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A Review of Transportation and Urban System in Istanbul via Innovation Process

Mehmet Çağrı Kızıltaş [a*] and Vail Karakale [b]

[a] *Istanbul Ticaret University, Istanbul, Turkey*
[b] *Istanbul Medeniyet University, Istanbul, Turkey*

Abstract

Highways in Turkey have a high share on modal distribution and mass transportation cannot get the share that it needs to be, so this case makes traffic problems getting worse. Local governments are aiming to manage the cities more effectively with innovative decision process. To minimize traffic congestion and congestion-related problems technical solutions, political decisions, and society management about changing habit culture habits are required. Urbanization, digitalization and sustainability are the mobility phenomena of 21st century. Intelligent transportation system has a unique role at this mentioned position for all elements, stakeholders and parties. Transportation policies and innovative approaches are necessary at this point. And an integrated plan and approach have a vital role for all stakeholders and the society. At this point in Turkey, big cities have some constitutional problems for years. Istanbul is a unique mega city in the country and all over the world. Government has to think and apply by a high level technique and hardware to this issue. Solutions for Istanbul o transportation and urbanization will be a huge experience for developed and developing countries. In this paper data on modal distribution of transportation modes in Istanbul are presented and the effect of mass transport in the city of Istanbul, especially the seaways is examined. This table is evaluated comparison to Bosporus bridges access traffic conditions.

Keywords: Modal Distribution; Mass Transportation; Maritime Transport; Car Ownership; Highway Transport Mode.

1. Introduction

After 1950's, automobile has started to form the urban especially in North America and Europa. Firstly, the areas between the railway line have expired, then the cities have extended averagely 50 km to periphery. The main characteristics of these urbans are disaggregation of residential areas and business areas, multi centered structure, low density locations and increasing of travel distances because of the other factors. Although the number of automobiles per 1000 person of United States of America is 1.5 times of Europe, usage of automobile of United States of America is 2.5 times of Europe (Ilicali, Çatbaş, Öngel, and Kızıltaş, 2014).

The unbalanced weight of road transportation in Turkey has been maintained for many years, but the situation has improved in recent years. Overall, the distribution trend in the transportation sector has shown that road transport has more than 90% weight in both passenger and freight transportation (Ilıcalı, Camkesen, Kızıltaş, and Ekinci, 2014). In the last years of the Ottoman Empire and the first decades of the Republic, investments were primarily made in railway transportation, followed by investments in highways through political engagements (Kızıltaş, 2018).

The number of metropolitan municipalities in Turkey is more than 30 and the powers and responsibilities of the metropolitan cities cover not only the central provinces but also the whole province boundaries (Román, Espino, and Martín, 2010). In this sense, both quantitatively increasing as well as qualitatively increasing investment in urban

*Corresponding author email address: themacagri@yandex.com
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planning and transport are also vital. In recent years, car ownership rates have increased exponentially in Istanbul due to the increase of the Gross National Product (GNP) (Kızıltaş, 2015).

In this context, the road investments made are not enough alone and in the long run the problem of traffic congestion cannot be prevented effectively due to lack of planning, integration, and unrelated transportation master plan-reconstruction plan originated from them. Furthermore, the rates of car ownerships in Turkey are higher than most European and USA cities (Altan, Kızıltaş, and Ayözen, 2020).

The main issue in Istanbul is that vehicles have a high time ratio in terms of traffic throughout the day. This primarily relates to the 'consumer culture' with the diversity and efficiency of the options offered to users (Altan, Kızıltaş, and Ayözen, 2020). Statement: The completion of the Kadıköy-Kartal Metro Line is an advantage, and there are necessary actions to ensure the operability of this line and to reduce traffic congestion as much as possible (Kızıltaş, 2016). Because integration is a priority here. As we explained earlier, this includes 'physical, spatial, commercial, operational' integration. In this sense, among the first things that come to mind to make the metro line efficient are well-designed minibuses and bus routes feeding the line, providing large parking lots at the main stations, and ticket integration. This research presents the modal distribution of Istanbul's transportation system and the impact of public transportation on traffic congestion on the Bosphorus bridges (Chen, 2017).

