HIGH SPEED RAIL DEVELOPMENT IN TURKEY: GOVERNMENT POLICY, INVESTMENTS AND USERS PERSPECTIVE

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ABSTRACT

HIGH SPEED RAIL DEVELOPMENT IN TURKEY: GOVERNMENT POLICY, INVESTMENTS AND USERS PERSPECTIVE

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Sustainable development has become a major goal for development policies of governments, local, national, and even supra-national. The transport sector often receives a major emphasis in these policies because it is currently one of the least sustainable sectors. It contributes significantly to the creation of greenhouse gas emissions that cause global warming. It is one of the major consumers of energy sources as well as land. In order to attain both a reduction in greenhouse gas emissions and energy efficiency, it is crucial to restructure transport policies and create a shift towards sustainable modes of transport. Due to its relatively lower emission impact and energy consumption (per passengers and goods carried), railways receive increasing emphasis that have resulted in extensive investment in rail networks.

High speed railway (HSR) investments are the one of the important components of this transport strategy to reduce carbon intensive long-distance travel because when high speed train operates, it is expected that there will be a shift from road and air to rail. As a result, high speed rail investments have increased significantly in the world.

In Turkey too, there is increasing investment in high-speed railways. Currently the transport sector in Turkey is predominantly dependent on road in both passengers and freight transport. Policies for over three decades have proposed the development of railways to create a shift from road to rail, although investment in railways still remained extremely limited so far. However, there is a recent trend in rail policies and projects in Turkey that focus on the development of HSRs. As a result extensive investments have been made in high speed rail, and a number of lines have already begun operation. In addition there are many projects that are in planning stage and about 20 years later there will be a very strong HSR network in Turkey which facilitates intercity transportation. Increasing investment of high speed train projects can bring many environmental, social and physical externalities. However, they can be effective in reducing CO_2 emissions in the transport sector. This is often the justification of investment in rail systems; however, this desired impact can only occur if there is a shift to railways from road and air transport since these are the main transport modes that cause fossil fuel combustion. Because of this, it is crucial that railway investment results in a shift from road and air to rail transport. If this does not happen, benefits expected from railway investments cannot be realized.

This thesis aims to analyze high speed rail investments in Turkey by focusing on possible passenger shifts from road to rail transport. First, both positive and negative environmental impacts of high speed rail projects will be evaluated taking into account expected change in airway and highway usage by passengers. In order to project that passenger shift, a user survey has been carried out in order to find how travel behavior of people change due to travel time and monetary cost

of different modes of transport. The survey was conducted in many cities that have HSR projects for future. The analysis also highlights what kind of policies should be implemented to encourage a modal shift from road to rail transportation.

Keywords: Sustainability, Climate Change, Greenhouse Gas Emissions, Railway Network, HSR, User Perspective, Modal Shift

ÖZ

TÜRKİYE'DE YÜKSEK HIZLI DEMİRYOLU GELİŞİMİ: DEVLET POLİTİKALARI, YATIRIMLAR VE KULLANICI BAKIŞ AÇISI

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Sürdürülebilir kalkınma devletlerin yerel, ulusal ve uluslararası ölçekteki kalkınma politikalarının hedefi haline gelmiştir. Sürdürülemez bir büyüme eğilimi kapsamında başlıca sektörlerden biri olarak ulaşım sektörü de bu politikalarda sıkça vurgulanmaktadır. Ulaştırma sektörü, küresel ısınmaya sebep olan sera gazlarının en fazla kaynaklandığı sektörlerden biri olup, aynı zamanda enerji ve alan ihtiyacı da çok fazladır. Hem sera gazı emisyonlarını azaltmak hem de enerji verimliliğini sağlamak için ulaşım politikalarının yeniden düzenlenmesi ve taşımacılığın sürdürülebilir ulaşım modları kullanılarak yapılmasının sağlanması önem arz etmektedir. Demiryolları emisyon ve enerji tüketimi açısından diğer modlarla karşılaştırıldığında daha az çevresel etkisi olduğundan demiryolu ağlarının geliştirilmesi konusunda tüm dünyada artan bir eğilim görülmektedir.

