the transport system and its functioning;
- Environmental aspect – reflects the potential harm of transport systems for nature and humans.

When calculating the sustainability index of transport systems, different types of indicators were used: absolute and relative, qualitative and quantitative. Such a variety of indicators made it possible to assess the state of urban transport systems from different angles. It also made it possible to assess the achieved level of transport development in each of the cities, and, at the same time, to conduct an objective comparison of cities in accordance with their area and number of inhabitants.

Due to the difference in the indicators used for their assessment, a different methodology was used, which made it possible to take into account each of them in the integral index.

To assess the quantitative indicators taken as of 2020, a point system was used on a scale from 0 to 10. The city with the best indicator was assigned a point 10. For the other cities under study, the assessment was calculated proportionally as:

$$R_i = \frac{10 * X_i}{X_{max}} \quad (1),$$

if the highest value of the indicator is recognized as the best,

$$R_i = \frac{10 * X_{min}}{X_i} \quad (2),$$

if the lowest value of the indicator among cities is recognized as the best.

Moreover, in formulas 1 and 2, Ri is the score of a particular city for a specific indicator, Xi is the value of the indicator of a given city, Xmax and Xmin are the maximum and minimum values of the indicator among the cities considered, respectively.

Qualitative indicators were also assessed on a scale from 0 to 10. This made it possible to compare qualitative and quantitative indicators and use them together in calculating the sustainability index of

urban transport systems. At the same time, the presence of a quality indicator in the city was assessed as a point 10, while the absence - as 0.

An overall score was calculated for each cluster. This made it possible to compare cities in separate blocks. For a more detailed analysis, individual indicators within the blocks were also considered in dynamics from 2014 to 2020. to identify general trends in their change.

The final index was calculated as:

$$I_i = \sum R_i \qquad (3),$$

where Ii is the integral index of an individual city, Ri is the city's score for each considered indicator of the development of the transport system.

To carry out a comparative analysis of the development of the city's transport systems, we also ranked from 1 to 5 places, where 1 place was taken by the city with the highest index score for the development of the transport system among the cities considered, and the 5 place was taken by the city with the lowest score among the cities considered.

The use of this technique made it possible to identify, based on the results of the study, some problems of organizing transport systems in large Russian cities, as well as to offer some recommendations for overcoming or reducing them.

3. RESULTS

The study carried out on the basis of the above methodology gave the following results.

The scoring of various indicators and the calculation of the integral index of the sustainability of urban transport systems are shown in Table 1.

The data in Table 1 allow us to draw a conclusion regarding each of the aspects of sustainable development of transport systems. So, Kazan turned out to be the leader in the social block. Its estimate is 49.42, which practically corresponds to the maximum possible estimate for this block. Within the framework of the economic bloc, Ufa is the leader. This city is significantly ahead of the rest of the considered cities in terms of the level of budgetary expenditures for the development of urban transport infrastructure. This factor ensures its leadership in this block. Yekaterinburg is the leader in the assessment of environmental indicators. His estimate is 27.18, which is more than 10 points, that is, 25% lower than the maximum possible estimate for this block. This fact suggests that Yekaterinburg, being the

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leader of this block, also has significant gaps in terms of environmental safety of urban transport, while the situation in other cities is even worse than in Yekaterinburg.

TABLE 1 - CALCULATION OF THE SUSTAINABILITY INDEX OF TRANSPORT SYSTEMS OF INDIVIDUAL CITIES OF RUSSIA

Indicator	Ekaterinburg	Kazan	Chelyabinsk	Ufa	Voronezh
Total length of city streets, km per city square	7,39	10	4,82	4,95	5,62
Total number of ground public transport units per 1000 population	10	9,74	8,22	7,24	8,92
Number of stops per sq. km	4,27	10	2,84	2,18	2,61
Availability of applications for tracking public transport	10	10	10	10	10
Number of cars per 1000 people	8,76	9,68	10	9,14	8,76
Social aspect	40,42	49,42	35,87	33,50	35,91
Possibility of non-cash payment of travel	10	10	10	10	10
The amount of fare payment in cash	8	10	6,57	5,71	6,57
Passenger traffic, thous.	10	8,36	6,25	9,51	7,57
State and municipal budget expenditures for the development of transport infrastructure	6,68	5,56	2,15	10	7,82
Economic aspect	34,68	33,93	24,98	35,22	31,97
Accidents per number of vehicles per 1000 people	9,32	5,86	5,71	5,63	10
Restrictions on the entry of private cars into the city center	0	0	0	0	0
Emissions of air pollutants, mobile waste sources per area of an entity, tons per sq km of area	10	4,94	8,48	9,31	5,27
Length of bike paths, km	7,86	10	6,66	9,71	6,60
Environmental aspect	27,18	20,8	20,85	24,65	21,87
Sustainability Index	102,29	104,15	81,7	93,37	89,75
City rank	2	1	5	3	4

You can also compare the assessments of each city for three blocks, having previously adjusted them taking into account the number of indicators in each of them. When comparing the estimates for the blocks, it was noted that for most of the cities considered, the estimate for the economic block turned out to be the highest. This suggests that while managing transport, the economic effect, that is, revenues from organizing public transport and the cost of developing transport infrastructure, are more significant. This partly contradicts the main goal of the social sphere in general and transport in particular - meeting the needs of the population of the territory. The lowest scores for each city are for the ecological block. This allows us to conclude that the transport systems of Russian cities are not yet fully consistent with the concept of sustainable development of the territory and its transport systems.

