IRSTI 39.21.02 https://doi.org/10.26577/JGEM.2023.v70.i3.03

L.B. Kenespayeva[1*], T.K. Rafikov[2], A.N. Mussagaliyeva[1]

[1]Al-Farabi Kazakh National University, Kazakhstan, Almaty
[2]The Kazakh State Agrarian Research University , Kazakhstan, Almaty
*e-mail: laura.kenespaeva81@gmail.com

ANALYSIS OF THE TRANSPORT INFRASTRUCTURE OF ALMATY CITY USING GIS-TECHNOLOGIES

The transport system plays a key role in the development of cities. It has a direct impact on many aspects of city life and infrastructure. An efficient transportation system helps move goods and people faster and cheaper, which contributes to a city's economic growth. A well-developed transport infrastructure can also attract investment and create new employment. The purpose of the study is to research the transport infrastructure of Almaty through the use of geographic information technologies. The use of geographic information technologies to research the transport infrastructure of the city of Almaty is a very promising approach. GIS enables the analysis and visualization of spatial data, which can lead to a deeper understanding of the relationships between transport and urban development. GIS can be used to estimate traffic volumes on different road sections and at different times of the day. This makes it possible to identify areas with the highest load and possible bottlenecks in the transport network. The article presents the results of a social survey among residents of Almaty. Including a social survey among city residents and conducting a SWOT analysis provides a complete picture of the current situation and prospects for the development of the transport network. These methods and analyzes are important tools for improving a city's transportation system and increasing the satisfaction of its residents.

Key words: transport infrastructure, geoinformation systems, spatial development, Almaty.

Л.Б. Кенеспаева[1*], Т.К. Рафиков[2], А.Н. Мусагалиева[1]

[1]Әл-Фараби атындағы Қазақ ұлттық университеті, Қазақстан, Алматы қ.
[2]Қазақ ұлттық аграрлық зерттеу университеті , Қазақстан, Алматы қ.
*e-mail: laura.kenespaeva81@gmail.com

ГАЖ технологияларын пайдаланып Алматы қаласының көлік инфрақұрылымын талдау

Қалаларды дамытуда көлік жүйесі шешуші рөл атқарады. Ол қала өмірі мен инфрақұрылымының көптеген аспектілеріне тікелей әсер етеді. Тиімді көлік жүйесі тауарлар мен адамдарды тезі және арзан тасымалдауға көмектеседі, бұл қаланың экономикалық өсуіне ықпал етеді. Жақсы дамыған көлік инфрақұрылымы да инвестиция тартуға және жаңа жұмыс орындарын ашуға мүмкіндік береді. Зерттеудің мақсаты – географиялық ақпараттық технологияларды қолдану арқылы Алматы қаласының көлік инфрақұрылымын зерттеу. Алматы қаласының көлік инфрақұрылымын зерттеу үшін географиялық ақпараттық технологияларды пайдалану – өте перспективалы тәсіл. ГАЖ кеңістіктік деректерді талдауға және визуализациялауға мүмкіндік береді, бұл көлік пен қала дамуы арасындағы қарым-қатынастарды анықтауға мүмкіндік береді. ГАЖ әртүрлі жол учаскелерінде және тәуліктің түрлі уақыттарында қозғалыс көлемін бағалау үшін пайдаланылуы мүмкін. Бұл көлік желісіндегі ең жоғары жүктеме және кедергілер мүмкін бар аймақтарды анықтауға мүмкіндік береді. Мақалада Алматы тұрғындары арасында жүргізілген әлеуметтік сауалнаманың нәтижелері берілген. Соның ішінде қала тұрғындары арасында әлеуметтік сауалнама жүргізу және SWOT-талдау жүргізу көлік желісін дамытудың ағымдағы жағдайы мен перспективаларының толық бейнесін береді. Бұл әдістер мен талдаулар – қаланың көлік жүйесін жақсарту және оның тұрғындарының қанағаттануын арттырудың маңызды құралы.

Түйін сөздер: көлік инфрақұрылымы, геоақпараттық жүйелер, кеңістікті дамыту, Алматы.

Л.Б. Кенеспаева[1*], Т.К. Рафиков[2], А.Н. Мусагалиева[1]
[1]Казахский национальный университет имени аль-Фараби, Казахстан, г. Алматы
[2]Казахский национальный аграрный исследовательский университет , Казахстан, г. Алматы
*e-mail: laura.kenespaeva81@gmail.com

Анализ транспортной инфраструктуры города Алматы с использованием ГИС-технологий

Транспортная система играет ключевую роль в развитии городов. Она оказывает непосредственное влияние на множество аспектов городской жизни и инфраструктуры. Эффективная транспортная система способствует более быстрому и дешевому перемещению товаров и людей, что способствует экономическому росту города. Хорошо развитая инфраструктура транспорта также может привлекать инвестиции и создавать новые рабочие места. Целью исследования является изучение транспортной инфраструктуры г. Алматы посредством использования геоинформационных технологий. Использование геоинформационных технологий для изучения транспортной инфраструктуры города Алматы является весьма перспективным подходом. ГИС позволяют анализировать и визуализировать пространственные данные, что может привести к более глубокому пониманию взаимосвязей между транспортом и развитием города. ГИС могут использоваться для оценки интенсивности движения на разных участках дорог и в разное время суток. Это позволяет выявить места с наибольшей нагрузкой и возможные узкие места в транспортной сети. В статье приведены результаты социального опроса среди жителей г. Алматы. Включение социального опроса среди жителей города и проведение SWOT-анализа дает полную картину текущей ситуации и перспектив развития транспортной сети. Эти методы и анализ являются важными инструментами для улучшения транспортной системы города и повышения уровня удовлетворенности его жителей.