Transportation has been at the center of economic, technical, and social developments from the past to the present. The phenomenon of rapid urbanization on a global scale today has brought to the forefront a series of transportation-related issues and new trends. The rapid increase in urbanization, especially in developing and underdeveloped countries, has brought various challenges due to the infrastructure not progressing at the same pace. Transport can develop solutions to all these problems by centering on the increasing concern for sustainability. However, at this point, it needs innovative technologies more than ever. Rapid urbanization and the aforementioned processes bring along some infrastructure-related problems within the city connected to transportation and/or can play a role in exacerbating them. Especially in some developing or underdeveloped countries where the pace of urbanization continues, and the pace of development cannot keep up with the pace of urbanization—which is a very likely scenario—infrastructure-related transportation problems emerge. The most prominent of these problems include traffic congestion, insufficient integration, housing issues, disruptions in basic services, noise and sound pollution (which can be traffic-related), planning inadequacies, and parking problems. It can play a role in increasing traffic congestion and can also lead to extra time lost in traffic searching for parking spaces and vehicle occupation. A series of problems in question require effective and timely solutions in the context of transportation and urbanization, making prior planning essential. In this regard, our cities, especially Istanbul, have been late. However, the delay in this matter has also become a global phenomenon and indicates a general problem. In this context, there is a need for innovative solutions in parking as well, and studies continue to be conducted on the potential benefits of smart parking applications. In developed and underdeveloped countries, the share of infrastructure investments in the total budget is low. In developing countries, however, this share is high. As a developing country, a significant portion of infrastructure investments in Turkey is in transportation investments. Transportation investments are one of the important indicators of development. The most common type of transportation system worldwide is highways. In today's world, significant changes in the parameters of transportation services are observed within the context of rapid technological advancements. It is even observed that new service parameters have formed in parallel with technical developments over the decades. The current advancements, however, are probably not of the kind that will yet introduce a new service parameter. However, in the not-so-distant future, the developments recorded in areas such as digitalization, sustainability, artificial intelligence, robotics, fuzzy logic, and neural networks seem to be seriously poised to give rise to much newer elements and to eliminate some of the existing ones. The phenomena of mobility in the 21st century are digitalization, sustainability, and urbanization. Digitalization is connected to innovation. Urbanization is arriving with an intensity and strength unprecedented in history. Sustainability has become a necessity for civilization's existence, alongside the limitation of resources and high-degree capitalism, to continue in the context of linear technological progress. Within these phenomena, the need for transportation in the new century, especially autonomous vehicles, is emerging. The dominance of highways is not expected to radically disappear in the new century. However, a type of road transportation that is reconstituted with a gradually radical transformation within the parameters of service can be expected. Parameters such as security, reliability, and safety, among others, are important in all service parameters, and sometimes the perception of the user is decisive in itself. As a result, it is the user who generates the demand. Therefore, it is as important to accurately reflect the actual level of performance to the user as it is to know what that level is. On the other hand, the user's needs, priorities, and capabilities must also be well

analyzed and understood. If the user has a perception of something that is different from reality, it can also be considered that there is a stage in the process of supply and demand that is functioning incorrectly.

1.1. *Transportation Data*

The rate of car ownership in Turkey and the use of highway transport are on extremely high levels. The use of public transportation is not at the desired level yet. In this context, the use of public transportation, the increase of transportation infrastructure investments and usage rate of subway and light rail systems are important points that should be enhance together (SUMP, 2015). Also, improvement and utilization of conventional railway lines on intercity travels and true investment selections of high-speed railway investments will regularly decrease the dependency level to oil together. It is an action that provides three layers of sustainability which are social, environmental, and economic (Gerçek and Demir, 2015).

The population of Istanbul has increased geometrically since the 1970s, with this increase amounting to approximately 4-5 times (Kızıltaş, 2016). During the same period, the number of private vehicles increased at a faster rate, with the increase amounting to approximately 30 times from 1970 to 2000 (Kızıltaş and Altan, 2017). The increase in vehicle ownership being higher than the population growth, the increase in Gross Domestic Product (GDP), the profound changes in consumption culture, and the effectiveness of the road transport mode, whether it be the transportation system or public transport, can be expressed (Kızıltaş, 2018). The transportation values in Istanbul highlight the necessity of using public transport at a higher level than the current situation. For this, a balanced modal distribution and modal integration are necessary.