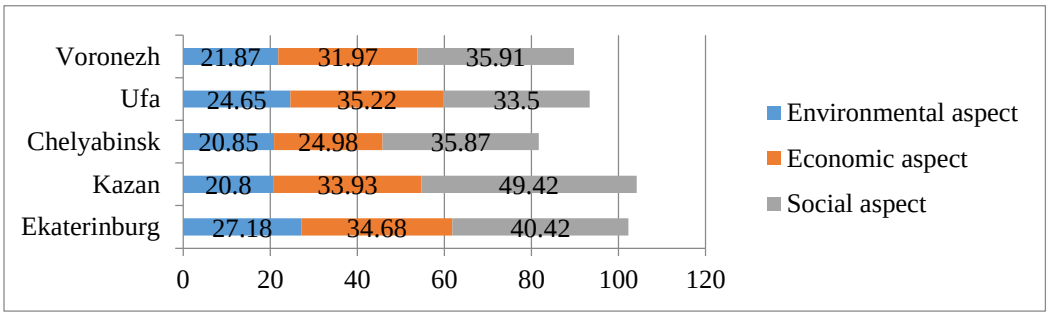

FIGURE 1 - GENERAL INTEGRAL ASSESSMENT OF THE STABILITY OF TRANSPORT SYSTEMS OF INDIVIDUAL RUSSIAN CITIES AND ITS COMPONENTS

If we compare the final integral assessments of cities (see Fig. 1), it can be noted that Kazan is the leader. The leadership of this city is provided with high marks in the social block (1st place) and in the economic block (2nd place after Yekaterinburg). However, we note that Kazan is an outsider in terms of the environmental factor and has the lowest rating among the cities under study. This fact also clearly demonstrates the conclusion that so far the environmental aspect remains the least significant in the organization of urban transport systems in the Russian Federation. Note that the final grade for Kazan is 104.15, which is almost 30 points (that is, almost ¼) less than the maximum possible integral grade. This fact indicates that now in the considered cities of Russia, the transport systems need to be changed in accordance with the concept of sustainable development.

When analyzing the transport system of each city, some dynamics were considered in more detail.

So, the indicator of the passenger traffic of public transport in each city was considered (see Fig. 2). This indicator was considered separately, since it reflects the need of society for public transport, and the possibility of earning income from the provision of transport services to the population. That is, this indicator is associated with both social and economic aspects of sustainable development of transport systems.

The data shown graphically in Figure 2, as well as the construction of a linear forecast based on them for each city, demonstrate, first of all, the general trend of reducing passenger traffic in all cities under consideration. If we compare these data with information about the level of motorization of the inhabitants of these cities, then the following can be noted. With more and more private cars, the utility of public transport is dwindling. Residents of the cities under study are beginning to use public transport less and less, preferring the comfort of a private car. At the same time, income from public transport services is falling, which stimulates an increase in prices for this service. The increase in the number of private cars leads to a slowdown in traffic in the city, which reduces the usefulness of the road network and public transport. In addition, it contributes to an increase in the number of road accidents on the roads. This

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conclusion is confirmed by the data on the dynamics of the number of accidents on the roads in the studied Russian cities. The ecology of the city suffers from the increasing emissions of carbon dioxide and other substances into the atmosphere from vehicles. This fact is confirmed by the analysis of the dynamics of such an indicator as the volume of emissions from transport of pollutants into the atmosphere.