Ключевые слова: транспортная инфраструктура, геоинформационные системы, пространственное развитие, Алматы.

Introduction

The transport infrastructure traditionally acts as the most important sphere of social production and occupies a special place in the system of a single economic complex of the country. It serves as the material basis for the division of labor in society and provides a diverse link between production and consumption, industry and agriculture, mining and processing industries, and between different economic regions. In general, the level of economic and technological efficiency of the functioning of all sectors of the economy of the region largely depends on the work of the transport industry (Semak Y.A., 2017).

Given the nature of cities as a complex system of economic, social and political activity, many different research approaches have been used to understand the complex structure of urban activity and forecast its future spatial development (Aljoufie M., 2011, Panfilov A.V., 2020).

However, there was no developed universal method or model. The development of the transport system is a consequence of further restructuring of the country's economy and leads to an increase in the consumption of domestic goods and services in the world market (Chimitdorzhieva E.C., 2013)

It has been scientifically established that there is a relationship between transport and urban growth. To understand this relationship, it is necessary to assess urban spatio-temporal changes and their associated causes and effects. It has been established that the expansion of the transport situation is strongly correlated with population growth, spatial expansion and changes in land use (Roj O. M., 2021) Achieving economic growth, improving the quality of life of domestic producers, improving the standard of living of the population and strengthening national security largely depends on the quality of the economic space, therefore, expanding the use of opportunities that affect its properties, expanding coverage is a transport infrastructure (Hristoforov, A.M., 2008)

The transport system is not so much the presence of appropriate mobile stock, means of communication and skilled workforce, but rather a special infrastructure and services for the transport process, communication hubs and unified dispatch service, which together make it possible to ensure the necessary speed of delivery of goods and passengers (Bazarbekova M.M., 2020, Budarova V., 2018).

Sustainable development is most relevant for cities that are hubs of various problems. One of the most acute for cities is the transport problem, ensuring high mobility of the population. Rampant motorization exacerbates the transport situation and

reduces the quality of life of citizens (the time spent on movement is increasing, the emission of pollutants is growing at a faster pace, the shortage of urban land limits the development of the road network and parking spaces, etc.) (Grishaeva J. M., 2018, Gudina T.T., 2022, L. Yang, 2020, J. Lee, 2020). The pursuit of sustainability is at the forefront of modern planning initiatives. However, the most recent research has focused on the environmental and economic aspects of developing a sustainable urban environment, while the social aspects have been largely ignored [N. Cuthill, 2019].

Kazakhstan scientists are conducting various studies on the analysis of urban transport systems in the city of Almaty, a theoretical justification has been carried out to improve the system of managing urban traffic flows in Almaty, and measures are proposed to improve and effectively manage urban transport systems (Smoljar I.M., 2008, Vuchik V.R., 2011, Zhanbirov Z.G, 2018, Molgazhdarov A.S., 2018).

The aim of the study is to research the transport infrastructure of Almaty using geographic information technologies and its impact on the spatial development of the city. During the study the current state of the transport system in Almaty, the problems and prospects for its development were considered. To identify the main problems of transport infrastructure the authors of the article conducted an online social survey among the population of Almaty.

Materials and methods

This research uses the theoretical and methodological analysis of scientific literature, methods of comparative, statistical analysis, GIS methods, structural analysis. To analyze the dynamics data for 2011-2021 were collected from statistical collections of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, monographs, scientific articles, publications and other sources.

Also to consider the impact of the transport system on the spatial development of the city of Almaty a social experiment method was chosen, namely a social survey. The specificity of the study lies in the fact that within the framework of the social survey special sociological methods of collecting information were used, as well as special sociological technologies, including sampling.

For this social survey, respondents were selected from among the residents of the city of Almaty, different districts, professions and ages. According to sociologists, for a city with a population of almost 2 million people, this sample is considered representative. 480 people participated in the survey, including 275 women and 205 men, people of different ages and different fields of activity participated.

Results and discussion

Almaty is the former capital (until 1998) and one of the largest cities of republican significance in the Republic of Kazakhstan, with a population of 2,005 thousand people at the end of 2021 (Statistics Committee, 2021). The city consists of 8 districts: Bostandyk, Auezov, Alatau, Almaly, Zhetysu, Medeu, Turksib and Nauryzbai. The city of Almaty is the financial and cultural center of the republic. More than 80% of the country's banks, more than 60 offices of international companies, the National Bank, and the stock exchange are located here. Almaty ranks 1st in the country in terms of GRP (19.5% in 2019) and is a center for the development of small and medium businesses.

Almaty is a major logistics hub on the Western Europe – Western China route. The city is connected by major intercity and international road, rail and air communications. The city is also one of the busiest in the road plan (Fig. 1.).

At present, due to migration and natural growth, the population of Almaty is growing, and accordingly, the need for the development and competent organization of transport infrastructure is also growing.

