



Analysis of Passenger Flows Served by Bus Routes in the city of Khujand



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ABSTRACT

The study considered the role of passenger road transport as one of the most important sectors of the national economy, which influences the entire economy of a country and its regions, as well as the quality of life of the population.

The analysis of the transport system in the city of Khujand, which is mainly dominated by road transport, has been carried out based on the results of the conducted survey on passenger flows on bus routes of the city, particularly, regarding origin-destination matrix, fare collectability.

The conclusions argue in favour of practicability of conducting regular systematic monitoring of passenger flows to optimise suggestions in the field of urban public transport development.

In fundamental terms, main problems of passenger transportation management were identified including lack of a regular timetable on certain routes, non-compliance with the traffic schedule, resulting in an increase in travel time, changes in routing due to the absence of sufficient number of passengers, systematic violations of traffic rules, excessively long stops at the hub stopping points, etc. The suggestions comprise approaches intended to reduce influence of organisational and managerial factors on

efficiency of passenger transportation, on the correct choice of rolling stock, that should be selected considering design features, possibility of serving all segments of the population (categories of passengers), traffic intensity, manoeuvrability, compliance with road conditions, etc. Conclusions were also made regarding techniques to justify the volume of passenger transportation, to identify average distance of passenger's trip, to calculate technical, operational, and quality indicators of operation of public transport, distribution of passengers per routes.

The analysis of the structure of passenger flows since it influences the indicators of the effectiveness of passenger transportation, plays the most significant role in the framework of development of new approaches to the solution of transport issues in the city of Khujand.

Implementation of full-scale monitoring of passenger flows will make it possible to develop appropriate timetables facilitating movement of passenger flows on routes, to select a rational type of rolling stock in terms of capacity, will contribute to time-saving passenger travelling, socialisation of transport tariffs, and improved quality of transportation.

Keywords: service, passenger transportation, public transport, passenger traffic, irregularity of passenger traffic, route, bus, quality of service.

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INTRODUCTION

Transport is one of the most important sectors of the national economy. In modern conditions, it is impossible to imagine economic development without this industry, which is closely related to others.

Various types of passenger transport, including buses, trolleybuses, trams, and minibuses, etc., are regularly used in urban, suburban, intercity, and international transport networks. Improving quality of road transport services and meeting the demand for transport services are among the main tasks.

The main goals when managing an urban transport system concern, first, minimising transport costs, time saving, increasing safety and comfort when transporting passengers.

The situation in some cities of Tajikistan, including Khujand [1–3], where passengers are transported mainly by buses and minibuses, shows that the level and quality of public transport services are still unsatisfactory and do not meet the needs of the urban population.

This discrepancy is primarily due to the lack of a proper and accurate timetable for public transport, which results in long waiting at stops; non-observance of traffic intervals; illegal parking of vehicles in prohibited places; overcrowding in vehicles; non-observance of the standardised stopping time at intermediate and final stops; violation of traffic safety rules. All these are very serious problems for urban transport and require immediate solutions.

Efficient use of work time, respect of timetables and travel modes, gap size, speed limits when transporting passengers, optimisation of costs while providing minimum reasonable travel time, correct operation of buses, high quality of services provided, regularity of route servicing can be implemented if urban public transport is wisely organised and operated.

It should be noted that one of the best methods for studying and further solving these problems is the study of passenger flows, i.e., «turnover» of passengers, mobility of passenger flows on certain days and at certain times, in a certain direction along city routes. The analysis of these flows can be carried out depending on the characteristics of the route, time of day, days of the week, during a month, season, on a separate route or on all routes, for one mode of transport or for all types of urban passenger transport.

A review of sources (e.g., [4–9]) has shown that analysis of demand for transport services,

information about the regularities of formation of demand for transportation of passengers, as well as detailed study of transport services use information about the rate of satisfaction of demand in the existing transport system. The study of passenger flows can be carried out in full for various modes of transport or individually for a particular mode of transport. Usually, in such studies, the reporting-statistical method, questionnaire method, field surveys are used.