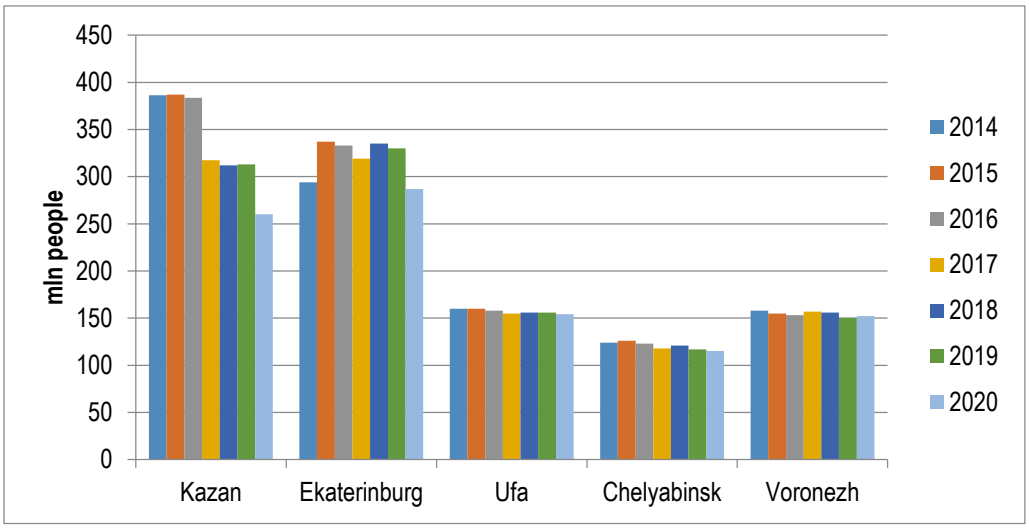

FIGURE 2 - PUBLIC TRANSPORT PASSENGER TRAFFIC IN SELECTED CITIES OF RUSSIA

Thus, it can be noted that the negative dynamics of passenger traffic negatively affects all the considered aspects of the stability of transport systems. In this regard, the following conclusion was made: so far, the transport systems of the studied Russian cities are not approaching, but, on the contrary, are moving away from the ideals of the concept of sustainable development of the territory and transport.

Based on the results of the integral assessment of the stability of the transport systems of Russian cities and the analysis of some individual statistical indicators, the following result was obtained:

1) While the level of stability of the transport systems of the considered Russian cities is far from ideal, that is, while these urban transport systems need to be improved in accordance with the concept of sustainable development;

2) At the moment, the economic factor has a more significant impact on the integral assessment of cities, while from the point of view of social orientation, transport systems, first of all, must satisfy the needs of society, that is, correspond to the social demand of the population of cities;

3) The least developed is the ecological aspect of the sustainability of transport systems. At the same time, environmental indicators are only deteriorating under the influence of motorization of the population of the studied cities;

4) The key problem in the development of transport systems of the cities under consideration is still a decrease in the population's interest in public transport. Against the background of general car ownership, residents of the cities under consideration are not so interested in using public transport. This situation is only exacerbated by the epidemiological situation in Russia and the coronavirus pandemic. At the same time, reduced passenger traffic in public transport has a negative impact on all aspects of sustainability. From a social point of view, this leads to a slowdown in traffic in the city and an increase in accidents. From an economic point of view, this reduces the profitability of public transport. From an environmental point of view, an increase in the number of private cars and a decrease in public transport passengers lead to an increase in air emissions.

3. DISCUSSIONS

The problem of the development of urban transport systems is relevant for most large cities in the developed countries of the world. At the same time, many cities have already been able to accumulate significant experience in overcoming transport problems. Let's turn to its consideration.

If we consider the experience of European cities, the following can be noted. The problem of reconstruction of urban transport systems arose in Europe in the second half of the 20th century.

In Germany, the Urban Transport Financing Act was passed in 1967 to improve urban transport systems. At the same time, taxes on gasoline were increased, and the network of public electric transport routes was significantly expanded. The network of public transport routes was formed as an intermodal system that encouraged the use of different types of passenger transportation. Due to this, the car flow has significantly decreased. In addition, the network of bike paths has been expanded. It also encouraged the abandonment of personal vehicles and had a positive impact on the environment. The result of such transformations, which began in the 60s, has been a gradual increase in passenger traffic since 1980. This indicates that the reorganization of transport systems takes a significant period of time and gives a result only after a long period.

The organization of intermodal transport systems by analogy with German cities was also resorted to in the cities of Austria, Switzerland, and France. At the same time, it was light rail transport that often became the basis of such systems. The residents' interest in using different types of transport was stimulated with the help of a "through" ticket, which could be used when transferring, as well as reducing the waiting time for transport.

The UK practice has shown that the creation of intermodal transport systems is significantly burdened by the development of private companies in the public transport market. The experience of British cities has

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shown that private carriers are not inclined to coordination, they are not interested in routes with less congestion, while duplicating popular routes in order to generate more income. This does not allow unloading the transport infrastructure, that is, it prevents the achievement of the stability of the transport system.

That is, foreign experience shows that the improvement of the transport system requires its reorganization as an intermodal system, which is based on the development of public transport. However, this process is quite long and gives its result only after a certain period of time.

If we turn to the documents on the strategic development of the considered Russian cities, it can be noted that the development of intermodal transport systems is not yet considered in them, which is an omission.

