Peculiarities of Sustainable Development of Transport Infrastructure of Tourism in St. Petersburg Agglomeration

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Abstract

The complicated geopolitical situation has become a factor in domestic tourism development in the Russian Federation. A significant number of objects of tourist interest have generated increased competition between Russian regions to attract tourists. A necessary condition for increasing tourist flow is the development of tourist infrastructure, including transport. The authors used various types of transport in the vast majority formation of tourist products, as well as in independent tourism. The purpose of this study is to analyse the relationships between tourist flow dynamics and the transportation system development indexes of St. Petersburg and the Leningrad region. Comparative, correlation and regression analyses showed a strong positive correlation between tourist flow and passenger transport by buses and suburban railway transport (especially in St. Petersburg). The study confirmed the problem of data reliability and availability for analysing tourist flow within the St. Petersburg agglomeration, although the palace suburbs, which are popular with tourists, are located within agglomeration boundaries. To solve the problem of tracking tourist flows when using transport in the agglomeration, the authors propose the development and implementation of a transport tourist map with advanced functionality. This digital tool application will allow not only the reliable tracking of tourist flows but also the optimization of the transport system of the St. Petersburg agglomeration. In addition, the analysis of tourist flow dynamics should be used to increase the positive effects of tourism development and reduce the negative effects of overtourism in achieving the sustainable development goals of St. Petersburg and the Leningrad region.

Keywords: tourist flow, transport, transport system, agglomeration, sustainable development, tourism infrastructure, region

Особенности Устойчивого Развития Транспортной Инфраструктуры Туризма Санкт-Петербургской Агломерации

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Аннотация

Сложная геополитическая ситуация стала фактором развития внутреннего туризма в РФ. Значительное количество объектов туристского интереса приводит к росту конкуренции между регионами России за привлечение туристов. Необходимым условием увеличения туристского потока является развитие туристской инфраструктуры, в том числе транспортной. Различные виды транспорта используются при формировании подавляющего большинства туристских продуктов, а также в самостоятельном туризме. Целью исследования является анализ взаимосвязей между динамикой туристского потока и показателями развития транспортной системы Санкт-Петербурга и Ленинградской области. Сравнительный, корреляционный и регрессионный анализ показали сильную положительную корреляцию между туристским потоком и перевозками пассажиров автобусами и пригородным железнодорожным транспортом (особенно в Санкт-Петербурге). Исследование подтвердило проблему достоверности и доступности данных для анализа туристского потока в рамках Санкт-Петербургской агломерации, хотя популярные у туристов дворцовые пригороды находятся в границах агломерации. Для решения проблемы отслеживания туристских потоков при использовании транспорта в агломерации авторы предлагают разработку и внедрение транспортной туристической карты с расширенным функционалом. Использование такого цифрового инструмента позволит не только достоверно отслеживать туристские потоки, но и оптимизировать транспортную систему Санкт-Петербургской агломерации. Кроме того, анализ динамики туристских потоков необходимо использовать для увеличения положительных эффектов от развития туризма и снижения негативных эффектов от овертуризма при достижении целей устойчивого развития Санкт-Петербурга и Ленинградской области.

Ключевые слова: туристский поток, транспорт, транспортная система, агломерация, устойчивое развитие, туристская инфраструктура, регион

1. Introduction

The object of this study is the transportation system within the St. Petersburg agglomeration. The study scope is the dependence of sustainable tourism development on the development of the transportation system of St. Petersburg and the Leningrad region. The study will examine the relationship between tourism development, considering the requirements of sustainable development and transport infrastructure development. The study's relevance appeals to the potential development of domestic and inbound tourism in the St. Petersburg agglomeration. It is also vital to note the unrealized potential of recreational travel for residents of St. Petersburg and the Leningrad region due to problems in the transportation system.

Researchers have studied various aspects of transportation, tourism and sustainable tourism development.

Tourism has become a significant factor in the economic development of multiple regions and countries, so the number of studies on regional tourism systems is growing (Gintciak et al., 2023, 2022; Liu and Wu, 2019; Darani and Asghari, 2018). The tourism development infrastructure impacts the possibility of creating tourist products (Berawi, 2016).