The analysis of passenger flows allows us to consider functioning of public transport, considering development and adoption of standards, i.e., regarding the indicators of transport operations, including the efficiency of transportation, comprising the average travelled distance, traffic speed (vehicle speed), the coefficient of vehicle population, the coefficient of the difference in passenger flows, the coefficient of regularity of routes servicing, etc. All these indicators should be adjusted considering the current situation. The revision and approval of the aforementioned indicators will allow development of an appropriate timetable on routes, choosing the appropriate vehicle capacity, reducing transport costs, ensuring passenger comfort, increasing the level of service and offering acceptable service rates. Subsequently, this will improve the quality of service and the efficiency of vehicle operation.

A successful solution of the problems of rational organisation of passenger transportation and efficient use of rolling stock is impossible without a systematic study of passenger flows within the transport network. In doing so, it is necessary to consider many factors and parameters.

So, e.g., the parameter of «the rate of passenger flows» is very important. It is understood through the number of passengers passing at a certain time through a specific section of the route or the entire transport network of a settlement in one direction [6]. At the same time, it is necessary to differentiate passenger flows that can be constant or variable; one-sided or two-sided; regular or irregular; periodic or intermittent. Variability of passenger flows on routes or in a certain area of the city plays an important role in organising and managing passenger transportation and should be considered when organising transport operations. To ensure a high level of operation of public transport, the quality of service provided to the population, as well as to design



optimal routes, it is necessary, based on the study of passenger flows, to determine the direction of movement and the number of passengers, as well as unevenness of passenger flows on the routes.

The distribution of the population by social categories such as workers, employees, schoolchildren, and students of secondary and higher vocational education is the main factor determining the rate of population mobility.

One of the main factors in improving quality of passenger transportation is the correct choice of vehicles. The fleet of operated public transport vehicles should be analysed in term of structure design, number of seats, passenger capacity, traffic intensity, driving, and other indicators, from the point of view of their operation in urban, suburban, intercity, and international transportation.

The analysis of passenger flows makes it possible to reveal the population needs in transportation and to organise the work of public transport considering new standards, that is, indicators of transport performance, including the average distance travelled by passengers, travel speed (operating speed), vehicle occupancy rate, coefficient of inequality of passenger flows, coefficient of regularity of the route servicing, etc., that will match the actual situation.

The study can be carried out in full (for all types of passenger transport); only for «individual» types (buses, trolleybuses, trams); selectively on separate routes or groups of routes.

The most common *methods* for studying passenger traffic are reporting and statistical method; questionnaire method; field surveys. Field surveys, in turn, can be represented by coupon, tabular, visual, silhouette and survey methods.

STATEMENT OF THE TASK

To improve the level and quality of passenger service by road transport in Khujand and increase profitability of the city's transport enterprises, it is necessary to study and analyse the flow of passengers.

The *objective* of the study was to present the results of primary analysis of passenger flows in the city of Khujand, particularly of those served by road public transport.

The results will allow to substantiate the practicability of further systematic and detailed study of passenger flow.

RESULTS

Khujand is one of the oldest cities in Central Asia. It is the second largest city in the Republic of Tajikistan and one of the main transportation, political, economic, cultural and scientific centres of the country. In terms of agglomeration, Khujand is second only to Dushanbe (population of Dushanbe accounts 916200 people, Khujand – 181600 people). The agglomeration area of Khujand is 3400 m², and the population density is 269 people/km.

To improve the quality of service and the use of the fleet on bus routes in Khujand, the analysis of passenger flows was carried out using the natural calculation (tabular) method.

The state municipal company «Musofirkashoni Dar Shahri Khujand» operates bus fleet. 18 buses LiAZ-529265 with a capacity of 114 passengers each operate on route No. 1. Passenger flows on bus route No. 1, which covers the territory from micro-district No. 3 of Khujand to st. B. Gafurovsky area (table 1), was studied together with the mentioned company and with the help of students.

