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Analysis of the Passenger Transportation in the City of Khujand and the Prospects for its Development

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ABSTRACT

The article examines the state of transport services in the city of Khujand in the Republic of Tajikistan. Particular attention is paid to development of road public passenger routes.

In the framework of the analysis of prospects for development of public transport, the authors suggest a method of analysis of future needs for passenger transportation based on processing array of data on volumes of past passenger flows and construction of trendlines using several mathematical models, comprising relational model. Prognostic model has been verified by comparing analytical and actual data available for the year of the study. Calculated trends of the growth in demand for passenger transportation have also been confirmed by expert assessment.

The analysis resulted in forecasting growing demand on passenger transportation with public transport in the city of Khujand.

The methods described are basic ones, and to better plan economic activity, more accurate forecasting tools are to be further used. However, convergence of the general trend towards accelerated increase in passenger transportation generated using different basic methods, allows building long-term strategy of development of the urban transport.

Keywords: passenger service, road transport, volume of passenger transportation, bus, quality of service, forecasting, mathematical module.

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Текст статьи на русском языке публикуется в первой части данного выпуска.

INTRODUCTION

In Tajikistan, due to geographical conditions, special attention is paid to development of road transport, which is the dominant mode of transport for movement of people. The development of highways and of new methods of organising passenger transportation in the Republic of Tajikistan is implemented with the use of modern automated traffic control systems.

The key current trends are[1]:

• Transformation of city streets and sidewalks according to the purpose and type of traffic to increase equability of traffic.

• A systematic approach to solving problems of the urban transport network by connecting the routes of all types of urban transport.

• Maximum elimination of points of conflict between transport streams and organisation of traffic streams at different levels.

• Expansion of urban highways.

For two years now, the State Communal Enterprise «Musofirkashoni Dar Shahri Khujand» has been providing its services to the population in the city. Its fleet consists of 104 buses of the brands LiAZ 429260 (25 units), LiAZ 529265 (75 units) and TATA (4 units).

The volume of transported passengers, passenger streams, the number of turnovers and their total number were analysed based on observations at transport facilities and on collected statistical data (Table 1).

The analysis has shown that the public transport of the city of Khujand was not able to fully fulfill the plans for circulation of buses in 2019 and to meet relevant preliminary calculations. The buses did not work out their time in accordance with the established standards and regulatory enactments.

In the course of observations, it was revealed that transport services are in demand by residents of the city from 5 a.m. to 10 p.m., but, unfortunately, buses operate from 5 a.m. till 7 p.m., and on some routes they work up to 6 p.m. As a result, the planned number of turnovers is not fulfilled.

The volume of passenger traffic traditionally decreases in summer, and increases in other seasons. The reason for the decrease in passenger transportation during three summer months is associated with students' and school holidays. According to statistics, about 30–35 % of passengers are students, schoolchildren and education employees and academic staff[2].

Today, the demand for transport services, the volume of passenger traffic and the need for public transport are constantly growing.

Obviously, it is necessary to predict the passenger traffic in advance for the coming years and, based on these data, make the right choice in terms of the structure of the vehicle fleet and improve the quality of passenger service. These steps will increase the profitability of the transport enterprises themselves, and will give a serious impetus to development of the entire economy of Tajikistan.

To achieve this *objective*, namely, to proceed with the analysis of the state of passenger traffic in the city of Khujand and to determine the prospects for its development for the near future, it is necessary to use mathematical *methods* of analysis that might provide adequate solutions.

RESULTS

To make a forecast of changes in passenger traffic for the medium term, it is necessary to analyse passenger traffic in Khujand over the past several years. The volume of passenger traffic in Khujand over the past five years is presented by the following statistical data (Table 2).

Table 2 shows that the volume of passenger traffic is increasing from year to year. In 2019, as compared to 2015, the volume of passenger traffic increased by 51,6 %. Using this data, we can calculate the forecast up to 2025. For this we use a forecasting model.

A model is an abstract representation of reality in some form (for example, in mathematical, physical, symbolic, graphic or descriptive form), designed to represent certain aspects of this reality and allowing getting answers to the questions under study.