In total the population in Almaty uses 3 types of transport, respectively, these are cars and taxis (including motorcycle and bicycle transport), public transport (buses and trolleybuses), as well as the metro. Every year there are various changes in the use of public transport, that is, electric buses have appeared, the Onay system is functioning in the city – within the framework of the project "Automated accounting and payment system for public transport in Almaty", elements of a smart city are being designed, special road bus lines, changes were made to the general plan of the city, namely the creation of new metro lines (General plan, 2021)

The process of work of the local executive bodies that influence the business and investment climate in the region has a great influence on the spatial development of Almaty. One of the main tasks is the development and use of transport statistics and the removal on this basis of the presence of restrictions for the development of small enterprises and industries (State program, 2010).

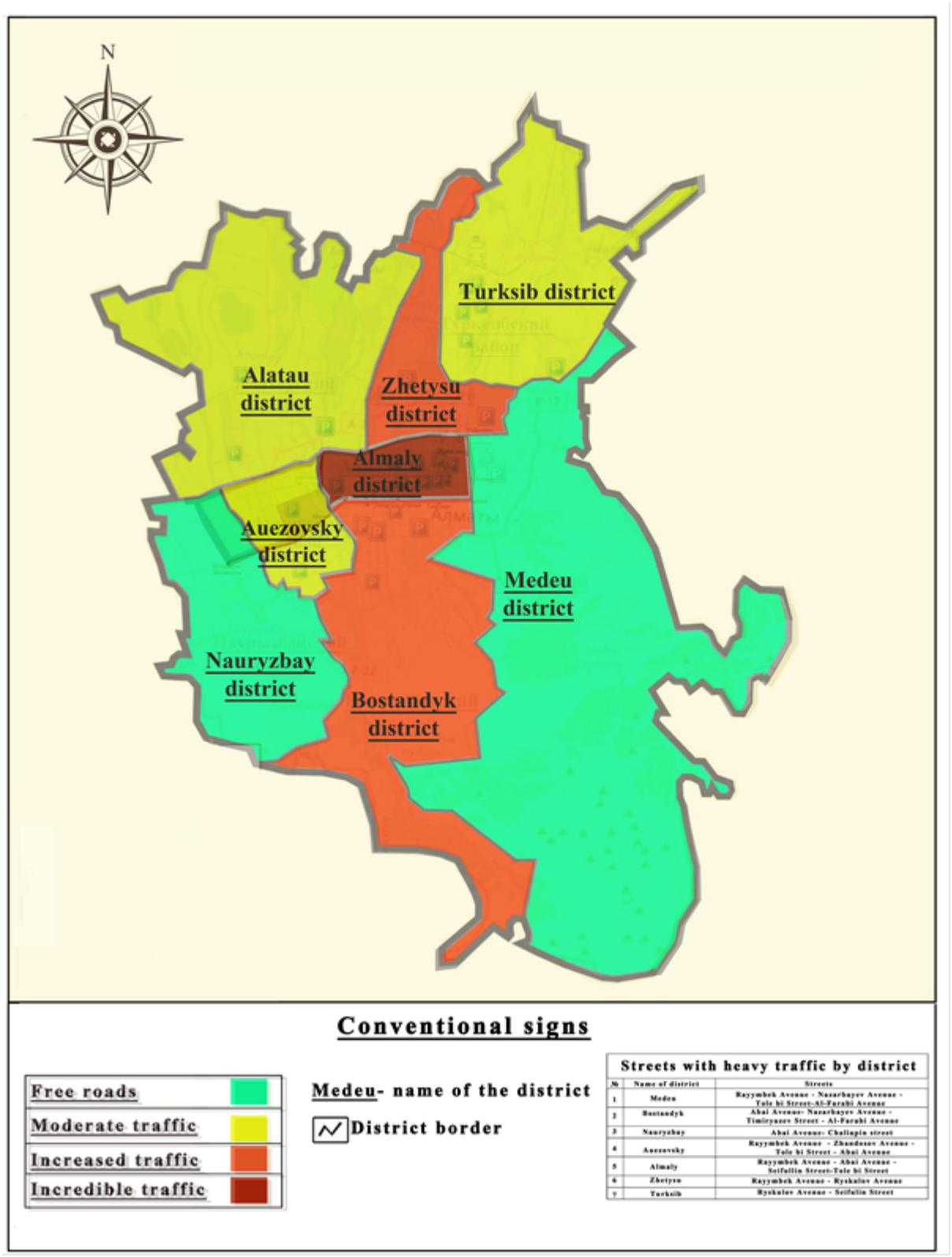

Figure 1 – Traffic conditions by districts in Almaty

As a result of monitoring statistical data with the help of geographical information systems, a map of the tension of roads in the center of Almaty was compiled. (Figure 2.).

Real-time or near-real-time traffic data can help authorities and commuters make informed decisions about their routes. It can also allow traffic management systems to optimize traffic flow and reduce congestion.

Urban planners can use this data to identify areas with high traffic congestion and plan improvements to transport infrastructure, such as adding new roads, expanding existing ones, or implementing public transport solutions.

Reducing traffic congestion can have a positive impact on air quality and reduce greenhouse gas emissions. Planning an efficient transport system can help create a more sustainable city.