This table shows the volume of passenger flows during the day at each of the stops. As it can be



**Results of the study of passenger flows on bus route No. 1:
«Micro-district No. 3 of Khujand–B.Gafurovsky area» (as of 11.06.2019)**

Passenger flow per single day, persons			
No.	Name of stops	Number of passengers embarked and disembarked per day, persons	
		Number of embarked passengers	Number of disembarked passengers
1	Makhallan 3	359	298
2	Kolechi tekhniki	144	123
3	Daromadi Sartukai	269	256
4	Magozai Ismatullo	189	225
5	Maktabi Bolaekat	184	226
6	Makhallai 8	477	415
7	Makhallai 12	366	413
8	Muassisai Sorbon	637	540
9	Pazharniy	260	312
10	Regional traffic police	389	449
11	TGU	345	432
12	HGU	375	598
13	Matbuot	374	497
14	Rakhimi	468	314
15	Varzishgokhi 20-Solagii Istikloiyat	283	263
16	Store	990	907
17	Stadium	432	428
18	Zafar	364	106
19	Panjshanbe	1570	1943
20	Gulbakhor	251	289
21	Zarbof	509	416
22	Bofanda	362	328
23	Korkhonai Romsar	128	150
24	Arbob	203	231
25	Mattaib	209	240
26	Autostation	429	422
27	Traffic police Khadzhenski	169	205
28	Atush bozor	499	110
29	Barakat	580	256
30	Sakhovat	68	467
31	Somon bozor	103	519
32	Gardishi Buston	169	234
33	SIMU 25	120	138
34	ChDMM Saier	221	228
35	Kasri Farkhang	117	150
36	Shubai shinosnomadikhii shakhraki B.Gafurov	178	155
37	Station	992	499
Total		13782	13782
Passengers enjoying discounts (children of school age and other categories of passengers with a discount of up to 50 %)		431	431
Passengers enjoying discounts (fully exempt from fare)		133	133



seen, the largest number of passengers entering and leaving is observed at the bus stop near Panjshanbe bazaar: 11,4 % of passengers embark and 14 % disembark at the bus stop. The busiest bus stops along the route are the stops near the department store, Barakat shopping center, Atush bazaar, Sakhovat bazaar and Somon bazaar, which are located at a distance of 100 to 250 meters from each other. Other «popular» stops are also Station stop, stops located in the centre of B. Gafurovsky area, next to Farovon central market. Research shows that passenger embarkation and disembarkation always increase at stops near shopping malls, businesses, health centres, universities, educational institutions and recreational facilities.

A similar survey on passenger flows was carried out on three more bus routes in the city.

On route No. 4 (micro-district No. 34 of Khujand city–Guliston town–Bakhoriston sanatorium), the analysis showed that 10 LiAZ-529265 buses operate on the route, accommodating 114 passengers each (transit capacity is 6855 passengers per day).

A study was also carried out on the route No. 5, quarter «Yova» («Galamaidon»)–Babadzhan Gafurovsky area (Seventh settlement). 18 buses of LiAZ-429260 brand, with a capacity of 85 people, operate on this route, daily transportation attained 7986 passengers.

After analysing these figures, the authors concluded that unevenness of the number of passengers on these routes depends on the working hours of the townspeople and the points of departure of passengers. From 6-00 till 8-00 a.m. the number of passengers exceeded the normal rate, so, there was a shortage of buses. Also at this time, one could observe an irregularity in bus traffic.

It was also recorded that toll collection was not carried out properly by the transport company

on these routes. As a result of the obtained data and calculations, it was revealed that the amount collected by the conductors is 15–20 % less than the normally calculated amount.

The analysis of operation of route No. 1 was carried out considering the volume of transported passengers, fare collectability, the number of passengers enjoying the discounts, tariff for transportation, income of motor transport companies from provision of services for transportation of passengers (Table 2).

It is necessary to consider the specifics of the city routes of Khujand. Some stopping points are located outside the city (in the nearby suburban areas). But the analysis of passenger flows shows that 70–80 % of passengers using this route are residents of the city of Khujand. The Table 2 analyses the number of passengers enjoying the discounts, including those who are entitled to completely free travel or to 50 % exempt from payment. This is considered in the calculations.

It can be seen from this table that passengers completely exempted from fare make up only 0,96 % of all passengers, and those exempted by 50 % (children of school age up to 12 years old belong to this category, according to the Instruction of the Procedure for Registration and Accounting of Privileged Passengers in Public Transport of the Republic of Tajikistan¹⁾ accounted for 3,1 % of the entire bus population.