There are three types of models, respectively, hierarchical, network, and relational model.

The hierarchical model has a tree structure and expresses vertical links of subordination of the lower level to the higher.

The network model is more complex and differs from the hierarchical model by the presence of horisontal links.

[1] National Development Strategy of the Republic of Tajikistan for the period up to 2030. Approved by the Decree of the Government of the Republic of Tajikistan dated October 1, 2016, No. 392.

[2] Tajikistan in figures 2019: Statistical collection. Dushanbe, 2019.

Table 1

Bus performance indicators by months 2019 [compiled by the authors]

Months of the year	Number of turnovers		Number of transported passengers, persons	Passenger turnover, passenger-kilometre	Bus traffic, km	
	As planned	Actual			Total	With passengers
January	38090	25367	1899834	28512158	566373	556916
February	32444	24269	2029321	30577002	543637	535521
March	32738	25073	1994136	30175980	565297	556065
April	32818	24272	1937239	29484286	557546	548093
May	33258	22402	1900677	28454251	571911	563199
June	30584	22987	1602420	24083188	533920	527056
July	29450	21477	1460112	22299933	507947	501333
August	25634	18449	1443757	22011988	449070	442562
September	29584	21766	1854558	27849930	505511	498824
October	29752	21527	1930247	29025388	506235	498989
November	27782	19871	1747894	26522211	471176	463964
December	27910	19763	1789615	27139416	476547	468578
Total per year	370044	267223	21580810	326135731	6255170	6161100

Table 2

The volume of passenger traffic in the city of Khujand (2015–2019) [compiled by the authors]

Years	Passenger traffic volume (thous. pass.)	Number of vehicles in service (units)		
		Total	Public	Taxi
2015	40151,5	951	890	61
2016	43531,1	943	877	66
2017	46664,1	917	782	135
2018	53793,7	1057	895	162
2019	60863,7	940	725	215

Table 3

Calculation of indicators of the linear formula to calculate the volume of passenger traffic from 2020 to 2025 [compiled by the authors]

Years	Volume of passenger transportation, thous. persons	X	x^2	x_y	yx = a + b • x
2015	40151,5	-2	4	-80303	38663,4
2016	43531,1	-1	1	-43531,1	43832,1
2017	46664,1	0	0	0	49000,82
2018	53793,7	+1	1	53793,7	54169,5
2019	60863,7	+2	4	121727,4	59338,2
Sum	245004,1	0	∑10	51687	
2020		+3			64506,9
2025		+8			90350,4

The relational model is represented as a set of tables, over which operations are performed, formulated in terms of relational algebra.

To implement our task, we use a mathematical relational model.

Mathematical models are formalisable, that is, they are a set of interrelated mathematical and formal-logical expressions, reflecting, as a rule, real processes and phenomena (physical, mental, social ones, etc.).

For calculations, the method of mathematical modelling is used. The graph of the data given above in Table 2 is determined based on a linear equation according to the following formula:

$$yx = a + b \cdot x, \quad (1)$$

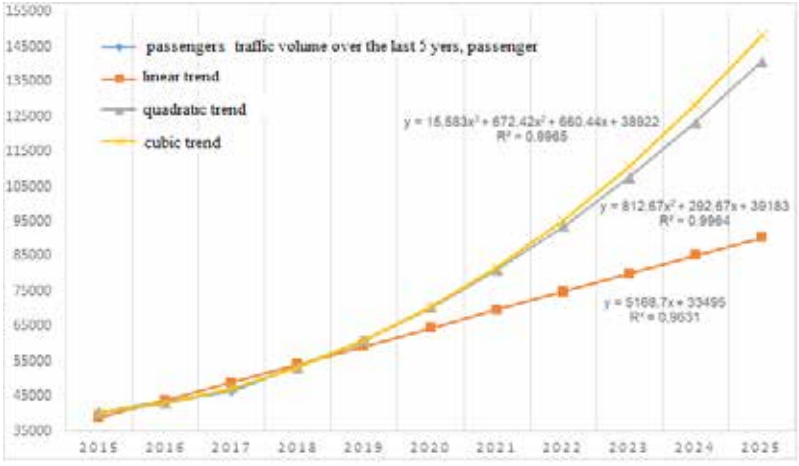
where yx – regional passenger turnover, persons;

x – the period of study of passengers;

a – indicator of the average volume of passenger traffic, persons;

b – indicators of the average increase in passenger traffic, persons.

