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METHODOLOGY FOR THE DEVELOPMENT OF A LOW CARGO NETWORK

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Abstract: In the context of rapid globalization and the growth of world trade, the volume of cargo transportation is growing significantly, which increases the requirements for the efficiency and stability of transport systems. Also, the complexity and dynamics of modern traffic flows require the development of new planning and management approaches that ensure optimal use of existing transport resources and infrastructure. Research aimed at developing a methodology for the development of the transport network based on the optimal distribution of cargo flows will help to increase the efficiency of the transport system of the region, promote sustainable economic development and minimize the negative impact on the environment. In the article, the indicators of the transport complex of the region are statistically analyzed. Also, in this article, in order to obtain a plan for the step-by-step development of road sections with insufficient traffic speed, graph theory and cumulative methods of evaluating network efficiency are widely used.

Keywords: transport, transport system, capacity, superiority, correlation, regression, social, economical.

Introduction. The availability of public hard surface roads of the regional districts is presented in Table 1 (comparison of 2010 and 2021). Development indicators of the road network are given in Figure 1. The density of the road network per 1,000 sq.km of area (S) is shown in Figure 2 and the change per 1,000 inhabitants (N) is shown in Figure 3.

Table 1. Provision of public hard surfaced roads of regional districts.

№	Districts	Length of the road, km		Highway network density per 1,000 sq. km area (S) and 1,000 inhabitants (N)			
				2010		2021	
		2010	2021	L/S	L/N	L/S	L/N
1	Termiz	228	235	256	1,18	264	0,89
2	Angor	113	121	289	1,12	310	0,90
3	Bandixon	88	77	440	2,00	385	1,00
4	Boysun	324	338	87	3,48	91	2,87
5	Denov	219	291	292	0,70	388	0,74
6	Jarqo‘rg‘on	108	168	94	0,65	147	0,75
7	Qumqo‘rg‘on	198	198	89	1,15	89	0,82
8	Muzrabod	168	219	227	1,53	296	1,51
9	Oltinsoy	195	194	348	1,48	346	1,07
10	Uzun	185	175	113	1,35	107	1,00
11	SHerobod	351	385	128	2,40	141	1,95
12	SHo‘rchi	158	153	185	0,97	180	0,71
13	Qiziriq	129	130	368	1,47	371	1,11
14	Sariosiyo	230	159	58	1,43	40	0,74
	By province	2694	2843	134	1,32	134	1,06

There is a partial difference in the length of the paved public road network between 2010 and 2021, which means that the road was built during these years (Figure 1).

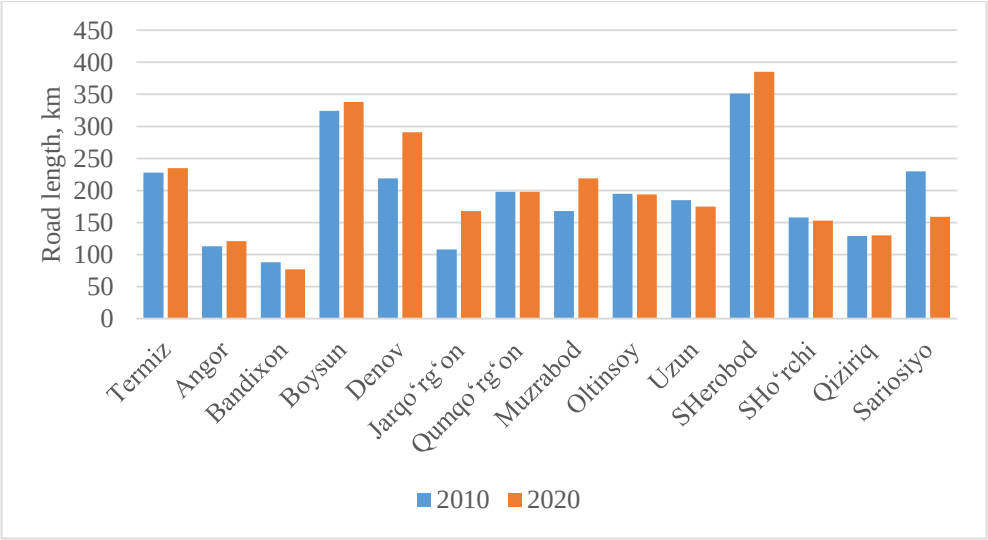

Figure 1. Development dynamics of the road network.

However, the density of the highway network per 1000 sq.km of area (S) (Figure 2) shows a partial change, and the density of the highway network per 1000 inhabitants (N) in 2010 it is shown that it decreased in 2021. This is explained by the fact that the construction of the public road network with a hard surface is not suitable for the growth of the population.