As shown in Table 2, the fare, according to observations within one day, amounted to 16 266 somoni, however, according to the reports of SUC «Musofirkashoni dar shahri Khujand», receipts from the proceeds for travel amounted

¹ «Instruction of the Procedure for Registration and Accounting of Privileged Passengers in Public Transport of the Republic of Tajikistan», approved by the Order of Minister of Transport of the Republic of Tajikistan No. 113 dated 16.08.2011.



**Analysis of passenger flows on bus route No. 1: «Microdistrict No. 3 of Khujand–B.Gafurovsky area»
as of 11.06.2019**

Table 2

No.	Bus state registration number	Number of passengers per day, persons					Toll collection, according to observations, somoni					Amount paid, somoni		Income difference, somoni		
		Total	Number of passengers, considering the fare, somoni			Privileged passengers ¹	Privileged passengers (completely exempt from payment)	Total	Direct direction	Reverse direction						
			1	1,5	2						1				1,5	2
1	7926	859	584	174	101	0	0	1047	488,5	558,5	584	261	202	0	830	-217
2	7931	727	495	131	69	25	7	842	360	482	495	196,5	138	12,5	702	-140
3	7932	823	485	207	87	32	12	985,5	515	470,5	485	310,5	174	16	805	-180,5
4	7942	761	508	128	91	24	10	894	409,5	484,5	508	192	182	12	778	-116
5	7958	935	582	212	124	12	5	1154	554,5	599,5	582	318	248	6	781	-373
6	7959	964	555	194	144	54	17	1161	579	582	555	291	288	27	840	-321
7	7964	307	209	59	34	5	0	368	214	154	209	88,5	68	2,5	808	440
8	7977	767	504	136	110	13	4	934,5	396,5	538	504	204	220	6,5	767	-167,5
9	7981	816	536	189	62	23	6	955	430,5	524,5	536	283,5	124	11,5	743	-212
10	7983	840	523	166	78	56	17	956	506	450	523	249	156	28	776	-180
11	7986	818	581	155	81	1	0	976	386	590	581	232,5	162	0,5	835	-141
12	7990	730	440	152	92	35	11	869,5	479	390,5	440	228	184	17,5	805	-64,5
13	7991	800	516	163	108	10	3	981,5	489	492,5	516	244,5	216	5	840	-141,5
14	7992	782	479	183	54	51	15	887	384	503	479	274,5	108	25,5	850	-37
15	7994	767	473	157	78	46	13	887,5	415	472,5	473	235,5	156	23	840	-47,5
16	7995	410	284	75	28	18	5	461,5	199	262,5	284	112,5	56	9	500	38,5
17	7996	945	747	148	16	26	8	1014	433,5	580,5	747	222	32	13	800	-214
18	7998	731	500	140	91	0	0	892	513	379	500	210	182	0	817	-75
Total		13782	9001	2769	1448	431	133	16266	7752	8514	9001	4153,5	2896	215,5	14117	-2149

¹ Privileged passengers (children of school age and other categories of passengers with a discount of up to 50%).



to 14 117 somoni. The difference from the proceeds was 2149 somoni, i.e., 88,8 % of the collected amount was handed over to the cashier of the enterprise.

Similar studies were carried out on bus routes No. 4 and No. 5 of the city of Khujand, where the situation was quite similar.

SHORT CONCLUSIONS

The results of the field survey on passenger flows, despite its once-only nature, have allowed to put forward few hypotheses. So, it is possible to suppose that the main factor determining the rate of population mobility is distribution of the population by social categories: workers, office employees, students, schoolchildren, pensioners. The survey has confirmed the relevance of developing technology for saving and generating income using modern technologies, e.g., through adoption of electronic tickets.

The main conclusion is that the conducted survey has confirmed core research hypothesis on the practicability of regular systematic monitoring of passenger flow to collect and analyse data to further develop suggestions on optimal organisation of the urban public transport operations.

Further research on passenger flows should help to respond to the issues of:

- Justification of the volume of passenger transportation.
- Determination of the average distance travelled by a pedestrian [to reach the stop].
- Calculation of technical, operational, and quality indicators of transport.
- Distribution of passengers per routes.
- Route system and its optimisation.
- Distribution of motor transport by routes and attribution of routes by zones of responsibility of motor transport companies.