As a result of monitoring of statistical data, a table of main risk indicators for the city of Almaty for 2011–2021 was formed:

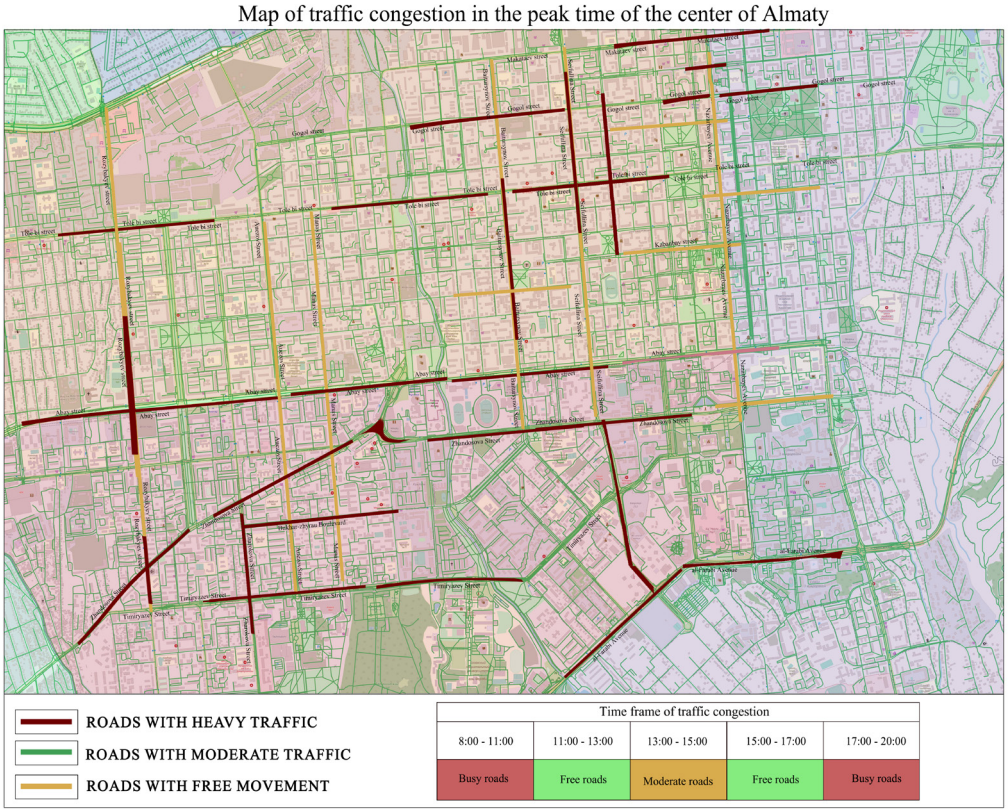

Figure 2 – Map of traffic congestion in the peak time of the center Almaty

Table 1 – The main transport indicators of Almaty for 2011-2021

Transport indicators \ Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cargo turnover of all types of transport, million tons	16 130,5	17 957,6	18 928,4	21 780,3	21 535,3	23 745,7	27 482,8	37 756	20 803	23 606	23 097,4
Transportation of goods by all modes of transport, million tons	109,2	108,2	115,5	111,5	106,5	108,7	100,9	247	257	252	246,0
Passenger turnover of all types of transport, million people	3 190,6	3 802,7	4 238,8	4 808,6	4 984,8	4 984,2	5 092,7	5 202,2	5 589	1 949	1 849,0

As can be seen from Table 1, in connection with the coronavirus infection (COVID-19) pandemic in 2019-2021, passenger traffic decreased by almost three times. Restrictive measures were gradually introduced, a state of emergency, and one of the reasons for the sharp decrease in freight traffic is the special state of the geopolitical situation in the region.

Further, for detailed research of public transport in the city of Almaty, the composition of transport for the period 2013-2019 is presented.

Table 2 – The composition of public transport in Almaty in the period 2013-2019

Years / Name	Unit of measure	2013	2014	2015	2016	2017	2018	2019
Number of all public transport	units	11030	9860	9566	9280	8655	8537	8980
Including:								
Buses	units	10757	9614	9327	9058	8433	8315	8758
Trolleybuses	units	239	212	215	215	215	215	215
Tramways	units	27	27	17	-	-	-	-
Metropolitan	units	7	7	7	7	7	7	7

There is a decrease in the dynamics of the number of public transport from 2013 to 2019 (table 2). Since 2015, the tram service in the city has been discontinued due to the need for transport reforms, the construction of light rail transport (LRT) was planned, and construction work is currently underway. Since 2016, the bus fleet has been regularly updated and a large number of electric buses have been introduced (Pelkmans M., 2008).

Satisfaction of the city population with the existing transport infrastructure is a very important issue. Both the quality of life of the urban population and the overall economic development of the city depend on this. For the development of any space, it is necessary to conduct a close dialogue with its inhabitants, which will ultimately allow us to identify the strengths and weaknesses of the city's transport infrastructure.

In connection with the COVID-19 pandemic, we conducted a social survey on the problems of the transport infrastructure of the city of Almaty in an online format using the modern Google Form service, thanks to which a large number of people passed the survey. Thanks to this service (Google form), the respondents were not afraid for their anonymity, thus the honesty during the survey was at a high level.

Also, with the help of various online services for conducting surveys, the coverage of respondents is rapidly increasing and spreading, and the conduct of the social survey itself is also possible without its administrator (survey owner).

The main objective of this survey was to identify the main problems of the Almaty transport system among the local population. To obtain correct data on the state of transport services in the city of republican significance of Almaty, respondents were asked to indicate the area they live (Figure 4).

For this social survey, respondents were selected from among the residents of the city of Almaty, different districts, professions and ages. According to sociologists, for a city with a population of almost 2 million people, this sample is considered representative. 480 people participated in the survey, including 275 women and 205 men, people of different ages and different fields of activity participated. Figure 3 shows the age chart of the respondents.