Railway systems, and especially metro investments, play a vital role in reducing traffic congestion in Istanbul. Additionally, due to Istanbul's location in the middle of the sea and its integration with the sea, the modal share of sea routes is very low (Zheng and Shiau, 1988). In the Bosphorus, maritime transportation parallel to the coastline has been attempted, but the desired efficiency has not been achieved. Here, the existing city ferry fleet between short distances is large enough and meets the general demand on a route basis. Due to the frequent deployment of parallel lines along the coast, it is necessary to schedule more frequent trips with smaller ferries and to design ferries with suitable physical characteristics for easier docking. In Istanbul, the Şehir Hatları is operating at 10% capacity, and utilizing 40-50% of the capacity would significantly reduce the traffic congestion levels on the Bosphorus bridges (TR 10th DP, 2016).

1.2. Modal Distribution and Sea Transportation

Istanbul contains a huge volume of population and employment that incorporates continuously positive and negative affects which comes from the position of being regional and international center. All of these effects reflect directly to Istanbulites too. As it is known, Istanbul is a city that continuously get a huge amount of immigrants. Istanbul is the biggest metropolitan and the most industrial city of Turkey.

Even today, it has one of the most important transportation corridors, just like in the historical period. In Istanbul, maritime transportation interacts with a focus on punctuality, comfort, and safety, ranging from traffic safety to modal integration, from consolidating public transport to enhancing service quality. In this context, it is observed that in Turkey (especially in Istanbul), both intercity and intracity travel will increasingly gain importance with each passing day, particularly in terms of sea and rail transport. Variable topography, socio-cultural structure, economic distribution, geographical location, and similar characteristics make a multimodal and integrated approach to transportation in Turkey and Istanbul both possible and necessary (Wong, Han, Ferreira, Zhu, and Sun, 2002).

Here another important point which is mass transport fleet can realize its potential on the parallel of increase level of the population and car ownership in mentioned years period. From this point, it can be said that the urgent necessity on increasing of effectiveness and efficiency of mass transport is integration, not fleet. On the same period the share of minibuses is 19.00% in 1987 and 16.71% in 2006 (Litman, 2013). The partial share decrease in minibus mode is due to the increase of GDP and enhancement of mass transportation operation. But it can be said that there is a considerable increase on minibus lines on the parallel of expansion of urbanization and extension of transportation networks. We must be confronted with the fact that the share of sea transportation which should be distributed in Istanbul is 20%. That share is far behind today’s (Kızıltaş, 2014).

Public transportation should provide a more integrated, comfortable, punctual, and safe service across all modes of transport, and visible returns can be achieved in the short term in this regard. At this point, the integration and

operability of railway systems are very important parameters. Here in Figure 1, the map of the Istanbul railway system is shown in detail. It is understood that the main railway axes of the city have emerged in an integrated, dense, and effective manner. Another important mode of public transportation in Istanbul is the BRT (Bus Rapid Transit) system called Metrobüs. The Metrobus is a vital component of the city's integrated public transportation system and handles a significant portion of Istanbul's passenger transport capacity. The Metrobüs has 44 stops, extending from the Asian side of Istanbul to the European side, providing access from the eastern point to the western point along the city's main southern axis. Here in Figure 2, a detailed Metrobüs map and its stops can be seen.