Transportation is one of the most significant branches of the region's infrastructure. Transport infrastructure development provides tourist mobility, especially in the independent tourism framework (Chen and Haynes, 2015; Liu et al., 2023; Van Truong and Shimizu, 2017; Zhang and Wen, 2023). Transport objects and elements of transport infrastructure can be objects of tourist interest (e.g. station buildings and retro trains).

However, there are no studies on the impact of transportation on tourism development regarding the requirements of sustainable development in the agglomeration.

Using the example of St. Petersburg and the Leningrad region, the authors will test the hypothesis of whether transport system development impacts tourist flow growth.

2. Literature review

It is vital to monitor the types of preferred transportation by tourists for the development of the territorial tourism market.

In addition, it is vital to analyse tourist satisfaction with different types of transport, route schedules, locations of public transport stops and road conditions. The development of the digital economy makes it possible to obtain a significant amount of data for analysis (Konyshev et al., 2023; Popova et al., 2023; Rodionov et al., 2023; Tan and Ismail, 2020).

The growth of tourist flows impacts the development of the territory in general and the transportation system in particular. On the one hand, transportation is a vital condition that impacts tourist flow. Regional governments improve the comfort of tourists' stays and maintain road infrastructure facilities by repairing roads and constructing parking lots for personal vehicles and tourist buses. Thus, the transportation system ensures the growth of GRP and employment and provides an opportunity to implement entrepreneurial initiatives. In some cases, it leads to accelerated urbanization of the territory (Feng, 2023; Kuchumov et al., 2023; Yu et al., 2023).

On the other hand, the expansion of the road network, the increase of anthropogenic factors in the territory, and the growth of passenger traffic may have insufficient effects on the regional environment. Therefore, it is vital to develop the transport infrastructure of tourism considering the sustainable development requirements to maintain a favourable environment (Buckley and Underdahl, 2023; Deng and Chen, 2024; Gössling et al., 2016; A. Tanina et al., 2023; Tanina et al., 2021; Yan and Phucharoen, 2024).

State aid has a significant impact on the development of transport as an infrastructural element of tourism, so it is vital to operate opportunities for interregional cooperation to form a unified agglomera-

tion transportation system (A. V. Tanina et al., 2023; Xu et al., 2023; Zhao and Dong, 2017).

3. Materials and methods

To realize the article's purpose, the authors operated St. Petersburg and the Leningrad region's statistical data, representing the development of the transportation system, together with the data of regional budget expenditures on tourism development. The authors used these sources to obtain the data: St. Petersburg Committee for Tourism Development[1], Leningrad Oblast Committee for Culture and Tourism[2], EMISS State Statistics Portal[3], St. Petersburg Open Budget[4], and Leningrad Oblast Open Budget[5].

The authors compared collected data with tourist flow as the prominent index of tourist activity in the territory. The authors chose data from 2015 to 2022 because in 2015, regional authorities began introducing state programmes, which more comprehensively describe the expenditures of budget functions on tourism and transportation system development. The authors chose correlation and regression analyses as the optimal research methods.

It is worth noting that from 2015 to 2017, the framework of programmes for cultural field development included tourism expenditures in both regions. St. Petersburg had the programme "Development of the Culture Field and Tourism", while the Leningrad region had the programme "Development of Culture". The authorities of both regions prioritized cultural industries; therefore, it is challenging to establish the exact budget performance for tourism development. The trend changed in 2018 when Russia declared the "Year of Tourism" in the run-up to the FIFA World Cup, and the authorities of both regions revised their views on the tourism sector, declaring it as an independent branch of the economy and forming separate state programmes for it. This significant change is also reflected in both datasets.

The authors labelled certain variables as follows: X1 – Budget expenditures for transportation, rubbles. X2 – Total length of public roads, km. X3 – Passenger turnover of public buses, people-kilometre. X4 – Suburban rail transportation, people. X5 – Budget expenditures for tourism development, rub. Y – Tourist flow, people (Tables 1–2).