REFERENCES

1. Transport and communications of the Republic of Tajikistan, statistical collection [*Transport i svyaz Respubliki Tadjikistan, statisticheskiy sbornik*]. Dushanbe, Agency on Statistics under the President of the Republic of Tajikistan, 2019.

2. Bobiev, R. S., Gafurov, F. J., Nadzhmudinov, F. N. Passenger transportation [*Passazhirskie perevozki*]. Dushanbe, 2017, 92 p.

3. Fattidinov, B. R., Bobiev, R. S., Boboev, M. M. Analysis of modern circumstances of passenger service by road transport in the city of Khujand, problems and development prospects [*Analiz sovremennykh obshchestvennoy transporta. Bulletin. Series: Engineering research*, 2019, Iss. 2 (46), pp. 99–107. [Electronic resource]: [http://vp-es.ttu.tj/userfiles/source_1580893662_Vestnik_%E2%84%962_\(46\)_S.I._-2019_g._v_pechat_.pdf](http://vp-es.ttu.tj/userfiles/source_1580893662_Vestnik_%E2%84%962_(46)_S.I._-2019_g._v_pechat_.pdf). Last accessed 26.03.2021.

4. Rakhmatullina, A. R. Methodological provisions for improving quality of urban public transport services. Ph.D. (Economics) thesis [*Metodicheskie polozheniya povysheniya kachestva uslug gorodskogo obshchestvennogo transporta. Dis... kand. ekonom. nauk*]. Samara, SSEU publ., 2014, 146 p. [Electronic resource]: <http://www.dslib.net/economika-xoziajstva/metodicheskie-polozheniya-povysheniya-kachestva-uslug-gorodskogo-obvestvennogo.html>. Last accessed 26.03.2021.

5. Kulev, A. V. Optimisation of passenger transport routes in the city. Ph.D. (Eng) thesis [*Optimizatsiya marshrutov passazhirskogo transporta v gorode. Dis... kand. tekhn. nauk*]. Oryol, State university – educational-scientific-production complex, 2015, 142 p. [Electronic resource]: <http://www.dslib.net/remont-transporta/optimizatsiya-marshrutov-passazhirskogo-transporta-v-gorode.html>. Last accessed 26.03.2021.

6. Boyko, G. V. Methods for optimizing the structure of transport for servicing urban passenger transportation. Ph.D. (Eng) thesis [*Metodika optimizatsii struktury transporta dlya obsluzhivaniya gorodskikh passazhirskikh perevozok. Dis... kand. tekhn. nauk*]. Volgograd, VolgSTU, 2006, 157 p. [Electronic resource]: <https://www.studmed.ru/boyko-gv-metodika-optimizatsii-struktury-transporta-dlya-obsluzhivaniya-gorodskikh-passazhirskikh-perevozok-b399abbfec.html>. Last accessed 26.03.2021.

7. Kitov, A. G., Permovsky, A. A. Organisation of work of buses on urban and suburban routes (diploma theses design): Study guide [*Organizatsiya raboty avtobusov na gorodskikh i prigorodnykh marshrutakh (diplomnoe proektirovanie): Uchebno-metodicheskoe posobie*]. Nizhny Novgorod, VGIPU publ., 2009, 110 p. [Electronic resource]: <https://docplayer.com/27471386-Organizatsiya-raboty-avtobusov-na-gorodskikh-i-prigorodnykh-marshrutakh-diplomnoe-proektirovanie.html>. Last accessed 26.03.2021.

8. Boboev, M. M. Analysis of passenger transportation in Sorditskiy area [*Analiz passazhirskikh perevozok v Sorditskoi oblasti*]. Scientific-methodical journal *Academy*, 2018, Iss. 1 (28), 103 p. [Electronic resource]: <https://elibrary.ru/item.asp?id=32314336>. Last accessed 26.03.2021.

9. Gudkov, V. A., Mirotn, L. B., Velmozhin, A. B., Shiryayev, S. A. Passenger Road transportation [*Passazhirskie avtomobilnye perevozki*]. Moscow, Goryachaya liniya Telecom, 2004, 448 p. [Electronic resource]: https://www.studmed.ru/gudkov-va-mirotn-lb-passazhirskie-avtomobilnye-perevozki_89a643f0e3.html. Last accessed 26.03.2021.

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