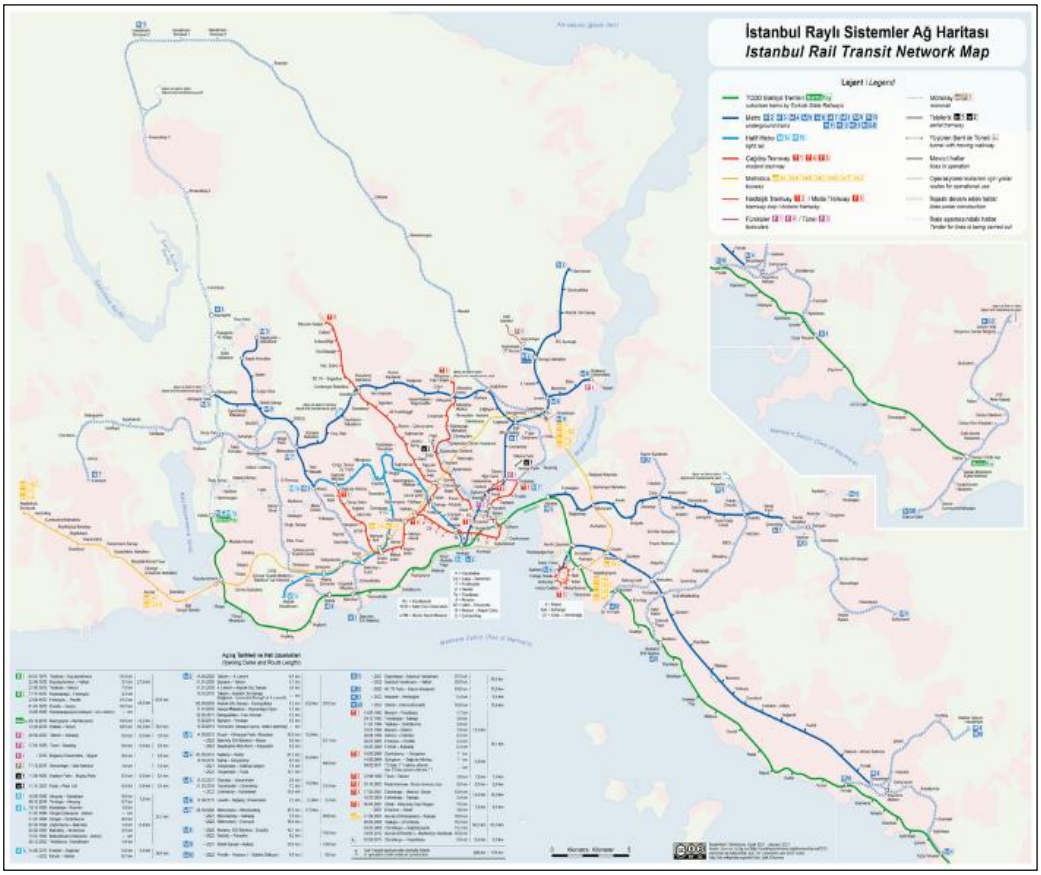

Figure 1. Istanbul Railway Transit Network Map (Kızıltaş, 2014)

When we look at the general data of mentioned year; according to the figures of the General Directorate of City Lines, we can see that City of Seaway works only with an occupancy capacity of 10%. This capacity even enhances to 50% levels; an additional roughly 1,000,000 passengers are shifted to the sea. Averagely a car in Istanbul carries 1-2 passengers; this would mean the decrease of 500-600 thousands of cars in main arterials (Kızıltaş, 2014).

When the Kanal İstanbul project is completed, international maritime freight transportation will significantly shift from the Bosphorus to the canal. Therefore, intercity maritime passenger transportation in the Bosphorus can utilize the entire Bosphorus region for longer hours and durations on more routes. As a result, passenger sea routes will reach much greater transport capacity. Here in Figure 3, the details of the Kanal İstanbul project can be seen.

For all these reasons, the Kanal İstanbul project plays an important role in issues such as public transportation in Istanbul, intermodal integration, balanced modal distribution, reducing traffic congestion, and increasing traffic safety, and it is addressed in various ways through different evaluations. In Figure 4, various transportation connections of the Istanbul Canal can be seen.