The main criterion for including a road section in the transport multi-network is its probability of participation in the option of comparison with other sections or lines. Therefore, some dead-end sections were not included in the network in order to reduce the size of the problem. In this case, the volumes of cargo transported from the network points were moved to the network transit points.

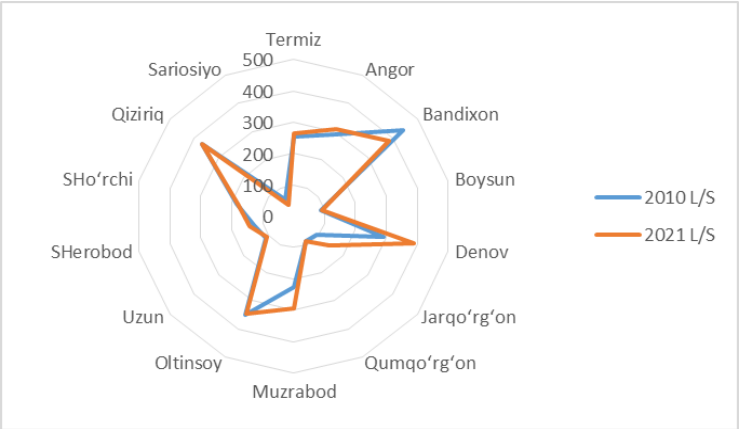

Figure 2. Highway network density, 1000 sq. km area (S).

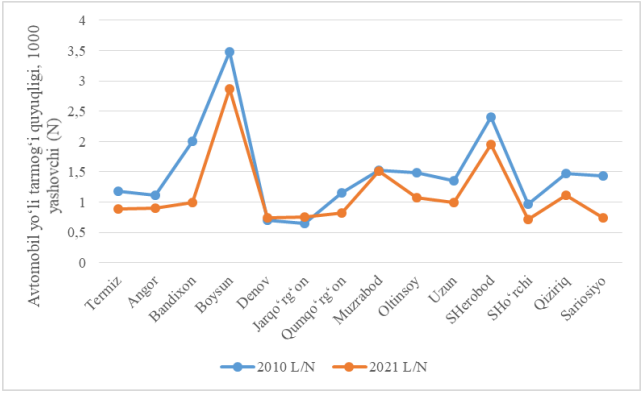

Figure 3. Highway network density, 1000 inhabitants (N).

The 3rd priority direction of the development strategy of the new Uzbekistan is the task of providing continuous and convenient transport services to the population based on the quality development of transport networks.

Literature review. Ensuring the convenience of transportation is not only the renewal of the vehicle fleet, but also the construction, reconstruction and repair of highways, the repair of dirt roads and the gradual transition to hard and gravel roads, It requires the gradual reconstruction and repair of bridges and other artificial structures and the development of cement-concrete roads.

Road conditions also affect the efficiency of vehicles and delivery services. The authors [1] stated that the funds spent on the improvement of the transport and operational indicators of roads with low intensity will have both social and economic effects for the same region.

It is stated in source [2] that international transport corridors are important in the development of the transport network of the region. Because transit cargo also affects the volume of cargo flows in the transport network.

In our republic, B.A. Khojayev, Sh.A. Botayev, G.A. Samatov, K.T.Khudaiberganov, A.M. Bagdasarov, N.N. Ibragimov, A.A. Mukhitdinov, R.Z.Nurmukhamedov, D.Ilyosaliev and other scientists made a significant contribution to the development of transportation optimization methods and algorithms and to the improvement of effective management of the mutual movement of various types of transport.

A surface transport multi-network of Surkhandarya region has been developed, in which cargo flows are optimally distributed taking into account public roads. An additional network providing the possibility of reloading loads between different types of transport was introduced, and a general scheme for the formation of a multi-network of road and railway transport was developed [3], [4].

The methodical approach to the development of the transport network based on the optimal distribution of the load flow in the transport network and the problem of determining the low-load sections of the network sections and the trends and possibilities of their development are analyzed [5]-[8].

Various traffic speeds are observed on sections of the highway network in any region. In this case, if the carrying capacity of some sections is fully used, some sections will not receive enough load. In the development of plots with a low speed of movement, first of all, preliminary data is prepared. In this case, the map of the settlements of the studied area, the scheme of the road network and the load flow formed as a result of the distribution of the load flow in the transport multi-network, the existing transport connections between the settlements in the area, these road sections according to the type of road surface.

Another necessary information for solving the problem is the distance between settlements, which was taken on the basis of the map of the studied area and the materials of the unitary enterprise of highways.

Each type of road surface on the road sections is evaluated by standard coefficients (SHNQ). A coefficient with a large value is equal to one, and the type of pavement is considered capital.