Table 1. Saint Petersburg dataset

Year	X1	X2	X3	X4	X5	Y
2015	1,069E+11	3412,1	3191380300	47622000	17826222800	6500000
2016	1,31876E+11	3489,2	3236909000	48839000	21499788200	6900000
2017	1,44025E+11	3508,2	3417939600	48864000	24961534800	7500000
2018	1,32663E+11	3536,4	3507240600	51609000	709569200	8200000
2019	1,40122E+11	3566,7	3578578900	55853000	814034500	10400000
2020	1,26913E+11	3580,2	2445963500	39301000	458584600	2900000
2021	1,67798E+11	3574,9	3344299200	48739000	806451000	6100000
2022	2,80155E+11	3583,9	4217304900	56298000	1710870200	8100000

Table 2. Leningrad region dataset

Year	X1	X2	X3	X4	X5	Y
2015	7720000000	22286,9	1284058500	26393000	1510000000	2000000
2016	9560361900	22298,938	1246684700	26425000	1470000000	3000000
2017	8531100000	22374,8	1248140600	26338000	2315400000	4200000
2018	8482600000	22559,57	1267334600	27446000	175100000	5230282
2019	7907300000	22879,617	1398296200	28485000	183500000	5734691
2020	10835900000	23129,604	979189900	21541000	297900000	4760016
2021	15273500000	23166,312	1086139500	24994000	331100000	4907605
2022	15490900000	23340,596	1550227100	27077000	166500000	6019015

Then the authors calculated the correlation of both datasets (Tables 3–4)

Table 3. Correlation of the Saint Petersburg data

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Column1	1					
Column 2	0,538298694	1				
Column 3	0,738441797	0,156963231	1			
Column 4	0,546152163	0,146969737	0,93765709	1		
Column 5	-0,334782265	-0,76292982	-0,091650061	-0,149100943	1	
Column 6	0,229150742	-0,0035942	0,77850986	0,930023964	-0,00521077	1

Table 4. Correlation of the Leningrad Oblast data

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Column 1	1					
Column 2	0,793385629	1				
Column 3	0,030654363	0,01601861	1			
Column 4	-0,265933094	-0,308474264	0,818652809	1		
Column 5	-0,444802406	-0,768127082	-0,05957913	0,05419715	1	
Column 6	0,453568903	0,763510687	0,260011295	0,12335531	-0,7140079	1

After calculating the correlation, the author also conducted regression analysis (Tables 5–6).

Table 5. Regression analysis of St. Petersburg data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,994950345
R Square	0,989926188
Adjusted R Square	0,964741659
Standard Error	403319,8175
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	5	3,19697E+13	6,39393E+12	39,30691631	0,024994571
Residual	2	3,25334E+11	1,62667E+11		
Total	7	3,2295E+13			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-40662820,87	18300893,86	-2,221903541	0,156385799	-119405211,8	38079570,06	-119405212	38079570,1
X Variable 1	-1,92995E-05	9,23746E-06	-2,089265524	0,171879767	-5,90451E-05	2,04461E-05	-5,9045E-05	2,0446E-05
X Variable 2	7595,458296	5249,248573	1,446961063	0,284846887	-14990,2354	30181,152	-14990,2354	30181,152
X Variable 3	0,000136933	0,002076806	0,065934461	0,953427885	-0,00879884	0,009072706	-0,00879884	0,00907271
X Variable 4	0,466002592	0,143438419	3,248798995	0,083104671	-0,151163114	1,083168299	-0,15116311	1,0831683
X Variable 5	3,3664E-05	2,28987E-05	1,470124699	0,279321772	-6,48613E-05	0,000132189	-6,4861E-05	0,00013219