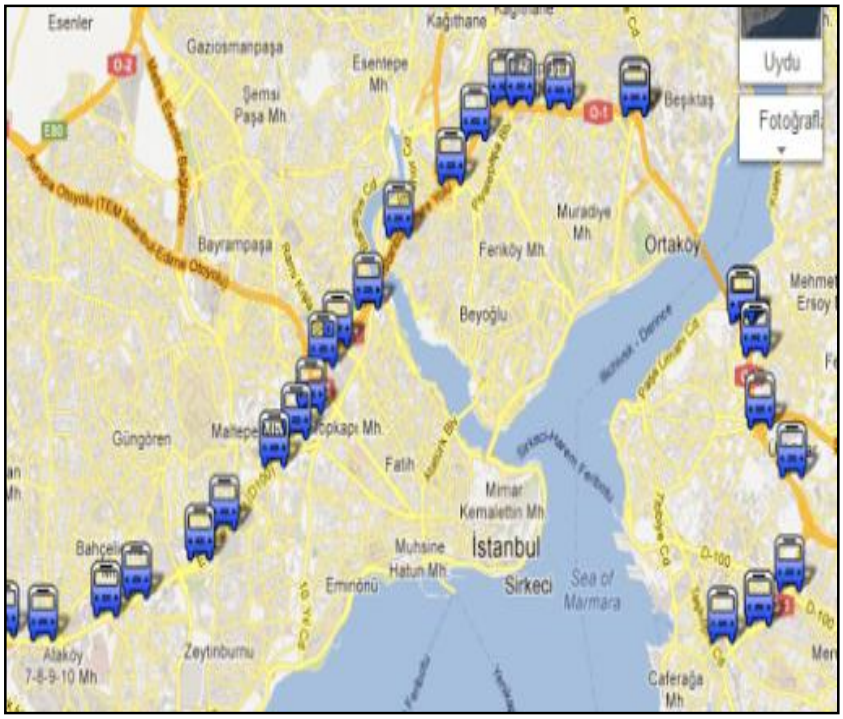

Figure 2. Istanbul Metrobüs Stations Map (Kızıltaş, 2014)

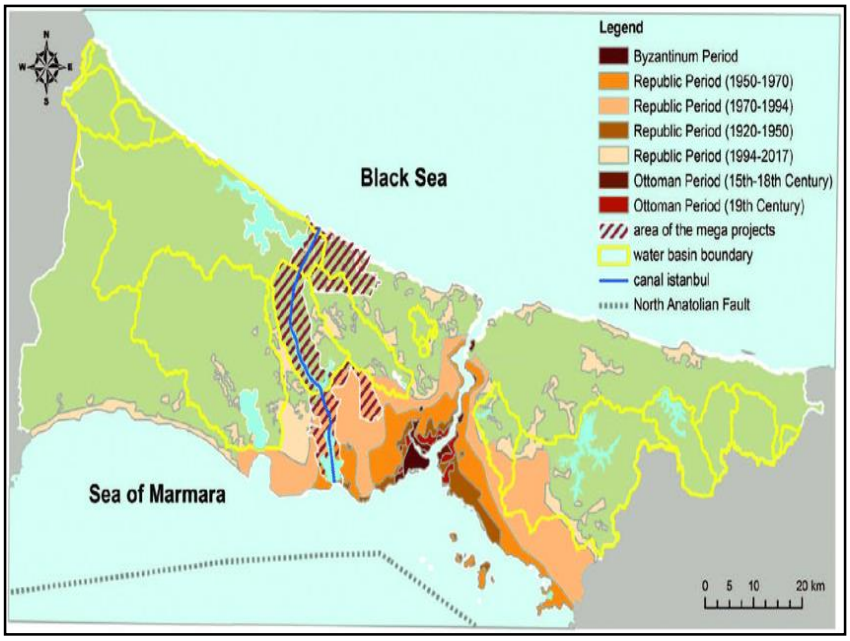

Figure 3. Channel Istanbul Project (Kızıltaş, 2014)

Figure 4. Channel Istanbul Transportation Connections (Kızıltaş, 2014)

Figure 5 shows the proportional distribution of public transport modes in Istanbul during the 2004-2015 period. It has been observed that a 10% reduction was recorded in the urban road transportation mode, and this rate was transferred to the railway systems with the number (Combes, Mayer, and Thisse, 2008). The Bosphorus Bridge becomes crowded, especially during peak hours, on many of its road lanes that are not wide enough. As seen in the figures, during the first phase of the bridge renovations, the reinforcement work carried out on the Fatih Sultan Mehmet Bridge resulted in a decrease of up to 30% in vehicle traffic (2nd Bosporus bridge). During the same period, a 10% increase was recorded on the Bosphorus Bridge. According to the results of the significant traffic decrease on the Fatih Sultan Mehmet Bridge, increases in demand were recorded for sea transportation and the Bosphorus Bridge.