As we can see from this diagram, the main age of the respondents is up to 40 years, that is, they are both schoolchildren, students (178 people under the age of 25) who constantly, actively use public transport, and older people, most of whom use personal transport (201 people aged 26 to 40).

Great emphasis on the number of respondents was placed on the areas with the highest density: Almaly, Auezov and Bostandyk districts. These areas are characterized by a high population density and accordingly, a high level of transport infrastructure is required (Smoljar I.M., 2008, Vuchik V.R., 2011). In accordance with this need, the respondents were asked to answer the question: "What type of transport is most preferable for you?". 54.3% of the 480 respondents exactly 261 people chose buses and trolleybuses. Currently, 131 bus lines operate in Almaty, some of which provide a connection

between the city and cities located near Almaty. In addition, some buses (about 800 units) were switched to natural gas (Burak P., 2014). Thus, public transport is the main mode of transport for the population and requires an appropriate level. Currently, due to modern geographic information systems, the public transport planning system and the search for the optimal route have been automated. Passengers know the schedule of each bus, it is displayed at bus stops, and due to online technologies, we can see in which part of the city any bus travels and see the status of traffic jams. All these indicators have a positive effect on the spatial development of the city of Almaty.

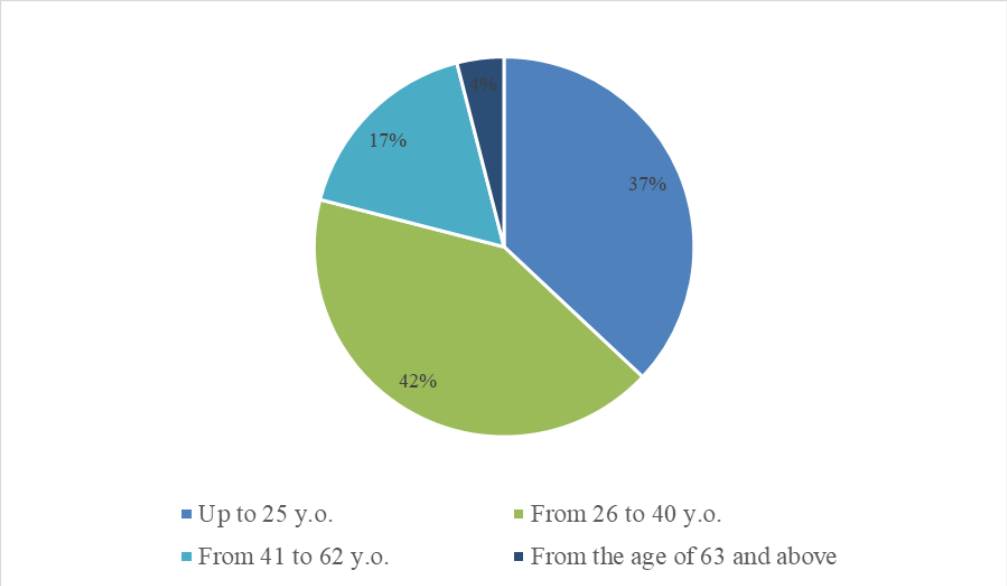

Figure 3 – Age of the respondents participated in the social survey on the quality of transport services in Almaty, 2021

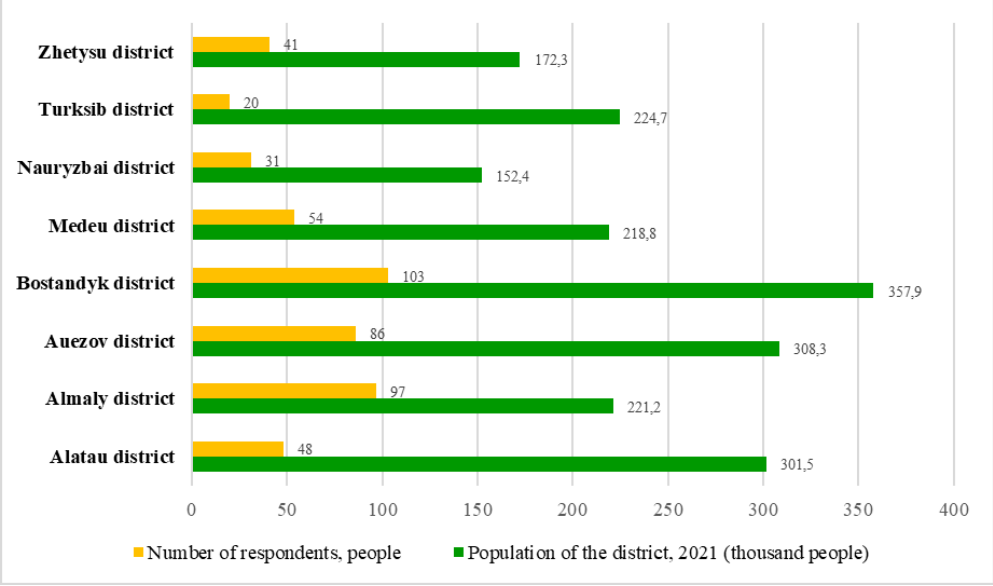

Figure 4 – Number of respondents depending on the area of residence in Almaty

To identify problems in the use of public transport, the respondents were asked the question: "What are the reasons, in your opinion, to prevent more frequent use of public transport?" For this question, you could choose several answers or offer your own option, the results are shown in Figure 5.