Table 6. Regression analysis of Leningrad region data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,895806653
R Square	0,802469559
Adjusted R Square	0,308643457
Standard Error	1141199,267
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	5	1,05815E+13	2,1163E+12	1,625004339	0,423138683
Residual	2	2,60467E+12	1,30234E+12		
Total	7	1,31862E+13			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-106020016,2	72339013,1	-1,465599428	0,280390527	-417269668,4	205229636	-417269668	205229636
X Variable 1	-0,000178111	0,000247036	-0,720991256	0,545802734	-0,001241021	0,000884799	-0,00124102	0,0008848
X Variable 2	4541,199504	3042,014408	1,492826428	0,274036863	-8547,532093	17629,9311	-8547,53209	17629,9311
X Variable 3	-0,002485852	0,005372948	-0,462660792	0,6890658	-0,025603781	0,020632076	-0,02560378	0,02063208
X Variable 4	0,459486867	0,493700869	0,930698923	0,450261784	-1,664736525	2,583710259	-1,66473653	2,58371026
X Variable 5	0,000215179	0,001010635	0,212914366	0,851124579	-0,004133233	0,004563591	-0,00413323	0,00456359

Further, interpreting the results is worthwhile.

4. Results

The authors formed diagrams to assess the prominent trends of the selected transportation and tourism development indexes (Figures 1–3).

Figure 1. Tourist flow in St. Petersburg and the Leningrad region 2015–2022, people
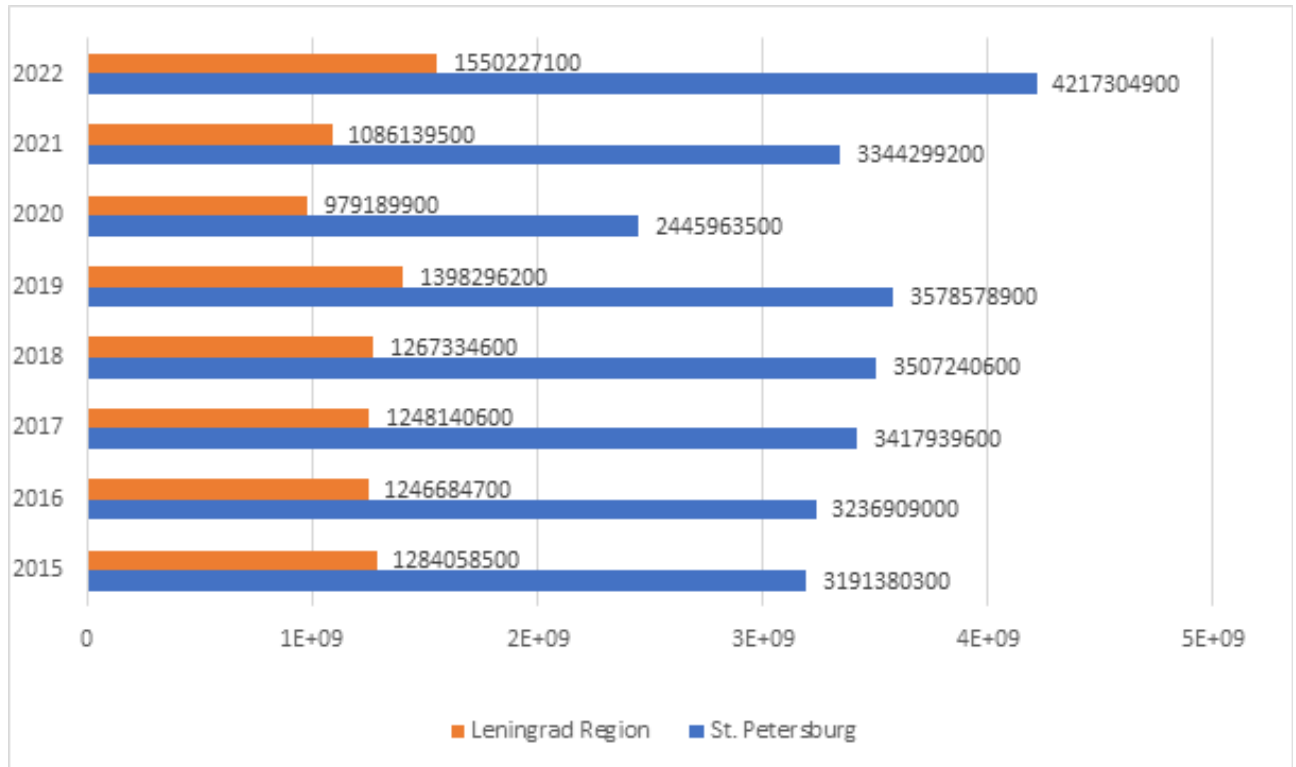