The average passenger traffic over the last five years (s) is determined by the following formula:



Pic. 1. Diagram of changes in the volume of passenger traffic for 2020–2025 [compiled by the authors].

$$a = \frac{\sum y}{n}, \text{ persons;} \quad (2)$$

$$a = \frac{245004,1}{5} = 49000,82 \text{ thous. persons.}$$

The increase in the average number of passenger traffic (b) is found by the following formula:

$$b = \frac{\sum xy}{\sum x^2}, \text{ pass.;} \quad (3)$$

$$b = \frac{51687}{10} = 5168,7 \text{ thous. pass.}$$

The indicators for 2020 are determined by extrapolating the series:

y = 49000,82 + 5168,7 • 3 = 64506,9 thous. pass.

After calculating these indicators, the result is displayed in Table 3.

Thus, we determined that in 2020 passenger traffic in Khujand should have amounted to 64506,9 thousand passengers. By 2025, passenger traffic is expected to increase by 48,4 % compared to 2019. According to scientists and researchers, such forecasts are close to reality, and on their basis, preliminary calculations can be planned.

Let's check the correctness of this forecasting method using Microsoft Excel. Similar methods are described in [3; 4]. With the help of this program, we will identify trends regarding increase in passenger traffic.

A trend is a type of input function that can be used to approximate a graph with data in a table. The trend is used to determine the upward tendency, it is obtained in the form of a chart and performs the analysis for various specified periods.

Let's get formulas using functions of Microsoft Excel.

To obtain data, the formulas drawn up are shown in the following table (Table 4).

According to the results of the calculations given in Table 4, a graph (diagram) of passenger traffic is drawn up (Pic. 1).

Using Excel functions and data of Table 4, it is also possible to predict the dynamics of passenger traffic growth in Khujand for 2020–2025, which is shown in the following table (Table 5).

BRIEF CONCLUSION

The forecast results obtained based on the methods of mathematical modelling have been indirectly confirmed through interviews with the experts who agreed with described trends.

Table 4

Trend analysis of passenger traffic volume

No.	Type of analysis	Indicators
1	Linear trend	$y = 5168,7x + 33495$, $R^2 = 0,9631$
2	Quadratic trend	$y = 812,67x^2 + 292,67x + 39183$, $R^2 = 0,9964$
3	Cubic trend	$y = 15,583x^3 - 672,42x^2 + 660,44x + 38922$, $R^2 = 0,9965$

Source: Authors' calculations using the data of Table 2.

Table 5

Dynamics of growth of passenger transportation and forecast of its development until 2025 [compiled by the authors]

No.	Years	Passenger traffic volume, thous. pass.	Linear trend	Quadratic trend	Cubic trend
1	2015	40151,5	38663,7	40288,34	40270,44
2	2016	43531,1	43832,4	43019,02	43057,22
3	2017	46664,1	49001,1	47375,04	47375,84
4	2018	53793,7	54169,8	53356,4	53319,79
5	2019	60863,7	59338,5	60963,1	60982,58
6	2020		64507,2	70195,14	70457,69
7	2021		69675,9	81052,52	81838,63
8	2022		74844,6	93535,24	95218,9
9	2023		80013,3	107643,3	110692
10	2024		85182	123376,7	128351,4
11	2025		90350,7	140735,4	148290,6

The forecast results, showing growing needs for passenger transportation with public transport of the city of Khujand, can be used to develop the corresponding preliminary plans for development of passenger transport, considering satisfaction of the needs of the urban population, improving quality of services, as well as creating an automated control system for passenger road transport.

While the described methods are basic ones and do not provide accuracy of forecasting, it is important to note that results obtained by different methods are consistent in the sense of unambiguously confirmed trend towards growing demand. More accurate forecasting tools should be used while planning implementation measures to develop urban public transport.

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