When designing a local highway in the transport network, the coefficient of road surface type indicators is taken separately for each section (Table 2) [9].

Table 2. Coefficients of pavement type indicators.

Type of road surface	According to the period between repairs	
	Capital	Medium
Capital	1,0	1,0
Light	0,62	0,5
Passer	0,4	0,4
Light	0,2	0,3

An initial graph was created for the development of a road section with a low traffic speed, showing the distribution of the road network and freight flows of the studied area (Fig. 4).

The initial graph was obtained based on the analysis of the results obtained on the optimal distribution of future cargo flows in the transport multi-network and the development of the surface transport system of the Surkhondarya region [10].

In the given graph, the centers of settlements were taken as nodes and marked with numbers. The arcs connecting the nodes represent the transport links (roads) between the points.

Based on the results of the calculation, the transport links with the least load on the graph, that is, the arcs, are determined. Based on the given graph, transport connections 2-7, 3-4, 7-6, 9-10, 10-7 had the least load.

Carrying out current repair work on road sections 3-4, 2-7, 9-10 with a low load level, and transferring road sections 10-7 and 7-6 from category IV to category III recommended. It was determined that 225.2 billion soums and 1269.45 billion soums will be spent on these activities, respectively (Table 3). It is not enough to absorb the funds provided at the same time.

Therefore, in the research work, plans for the step-by-step development of road sections were developed.

It is necessary to select the least loaded transport links for improvement. The selected transport connections with the least load should be maximally compatible with the socio-economic development of the studied area [11, 12].

Table 3. Capital funds for road sections.

	3-4	9-10	2-7	7-6	10-7
Road length, km	28,1	55,7	28,8	39,2	25,9
Total estimated costs, billion soums	56,2	111,4	57,6	764,4	505,05
Cost per 1 km, billion soums	2,0	2,0	2,0	19,5	19,5

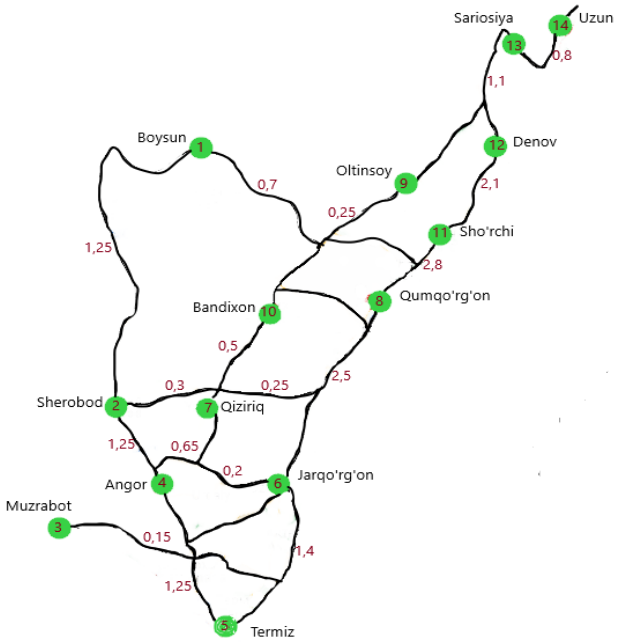

Figure 4. Road network and settlement scheme of the region.

The priority of the road network according to the drawing. It is known from the analysis of the location of transport networks 3-4, 9-10, 2-7, 7-6, 10-7 that they are connected with the center of the region through transit points (Fig. 4). However, the 7-6 transport network connects three districts with the center of the region. Transport connections 3-4, 9-10 do not connect any district with the center of the region. 3-4 and 7-6 are connected with the center of the studied area by one transport link, but the transport link 7-6 connects three districts with the center of the area. Therefore, he was given a preference of -1. Based on this, priority was assigned to 2-7 and 10-7 transport links -2 and 3-4 and 9-10 transport links -3 (Table 4).

Table 4. Priority on the map of the road network.

Order of transport connections	Priority on the map of the road network
3-4	3
9-10	3
2-7	2
7-6	1
10-7	2

Predominance in the number of people moving in the region of transport connections. It is determined on the basis of the population of the settlements in the region of the studied transport links (Table 5).

In order to calculate the advantage in terms of socio-economic efficiency, all transport connections under consideration are improved with a classification of load characteristics. Including changing from a low road surface to a passing road surface.

As a result of the improvement of all transport links, the length and density of the improved road network with hard surfaces will increase.

Table 5. Population superiority.