Figure 2. Passenger turnover of public buses in St. Petersburg and the Leningrad region 2015–2022, passenger-kilometre
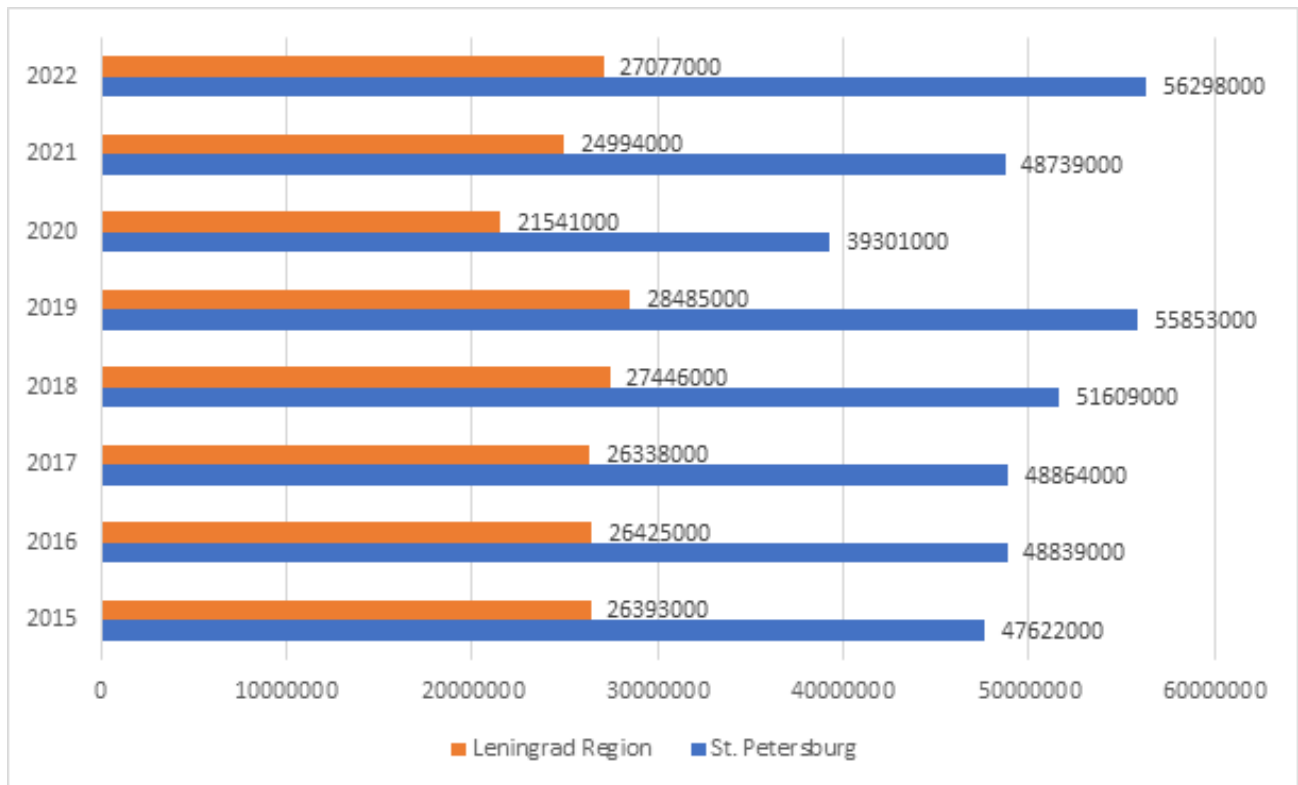
Figure 3. Suburban rail transportation in St. Petersburg and the Leningrad region 2015–2022, people

Figures 1–3 show that, in general, it is possible to observe general patterns between passenger movements and tourist flows. During the COVID-19 pandemic in 2020, there was a significant decrease in the number of tourists in St. Petersburg (more than 3.5 times), but tourist flows to the Leningrad region did not decrease as much (about 20%). According to the authors, this is due to the region's popularity as a territory where it was possible to leave St. Petersburg during travel restrictions, especially for the population with remote work. When the officials revoked pandemic restrictions, the Leningrad region increased its popularity as a region for ecological, rural, health and other types of tourism, which are less developed in St. Petersburg.