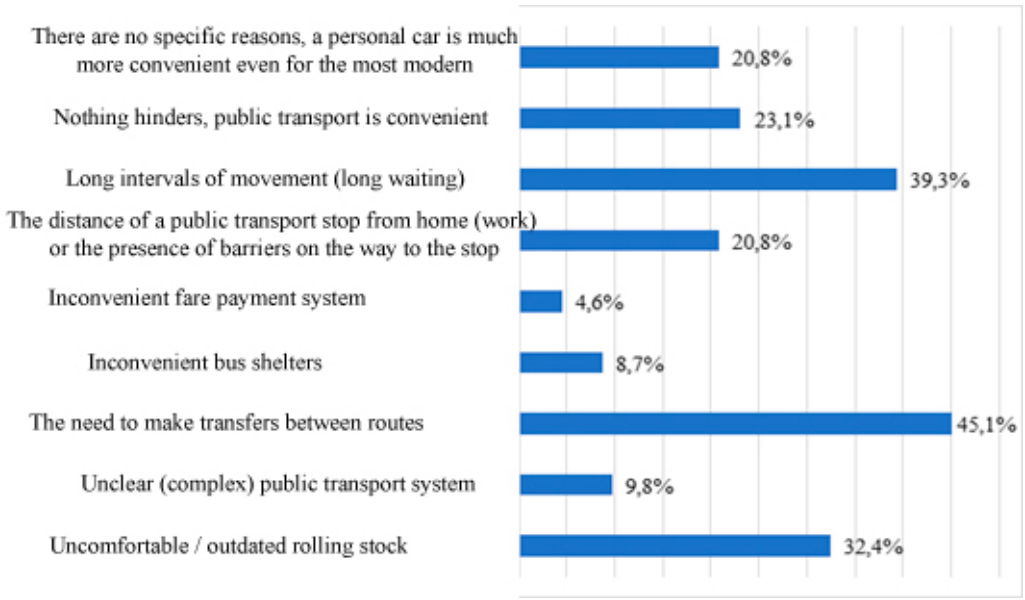

Figure 5 – The main reasons for the infrequent use of public transport among the respondents of the social survey.

The survey showed the main reasons that prevent the population from actively using public transport. As we can see, the main reasons are the need to make transfers between routes, long waiting times for some routes, and uncomfortable rolling stock.

On the question "Are you satisfied with the quality of service from the staff of organizations providing transport services?", 68.5% of respondents (329 people) answered that they were satisfied; 31.5% (151 people) answered that they were not satisfied.

A big plus of the transport system, as revealed by the survey, is considered to be a single payment in buses, trolleybuses, metro. Thanks to one card, city residents can move around using non-cash payments. Also, for the convenience of using these cards, there is an application through which you can monitor the amount on the card, build a route, and also see where the desired bus is located.

The main problem of Almaty, according to respondents, is the problem of traffic jams. Traffic jams are a problem in all densely populated cities. For a long time, the Almaty authorities have been solving this problem by classical methods: tuning of traffic lights, widening and punching new roads, as well as building road junctions.

In accordance with this, when conducting a social survey, respondents were asked the question: "How much time per day do you spend traveling from home to work and back." Basically, traffic jams occur on weekdays on the way to work from 8:00 to 10:00, and accordingly, the rush hour begins in the evening, from about 17:00 to 20:00. The results are shown in Figure 6.

As we can see from Figure 6, residents of the city of Almaty spend up to two hours on travel to and from work a day. The main reason for this is traffic jams, which continue on some streets regardless of working hours (Rozybakiev St., Timiryazev St. and others).

Due to the conducted social survey, it was possible to establish the attitude of the local population of the city of Almaty to the existing transport system, identified the main problems of public transport, and assessed the satisfaction with the arrangement of public transport by the residents of Almaty.

To determine the current situation in the spatial development of the city of Almaty and identify strengths, weaknesses, opportunities and threats, a SWOT analysis was used.

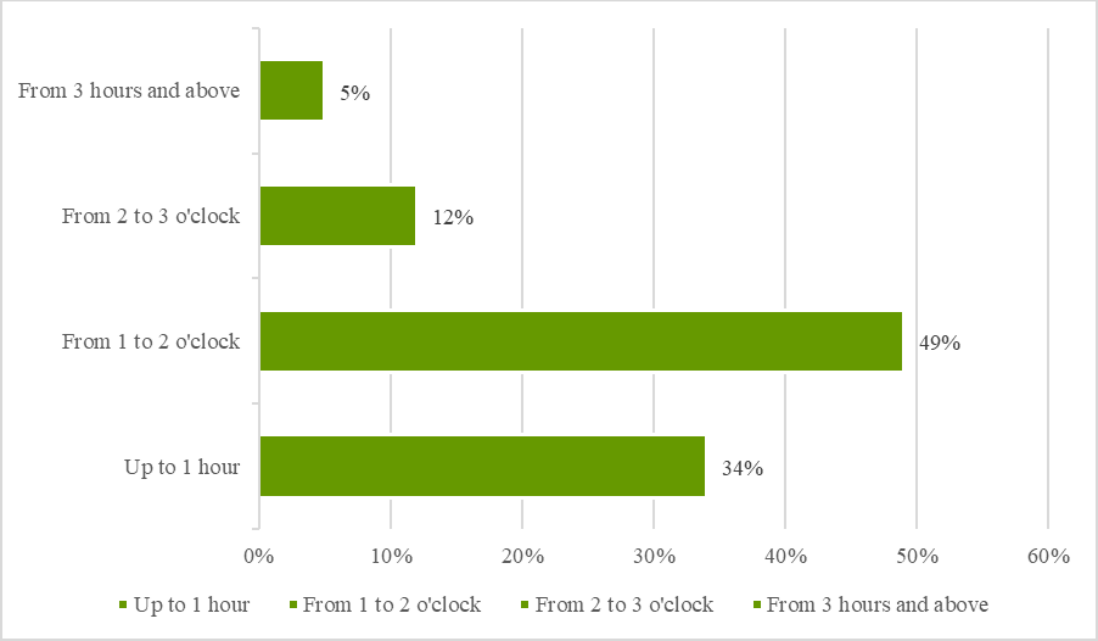

Figure 6 – The amount of time spent by respondents per day in a vehicle

SWOT-analysis of the development of the transport system of Almaty city:

Internal → environment Strengths (internal potential) (S):

1. Highly developed urban infrastructure
2. Favorable environment for continuous development
3. A large number of areas of urban development
4. Favorable environment for tourist travel
5. A large number of attractions
6. The number of jobs is more than in other regions
7. The only city with a functioning metro

Internal environment → Weaknesses (internal disadvantages) (W):

1. Insufficient culture of acceptance of innovations
2. Poor air quality
3. Use of outdated methods of data analysis and management
4. The problem of traffic congestion, traffic jams in the city reach strong proportions, on some streets
5. The problem of overcrowded buses
6. The problem of unfinished interchanges in the city

External environment → Potential Opportunities (O):

1. The emergence of smart city elements (smart stops, smart traffic lights, and so on)
2. Improving the quality of service of the transport system
3. Sustainable development of ecological infrastructure
4. Active involvement of citizens in the management of the city, thereby a possible impact on the development of the transport system
5. Changing the state of traffic jams for the better
6. Development in the city of LRT (Light Rail Transport), which should relieve the city's roads

External environment → Current Threats (T):

1. Further environmental deterioration of the city
2. Threats of mudflow destruction in some areas of the city
3. Crowded routes may lead to a worsening of the epidemiological situation in the city
4. Seismic hazard

In accordance with the long-term programs and development strategy of the city of Almaty, the potential development of the city in various directions is also possible:

1. Development as the center of the creative industry;
2. Development based on the priority of science, education and innovative business;
3. Diversification of economic sectors with a focus on high-performance and export-oriented sectors, including tourism.

There are also various strategies for the development of the spatial development of the city of Almaty through the transport infrastructure. For example, the Development Strategy "Almaty -2050", which, taking into account the historical

place of the city at the junction of cultures and civilizations, the challenges it faces, as well as its strengths and potential, defines the vision of Almaty in 2050.

Almaty of the future will be a "smart" city applying the best smart practices, smart forecasting, proactive planning and management in all spheres of life: in the construction and development of urban spaces, environmental protection, transport, security, healthcare, education, public services. Almaty will be the cultural and intellectual capital of Central Asia with a developed innovative environment and an advanced lifestyle that sets fashion and standards. The city will host world-class events in the field of science, innovation, culture and art.

To do this a single information ecosystem will be created in which all kinds of sensors, cameras, networks, data storages and other "smart" devices will be interconnected into the "central nervous system of the city" – Big Data Almaty. This system will monitor weather changes, the environmental situation, the state of urban engineering and road transport infrastructure, the situation on the streets and urban facilities, and many other parameters of the city's "health" in order to automatically manage urban infrastructure using artificial intelligence, as well as instantly warn about any emerging risks and help to better manage the development of the city.

We believe that when solving problems related primarily to the density of traffic, the problem of traffic jams in the city, Almaty will improve its various indicators, including the quality of life of the population. First of all, air quality indicators, since there is large air pollution in the city. Air pollution has a wide-ranging detrimental effect on human health, especially on the cardiovascular system.

Secondly, when solving problems with road congestion, namely, with the further construction of interchanges, smart traffic lights, the capacity of roads will increase.

Thirdly, when solving problems related to traffic congestion in the city center, as well as involving citizens in city management, there will be a development of the transport system, and, accordingly, spatial infrastructure.

Conclusion

The main goal of the transport infrastructure of cities is to meet the needs of the population in transportation. In this regard, it is necessary to continuously improve the efficiency of urban transport, taking into account the strategic plans for the development of the territory for the future and international transport requirements and standards. Providing the growing population of the city of Almaty with the quality functioning of city routes, improving safety and comfort for passengers and drivers of road traffic, optimal tariff policy, the introduction of alternative modes of transport to maintain the city's ecology taking into account the rational principles of urban construction planning are the main tasks of modern transport infrastructure.

In this research the features of the transport sector of the city of Almaty were studied. The conducted social survey revealed the main reasons that prevent the population from actively using public transport. The need to make transfers between routes, a long wait for some routes, uncomfortable rolling stock are problems that the city authorities need to pay special attention to. Since the active use of public transport by the population would make its own adjustments in solving the problems of traffic jams and air pollution with exhaust gases in the city of Almaty.

The compiled SWOT analysis revealed the strengths and weaknesses, the main opportunities and threats to the transport development of the city of Almaty. Based on the results of the study, we offer directions for solving the existing problems of the transport infrastructure of the city of Almaty.

Acknowledgements

This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19677682 – Comprehensive geographical assessment of sustainable development of large cities of the Republic of Kazakhstan) (2023-2025 years).

References

Aljoufie M., Zuidgeest M., Brussel M. & M. van Maarseveen. Urban growth and transport: understanding the spatial temporal relationship. WIT Transactions on The Built Environment, Vol 116, © 2011 WIT Press doi:10.2495/UT110271.