4. CONCLUSIONS

The study showed that urban transport systems are not yet fully consistent with the concept of sustainable development. The most promising, as the foreign experience shows, is the development of public transport. It allows you to reduce the flow of private cars. At the same time, traffic jams are reduced, traffic on the roads becomes freer and faster. Reduced emissions of pollutants from cars. At the same time, the transport system as a whole is approaching the idea of sustainable development.

At the same time, the development of public transport in Russian cities should correspond to certain trends. First, public transport must be organized as an intermodal system. That is, different types of public transport and their routes should not duplicate, but should complement each other. This will expand the area covered by public transport and optimize traffic. Second, greener modes of transport are prioritized. It could be electric vehicles. However, the development of such transport requires, as a rule, significant investments in infrastructure (creation of tram lines, subways, etc.) and is a long process. This must be considered when planning changes in transport systems. Vehicles such as buses can also be used. But here it is important to take into account that buses must run on fuel of a high environmental standard. The old bus models must therefore be replaced with more environmentally friendly new models. Thirdly, it is necessary to attract the attention of citizens to the use of different types of transport by means of "pass-through" tickets or reducing the waiting time.

Such measures will help stimulate the development of urban transport systems and make them more comfortable, convenient and useful for the population of Russian cities.

REFERENCES

Bolivar, M. P. R., Sanchez, R. G., Lopez Hernandez, A. M. (2015) Managers as drivers of CSR in state-owned enterprises. *Journal of Environmental Planning and Management*, 58 (5): 777-801.

Brunet, M. (2018) Governance-as-practice for major public infrastructure projects : A case of multilevel project governing. *International Journal of project management*, 37(2): 1-15

Dicks, R. S. (2000). The paradox of information: Control versus chaos in managing documentation projects with multiple audiences. Proceedings of the 18th annual ACM International Conference on Computer Documen- tation. Technology and Teamwork. Cambridge, MA, (pp. 253–259).

Ding S., Chunxin, J., Wu, Z., Zhang, X. (2014) Executive political connections and firm performance : Comparative evidence from privately – controlled and state – owned enterprises. *International Review of Financial Analysis*, 36(C): 153-167.

Eklund, A. R., Simpson, B. (2019) The Duality of Design(ing) Successful Projects. *Project Management Journal*, 51(2): 1-13.

Goldman, T., Gorham, R. (2006) Sustainable Urban Transport: Four Innovative Directions. *Technology in Society,* 28: 261-273.

Ilias Alami, Adam D Dixon. (2019) State capitalism(s) redux? Theories, tensions, controversies. *Competition & Change,* 24(1): 1-25.

Karolyi, G. A., Liano, R. C. (2013) State Capitalism`s Global Reach: Evidence from Foreign Acquisitions by State-owned Companies. *Journal of corporate finance*, 6: 1-55

Levine, O. (2017) Acquiring growth. *Journal of financial economics,* 126(2): 300-319.

Kumar, A., Anbanandam, R. (2019) Development of Social Sustainability Index for Freight Transportation System. *Journal of Cleaner Production,* 210: 77-92.

Leung, N. W., Cheng, M.-A.(2013). Corporate governance and firm value : Evidence from Chinese state-controlled listed firms. *China Journal of Accounting Research*: 6 (2): 89-112.

Lin, H., Wei, J. (2019) Optimal Transport Network Design for Both Traffic Safety and Risk Equity Considerations. *Journal of Cleaner Production,* 218*:* 738-745.

Megginson, W. L., Ullah, B., Wei Z. (2014) State ownership, soft-budget constraints, and cash holdings : Evidence from China`s privatized firms. *Journal of Banking & Finance*, 48 (C): pp. 276-291.

Musacchio, A., Lazzarini, S. G., Aguilera, R. V. (2013) New Varieties of State Capitalism: Strategic and Governance Implications. *Academy of Management Perspectives*, 29(1): 1-37.

Palcic D., Reeves E. (2013) State-owned Enterprise Policy and the Loss of Economic Sovereignty : The Case of Ireland. *Public Organization Review*, 13(2): 117-130.

Salovaara, P., Savolainen, J., Ropo, A. (2020) Project Is as Project Does : Emerging Microactivities and Play Ontology. *Project Management Journal*. 51(1): 49-61.

Sustainable Cities Mobility Index 2017. Bold Moves. – Arcadis Report 2017. – Retrieved from: https://www.arcadis.com/en/global/our-perspectives/sustainable-cities-mobility-index-2017/

Tian, N., Tang, S., Che, A., Wu, P. (2020) Measuring Regional Transport Sustainability Using Super-Efficiency SBM-DEA with Weighting Preference. *Journal of Cleaner Production,* 242: 77-92.

Vuchic, V. R. (1999) *Transportation for Livable Cities*. CUPR/Transaction.

Vuchic, V. R. (2007) *Urban Transit Systems and Technology*. John Wiley & Sons.