Order of transport connections	Population in settlements, thousand people	Population superiority
3-4	136	3
9-10	168,4	2
2-7	186	1
7-6	130,5	4
10-7	35	5

In the example of the region, in the process of solving this problem, as a result of the improvement of the technical and operational quality of road section 3-4, the density of the road network is 2.13 km/1000km2, 9-10 transport links are 3.48 km/1000km2, 2- 7 transport connection was 12.8 km/1000 km2, 7-6 transport connection was 5.9 km/1000 km2, and 10-7 transport connection was 5.2 km/1000 km2 (Table 6) [11] .

Regression equations [11] for each indicator were determined based on the correlation-regression model of the problem solved on the basis of the problem of the development of a road section with low traffic speed (1-5) and in determining the superiority in terms of socio-economic indicators was used.

$$y_1 = 4{,}0773x^2 + 1220{,}7x - 84552\,, \quad (1)$$

$$y_2 = -11{,}191x^2 + 3516{,}3x + 247651\,, \quad (2)$$

$$y_3 = 0{,}5695\,x^2 + 9{,}9079\,x - 7937{,}9 \quad (3)$$

$$y_4 = -0{,}756\,x^2 + 201{,}41x - 11705 \quad (4)$$

$$y_5 = -0{,}6778x^2 + 185{,}46x - 10079 \quad (5)$$

To solve the problem, the indicators of the statistical data of the Surkhandarya region were used, in which the indicators of the area in the cross-section of years were accepted [11].

Table 6. Superiority in socio-economic efficiency.

Procedure for transport communication	Number of inhabitants in the district, thousand people	Transport communication distance with improved coating, km	Transport communication distance, km	Prospective density of the road network in the studied area, km/1000 sq.km
3-4	136	158	28,1	2,13
9-10	168,4	195	55,7	3,48
2-7	186	351	28,8	12,8
7-6	130,5	119	39,2	5,9
10-7	35	78	25,9	5,2

To solve the problem, the indicators of the statistical data of the Surkhandarya region were used, in which the indicators of the area in the cross-section of years were accepted [11].

The values of the density of the hard surface road network obtained after the improvement of the road sections with low traffic speed (transportation connection) are put into the above correlation-regression equations (1-5) and the K_1 – volume of industrial product, billion soum; K_2 – GDP of Surkhandarya region, billion soums; K_3 – investments in fixed capital per capita, thousand soums; K_4 – population employment; K_5 – population, thousand people, the results of socio-economic efficiency, all indicators are determined (Table 7).

Table 7. Values of socio-economic indicators.

Plot	K_1	K_2	K_3	K_4	K_5	Final assessment
3-4	-56701,16	317470,98	-67217,66	-7757,84	-6436,22	5
9-10	-37133,87	356465,54	-6903,34	-5610,93	-4445,84	4
2-7	**138500**	**514384,06**	**2660,99**	**1689,18**	**2553,93**	**1**
7-6	1662,38	416156,83	-5370,9	-2453,44	1496	2
10-7	-10050,59	400238,14	-5882,76	-3275,9	1316,22	3

It was revealed from the results of the calculation that transport links 2-7 have the advantage in the assessment of socio-economic efficiency (Table 7).

A plan for the development of the highway network was obtained based on the system of indicators for the use of transport in conditions of low traffic intensity and the summary method of evaluating the efficiency of the network, taking into account the transport-operational indicators (Table 8).

Table 8. Superiority results on three indicators.

Areas with low traffic intensity	Superiority			
	Priority in terms of transit	According to the number of moving population	Socio-economic indicators	General
3-4	3	3	5	11
9-10	3	2	4	9
2-7	2	1	1	4
7-6	1	4	2	7
10-7	2	5	3	10

It was recommended to implement the sequence of improvement of road sections with low traffic speed based on the received plan. In this case, the load level is small, i.e. performing surface treatment works on road sections 3-4, 2-7, 9-10 and transferring road sections 10-7 and 7-6 from category IV to category III recommended. 1,494.65 billion soums are required for simultaneous implementation of these activities, and the possibility of its implementation is insufficient. That is why it is urgent to develop plans for the step-by-step development of designated road sections.

Conclusion. Methodical approaches and recommendations for the development of the transport network itself in the mastering of cargo flows in a multi-sectoral transport network are important for science and practice. Thus, significant improvements are being made in the planning and use of transport resources, which directly affect the economic development and well-being of the regions.

In the 2021 plan of public highways in the region, the transport and operational indicators of a total of 132.7 km of highways have been improved, and as a result of these measures, the overall efficiency is as follows.

$$S_c=S*L_{II}=348047*132,7=46185836 \text{ thousand sum}$$

In this case, according to the L-annual plan, the length of the repaired highways in the region, km.

It was found out from the calculations that the economic efficiency due to the increase in the speed of vehicles on highways is Sc=348047 soums for 1 km of road for one year and Sc=46185836 based on the one-year work plan. is one thousand soms.

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