Due to the more developed transportation system of St. Petersburg (the prominent types of passenger transport are metros, buses, trolleybuses and trams), the pandemic impacted passenger traffic. The drop in passenger traffic by buses in the pandemic in 2020 amounted to 46%. A similar situation happened in the Leningrad region, with a drop in passenger traffic of 42.8%.

On April 1, 2022, city officials implemented a transport reform in St. Petersburg. The primary purpose was the abolition of commercial shuttle cab routes (in which city transportation cards were not valid) and the enactment of new social routes (in most of them, only cashless fare payment is possible). The result of the reform was the growth of bus transportation, which is observable from the 2022 statistics (26% growth).

The situation in the Leningrad region is not evident. In 2015–2018, there were slight fluctuations in passenger traffic in bus transportation. Then, there was growth in 2019, followed by a decrease in 2020. The region reached pre-pandemic values only in 2022.

Compared with bus transportation, suburban rails lost fewer passengers in the pandemic. For St. Petersburg, the decrease amounted to 42%, and for the Leningrad region, it was 32.2%. In 2022, suburban rail did not return to pre-pandemic values.

The lack of reliable data on other modes of transportation and movements of residents of St. Petersburg and the Leningrad region for tourism purposes makes it difficult to obtain objective information on the results of the comparative analysis. Therefore, the authors conducted regression and correlation

analyses on the available data.

First, the authors conducted the correlation of Saint Petersburg and the Leningrad region datasets. There are some curious observations:

The tourist flow of Saint Petersburg has a strong positive correlation with the passenger turnover of public buses ($r > 0.6$) and a very strong positive correlation with suburban rail transportation ($r > 0.8$). Also, these stated variables (X3 and X4) have very strong correlations among themselves ($r > 0.8$).

Budget expenditures for transportation of Saint Petersburg have a strong positive correlation only with the passenger turnover of public buses ($r > 0.6$). The rest have moderate and weak correlations.

The tourist flow of the Leningrad region has a surprisingly strong negative correlation with the budget expenditures for tourism ($r < -0.7$). This means that officials may spend less budget money and tourist flow may rise.

Also, budget expenditures for transportation in the Leningrad region have a strong correlation with road length. This statement is worthwhile because this budget item aims to build new roads.

According to both datasets, there are two common trends. First, there is a very strong correlation between suburban rail transportation and passenger turnover of public buses. Second, there is a strong negative correlation, with almost identical values between budget expenditures for tourism and road length.

In the regression analysis of St. Petersburg data, R square exceeds 0.95, so there is a high degree of approximation. The significance of F does not exceed 0.05; therefore, the regression model is statistically significant, but the independent p-values exceed 0.05.

In interpreting the results of the Leningrad region dataset, it is worth noting that F significance exceeds 0.05 and p-values exceed 0.05, but the R square value corresponds to the average approximation.

The authors appealing to correlation and regression analysis results show that the values of both analyses are more significant and worthwhile for the Saint Petersburg dataset, but both datasets at the same time have two common trends in correlation values. We assume that the prominent causes of such results are different territory administration modes, other quantity and quality of economic resources and infrastructural ties between regions.

5. Discussion

The article's authors faced several problems while studying the primary topic of the article.

1. Insufficient data to draw more accurate conclusions about the transportation system. For example, there are no data on regional bus passenger transportation before 2021, so the authors did not include it in the datasets.

2. Different approaches to tourist flow assessment by regional officials and Rosstat, including Rosstat implementing its assessment methodology only in 2022.

3. Lack of a unified data pool by sector of life in the St. Petersburg agglomeration. If the data pool existed, it would presumably have facilitated the research work.