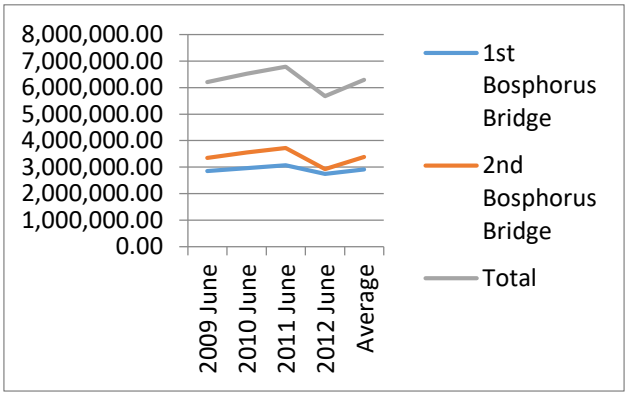

Figure 5. One Direction Monthly Based Total Accessed Vehicle Numbers (Rawat, Rodrigues, and Stojmenovic, 2015)

As seen in Figure 8, Üsküdar-Eyüp ferry line values have recorded an increase that was 11.12% in a short period during Fatih Sultan Mehmet Bridge maintenance period. These values are; for the Kadıköy-Kabataş line is 22.03%. The increase in Üsküdar-Beşiktaş Line reached its peak that was 19.22%. Besiktas-Kadikoy Line in the previous week according to an increase of 19.79%. In Eminönü-Üsküdar, which is another of the dense lines, these value is 8.77%. We have also shown that the case of using sea transportation is accelerating in one year as a whole. If we look at the reflections of the amendments to the total change of the City Lines flights; the number of weekly passengers increased by 125,825 in a week. This corresponds to an increase of 11.76%, an increase of 188.858 passengers (Marsh and Shilling, 1994).

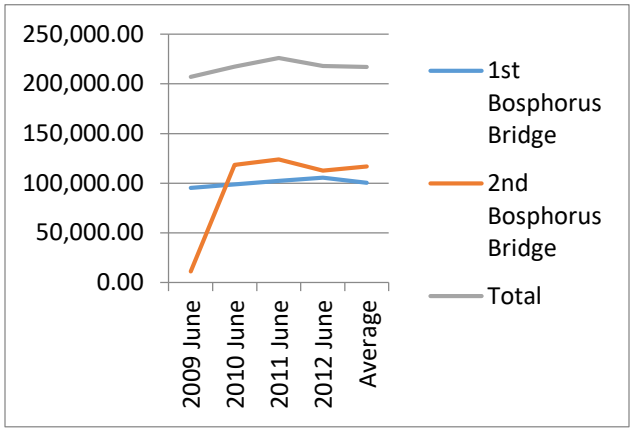

Figure 6. One Direction Monthly Based Daily Average Accessed Vehicle Numbers (BTSRITA, 2011)

In the same way; a significant number of passengers are transported by Bostanci-Bakırköy, Maltepe-Bakırköy, Bostanci-Kabataş. On these lines; it is possible to achieve an optimum level of service on the basis of scales such as cost-time-supply/demand-comfort relation.

Another issue in increasing the share of sea transportation mode has a relation with shifting service vehicles to Bosporus bridge accesses. Research conducted in this context includes values that can provide the appropriate background for the necessary studies.

2. Results

One of the important problems that we have not yet been able to fully address in Turkey, in intra urban and inter urban routes is about combined flow of private cars and heavy vehicles in mixed traffic can turn into a complete complex (BTSRITA, 2011).