Bazarbekova M.M., Asipova ZH.M., Moldagalieva A.E., Bejsembinova A.S. "Analiz razvitiya transportnoj sistemy goroda Almaty [Analysis of the development of the transport system of the city of Almaty]." Moskovskij ekonomicheskij zhurnal no 10 (2020): – (In Russian).

Budarova V., Martynova N. and Budarov V. Application of geospatial technologies for analysis and development of transport infrastructure and cadastral activities in urban areas. IOP Conf. Series: Materials Science and Engineering 451, 2018.

Burak P., Il'ina I. N., Kirillova A. N. M. "Ekonomika i organizaciya upravleniya krupnym gorodom [Economy and organization of management of a large city]". Izdatel'skij dom Mezhdunarodnogo universiteta v Moskve, 30-53 (2014): – (In Russian).

Chimitdorzhieva E.C., Vahromeev I.I. "Rol' transportnoj infrastruktury v povyshenii effektivnosti prostranstvennogo social'no-ekonomicheskogo razvitiya regiona [The role of transport infrastructure in improving the efficiency of spatial socio-economic development of the region]." Statistika i Ekonomika no 5, 125-129, (2013): – (In Russian).

General plan of the city of Almaty. Research Institute "Almatygenplan.– URL: https://almatygenplan.kz/. Accessed 30.04.2021.

Grishaeva J. M., Matanceva O.J., Spirin I.V., Savosina M.I., Tkacheva Z.N., Vasin D.V. "Ustojchivoe razvitie transporta v gorodah Rossii: opyt i aktual'nye zadachi[Sustainable development of transport in Russian cities: experience and current tasks]." JuG ROSSII: RAZVITIE Tom 13 no 4 (2018): – (In Russian).

Gudina T.T. A review on the socio-economic impacts of informal transportation and its complementarity to address equity and achieve sustainable development goals. Journal of Engineering and Applied Science 69, 28, 2022.

Hristoforov, A.M. "Sovershenstvovanie transportnoj sistemy regiona [Improving the transport system of the region]." Avtoreferat na soisk.uch.stepeni k.e.n. CHeboksary, (2008): – (In Russian).

Juhyun Lee, Jos Arts, Frank Vanclay and John Ward. Examining the Social Outcomes from Urban Transport Infrastructure: Long-Term Consequences of Spatial Changes and Varied Interests at Multiple Levels. Sustainability 12, 5907, 2020.

Liu Yang, Koen H. van Dam 3 and Lufeng Zhang. Developing Goals and Indicators for the Design of Sustainable and Integrated Transport Infrastructure and Urban Spaces. Sustainability, 12, 967, 2020.

Molgazhdarov A.S., Bazarbekova M.M. "Osnovnye aspekty i problemy avtomobil'nogo transporta goroda Almaty [The main aspects and problems of road transport in the city of Almaty]." Vestnik KazATK..-no 100 (2018) — S.82-89.

Neil Cuthill 1, Mengqiu Cao, Yuqi Liu, Xing Gao 1 and Yuerong Zhang. The Association between Urban Public Transport Infrastructure and Social Equity and Spatial Accessibility within the Urban Environment: An Investigation of Tramlink in London. Sustainability 2019, 11, 1229

Panfilov A.V., Korotkiy A.A., Panfilova E.A. and Lagerev I.A.. Development of transport infrastructure of urban mobility based on cable metro technology. IOP Conf. Series: Materials Science and Engineering 786 (2020) 012067.

Pelkmans, Mathijs. Review of Urban Life in Post-Soviet Asia ed. by Catharine Alexander, Victor Buchli, Caroline Humphrey. Ab Imperio 2008, no. 3 (2008): 453-457. doi:10.1353/imp.2008.0062

Roj O. M. "Osnovy gradostroitel'stva i territorial'nogo planirovaniya: uchebnik i praktikum dlya vuzov [Fundamentals of urban planning and territorial planning : textbook and workshop for universities]" YUrajt, 249 (2021): – (In Russian).

Semak Y.A., Raimbekov B.Kh., Assanova M.K., Kozhabergenova A.Y. Razvitie transportnoj sistemy Respubliki Kazahstan [Development of transport system of the Republic of Kazakhstan]. Bulletin of the Karaganda University, no. 1 (85) (2017): 45-52: – (In Russian).

Smoljar I.M. "Gradostroitel'stvo kak pravovaja planirovochnaja system[Urban planning as a legal planning system]." SPb.: Rech', 115, (2008): – (In Russian).

State program for development and integration infrastructure of the transport system of the Republic highlights of Kazakhstan until 2020 and additions in the Decree of the President of the Republic of Kazakhstan dated March 19 2010 No. 957 "On approval of the List of state national programs." URL: https://adilet.zan.kz/rus/docs/U1400000725. Accessed 30.04.2021.

Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan, Accessed 30.04.2021 – URL: http://stat.gov.kz

Vuchik, Vukan R. "Transport v gorodah, udobnyh dlja zhizni[Transportation in cities that are convenient for life]." M: Territorija budushhego, 574 (2011): – (In Russian).

Zhanbirov Z.G., Sabraliev N.S., Bazarbekova M.M. "Osnovy sistemy upravleniya gorodskimi transportnymi potokami [Fundamentals of the urban traffic management system]." Vestnik KazATK, 2018.- no 107, S.88-96. (2018): – (In Russian).