4. Different numerical indexes of tourist flow from the regional authorities Rosstat and EMISS on tourist flow. For example, the tourist flow calculated according to the Turbarometer of St. Petersburg for 2023 was 9.4 million, and the EMISS value was 15.2 million. Therefore, the authors chose the tourist flow data issued by the authorities of both regions.

Official statistics, information from tourist market participants, and data from cell phone operators and banks issuing credit and debit cards are prominent data sources on tourist movements. The data obtained from different sources are quite different, which does not allow us to conclude something reliable

but to make only evaluative judgments. The lack of reliable statistics on the usage of different modes of transportation by tourists does not allow us to offer a comprehensive solution to the problems of transport accessibility, at least within the St. Petersburg agglomeration, for visiting the palace suburbs.

It is vital to actively use digital technologies to track the movements of tourists to solve this problem.

The transport reform implementation in St. Petersburg with digital technologies in the transportation system integration (from payment systems to the construction of multimodal routes and real-time tracking of a particular transport object) allows for obtaining information about the movement of passengers. This information is applicable for forming routes and making public transport schedules to optimize passenger flow.

The Leningrad region is not so actively using digital technologies in the transportation system—only recently has the possibility of paying fares with bank cards on buses emerged. The absence of a unified digital fare payment tool for St. Petersburg and the Leningrad region reduces the tourist attractiveness of regional attractions.

6. Conclusion

In general, the authors revealed a regularity between the growth of tourist flows and the development of the transportation system in St. Petersburg and the Leningrad region.

There is a conclusion that the regression model for St. Petersburg has statistical significance with the same variables but not in the model of the Leningrad region. Further research, when more relevant and complete data become available, will make it possible to find out more about interrelations and draw conclusions.

A promising research area for the joint development of transportation and tourism in St. Petersburg and the Leningrad region may be the study of the tourist flow growth impact on the implementation of sustainable development goals in the regions. The growth in the number of tourists has positive and negative consequences for agglomeration.

On the one hand, the increase in tourist travel (almost any tourist product includes the use of one or another mode of transportation) impacts the gross regional product, provides employment and facilitates business initiatives. It allows the implementation of such sustainable development goals as "decent work and economic growth", "industrialization, innovation, and infrastructure", and "partnership for sustainable development".

On the other hand, there is a significant increase in tourist flow to the overtourism level, leading to harmful effects on the environment, a decrease in the share of green spaces and natural objects in general for tourist infrastructure construction, an increase in prices of real estate and consumer goods, an increase in the amount of garbage, excessive load on the transportation system, and a reduction of recreational areas for residents, which all cause dissatisfaction among the population. Such unsuitable effects reduce the possibility of realizing such sustainable development goals as "responsible consumption and production", "clean water and sanitation", "conservation of marine ecosystems", and "conservation of terrestrial ecosystems".

Under the Sustainable Development Goal "responsible consumption and production", the Russian Federation is developing index 12.b.1 "implementation of standardized accounting methods to track economic and environmental characteristics of tourism sustainability". However, according to the Federal State Statistics Service, this index is presented only for the country without defining data by region.

The authors believe it is vital to use Moscow's experience in integrating fare payment by any mode of transportation within the boundaries of the metropolis and on suburban electric trains using the "Troika" card[6]. Here are engaging and applicable additional services on the Troika card: visiting zoos,

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[6]Troika card. URL: https://www.mosmetro.ru/payment/tickets/troyka

skating rinks, museums and traveling on the cable car and Aeroexpress trains. Such functionality can be appropriate to produce a tourist transportation card for the St. Petersburg agglomeration (in the future – for the entire territory of St. Petersburg and the Leningrad region).

This digital service will not only increase the attractiveness of travel in the two regions but also help track the movements of tourists to:

1. Optimize the route network;

2. Develop new routes and change the schedule of existing routes during peak demand periods in the high tourist season (white nights, etc.);

3. Formulate investment proposals within the framework of public-private partnership for the construction of transport infrastructure facilities for tourism in places near the objects of tourist interest; and

4. Determine the traffic load on the road network, considering the increased load on the roadway and railroad during the visit of tourists by personal and public transport.

Acknowledgements

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