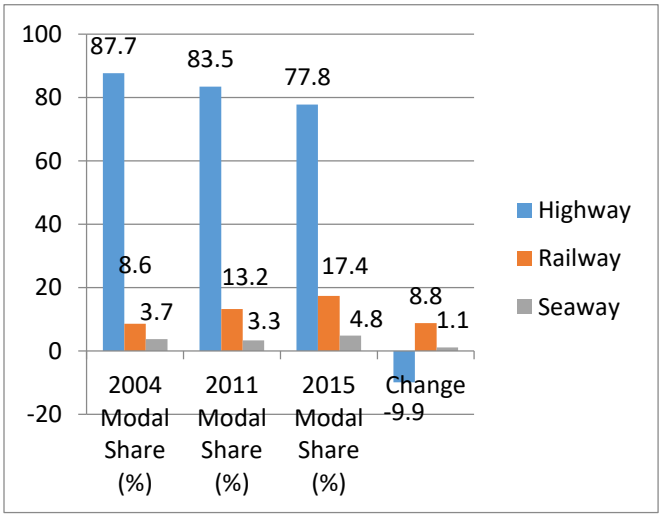

Figure 7. Modal Share of Mass Transport (BTSRITA, 2011)

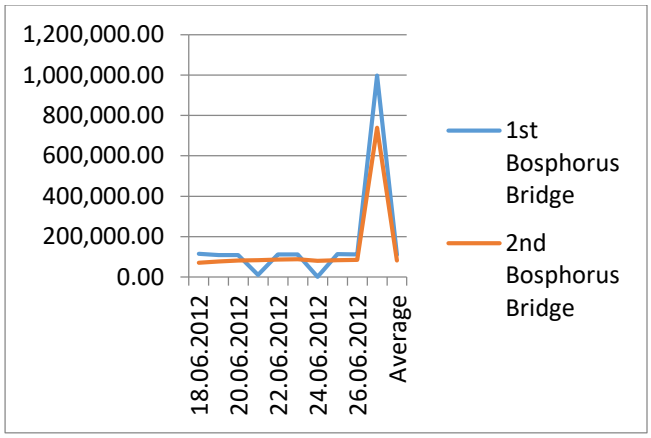

Figure 8. Changes On Number of Accessed Vehicles in Maintenance Days (BTSRITA, 2011)

For this purpose, it is proposed to implement a 'special lane' based on the principle of 'private vehicle lane' and 'public transport vehicle lane'. In this context, the systematic and appropriate collective guidance of maritime transportation services will provide us with significant benefits (Perugia, Moccia, Cordeau, and Laporte, 2011).

According to the counts conducted between 07:00-09:30 on 29.06.2012, the service trips on the Bosphorus bridges are presented in Figure 3 and Figure 4. As can be seen in the figures; both bridges have a heavy flow from Asia to Europe during the morning rush hours. The conclusion that can be drawn from this is as follows: Asia-Europe is the dominant direction of Bosphorus crossings during the morning rush hours, which indicates that these vehicles are transporting passengers to the European side for work, school, and similar purposes. And similar congestion is also observed during the evening rush hours from Europe to Asia (Kızıltaş, 2018).

The total number of service vehicles passing in both directions during the morning rush hours on both bridges is 7,160. Of these, 4,813 are being moved to Europe during the morning rush hours in the same period. Another result of this data is the heavy traffic on the Bosphorus bridges in both directions (Altan and Kızıltaş, 2018).

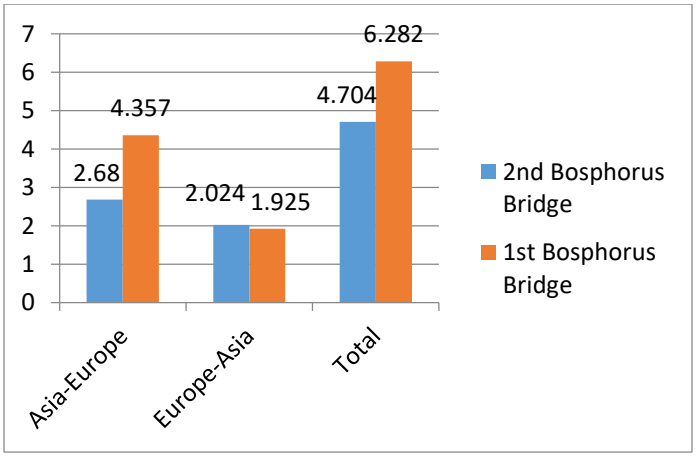

Figure 9. Number of Total Accessed Service Vehicles On Both Direction by The Bosporus Bridges (29.06.2012) (Rawat, Rodrigues, and Stojmenovic, 2015)

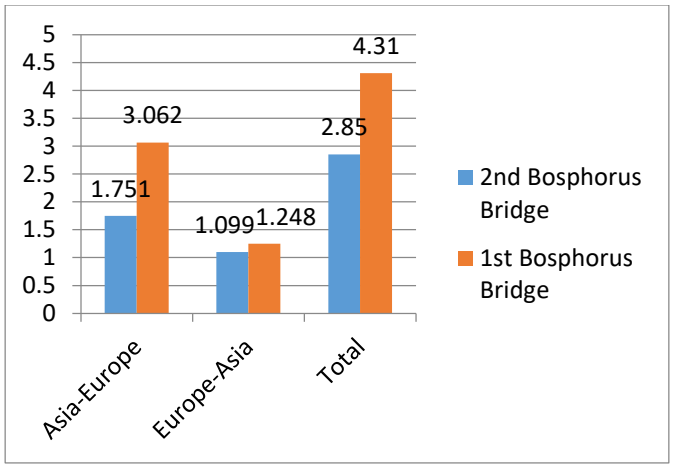

Figure 10. Number of Full Capacity Accessed Service Vehicles On Both Direction by The Bosporus Bridges (29.06.2012) (Rawat, Rodrigues, and Stojmenovic, 2015)

3. Conclusions

In recent years, car ownership rates have increased exponentially in Istanbul due to the increase of the Gross National Product (GNP) (Rawat et al., 2015). The main problem in Istanbul is the car has a high rate of time in terms of traffic during the day arteries (Altan and Kızıltaş, 2020). And this shows necessity to use public transportation in a higher level than in the existing situation (Altan and Kızıltaş, 2020). Railway systems, and especially metro investments, play a vital role in reducing traffic congestion in Istanbul (Kızıltaş and Altan, 2018). Additionally, due to Istanbul's location in the middle of the sea and its integration with the sea, the modal share of sea routes is very low (Roga et al., 2023). In Istanbul Ferry Lines is operating at 10% capacity (Roucolle, 2024). This capacity increases to 50%, with approximately 1,000,000 additional passengers being diverted to the sea (Mahdzir, Xuan, Yu, Tiean, and Kun, 2024). On average, a car in Istanbul carries 1-2 passengers; this means a reduction of 500-600 thousand cars on the main. And this will significantly reduce the levels of traffic congestion on access to the Bosphorus bridges. During the 2004-2015 period, a 10% decrease was recorded in the urban highway transportation mode

This rate has transferred to railway systems. Also the study shows that a significant number of passengers are transported by Bostanci-Bakırköy, Maltepe-Bakırköy, Bostanci-Kabataş. On these lines; it is possible to achieve an optimum level of service on the basis of scales such as cost-time-supply/demand-comfort relation (Herawatie, Siswanto, and Widodo, 2024).

In this concept basic conclusions for Istanbul traffic and urban environment:

- Istanbul goes to a multi centric structure. This trend will be strengthen.
- Seismic risk is a big problem for the city.
- Istanbul main arterial traffic (1st Bosphorus Bridge and connections) will have heavier traffic.
- Subway investments will enhance.
- Carownerhip ratio is enhancing.
- City planning lackness is going on.

Recommendations are:

- Integrated city planning establishment.
- Increasing smart technologies as a whole.
- Sustaining to subway and intra urban railway investments (Campisi, Russo, Bouhouras, Tesoriere, and Basbas, 2023)
- More subvention to mass transport and railways.
- Establishing alternative bus rapid transit lines.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability Statement

All graphs and data obtained or generated during the investigation appear in the published article.

Author's Contributions

Ethics

There are no ethical issues with the publication of this manuscript.

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