Bu kapsamda, yüksek hızlı tren yatırımları, uzun mesafe taşımacılığında karbon ağırlıklı karayolu ve havayolu ulaşımının rolünün azaltılarak demiryollarının kullanımının arttırılması beklentisiyle ulaştırma stratejisinin önemli bir parçasını oluşturmaktadır. Dünyada hızlı tren yatırımları hızla artmaktadır. Türkiye'de de hızlı trenler için artan bir yatırım olduğu görülmektedir. Mevcut durumda, Türkiye'de ulaştırma sektörü hem yolcu hem de yük taşımacılığında büyük oranda karayoluna bağımlı durumdadır. Son 30 yıldır önerilen politikalar her ne kadar demiryolu gelişimini ve karayolundan demiryoluna geçişi özendirmeyi hedeflemişse de, demiryoluna yapılan yatırımlar sınırlı kalmıştır. Bununla birlikte, son yıllarda hızlı tren yatırımları konusunda artan bir eğilim görülmekte olup bazı hatlar işletmeye açılmıştır. Ayrıca, planlama aşamasında pek çok proje bulunmaktadır ve yaklaşık 20 yıl içerisinde Türkiye'de kapsamlı bir hızlı demiryolu ağının oluşması beklenmektedir. Hızlı trenlerin işletilmesi ile ulaştırma sektöründe karbon emisyonlarında azaltım sağlanacağı beklenmektedir. Bu beklenti genelde demiryoluna yapılan yatırımların temel gerekçelerinden biri olarak gösterilmektedir. Öte yandan beklenen pozitif etkiler ancak ulaştırmanın fosil yakıt kullanan karayolu ve havayolu türleri yerine demiryolları ile yapılması halinde gerçekleşecektir. Eğer bu değişim sağlanmazsa, beklenen faydaların gerçekleşmesi mümkün değildir. Bu tez, yolcu taşımacılığında karayolundan demiryoluna olasıgeçişlere odaklanarak Türkiye'deki hızlı tren yatırımlarını analiz etmeyi amaçlamaktadır. Karayolu kullanımındaki değişimleri öngörebilmek için, insanların ulaşımdaki davranışlarını, farklı ulaşım türlerinin zaman ve maliyet unsurlarını göz önünde bulundurularak hızlı tren sistemlerinin devreye girmesi durumunda yolculuk alışkanlıklarını nasıl değiştireceklerini sorgulayan bir anket hazırlanmıştır ve hızlı tren projelerinin planlandığı pek çok ilde uygulanmıştır. Ayrıca bu çalışma, analiz sonuçlarına dayanarak karayolundan demiryoluna geçişi teşvik etmek için ne gibi politikalar uygulanması gerektiğini de içermektedir.

Anahtar Kelimeler: Sürdürülebilirlik, İklim Değişikliği, Sera Gazı Emisyonları, Demiryolu Ağı,Yüksek Hızlı Demiryolu, Kullanıcı Bakış Açısı, Mod Değişimi

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CHAPTER 1

INTRODUCTION

There is an increasing emphasis on sustainable development all over the world. Climate change, which is directly related with sustainable development, is the biggest problem that the world faced in the last decades and the impacts of climate change is expected to increase in the near future.

The transport sector, which contributes significantly to the climate change because of the fossil fuel combustion and ever-increasing traffic levels and travel distances, is one of the least sustainable sectors. Not only the contribution to the climate change but also its consumption of land and energy, and hence depletion of resources makes the transport sector critical if sustainable development goals are to be attained. Many countries have committed themselves to decrease the amount of man-made greenhouse gas emissions (GHG) and energy consumption in transport sector. This is only possible with the restructuring of transport policies and creating a shift to sustainable transport modes.

Road and air transportation are the major consumers of fossil fuels that lead to climate change; and the dominance of these modes increases GHG emissions in the atmosphere and lead to the depletion of the ozone layer. Railway transportation is seen as a sustainable alternative when compared to road and air transportation because it uses electricity as its power supply. It should be noted that the production of electricity also results in GHG emissions; however, if railways are capable of carrying major bulk of freight and sufficient numbers of passengers then the energy used and emissions created per unit of freight and per passenger are much lower when compared to those for road and air transportation.

Therefore, railways receive increasing emphasis all over the world for both freight and passenger transportation. It is on the agenda of both national and supranational policymakers to develop railways for not only inter-city but also international transportation to strengthen the world wide railway network.

For passenger and freight transportation, high speed railway (HSR) investments are seen as an effective alternative for air and road transportation especially for middle and long distance travels. Therefore, there is an increasing investment for HSR projects to create a shift from road to railway. As a result, HSR investments have increased significantly in the world.

In Turkey too, there is an increasing investment for HSR projects. After the 1950s, railways have lost their priority in transport investments in Turkey and road oriented policies have been implemented since. Although national development plans, which comprise investment priorities and policies for each sector in the country, have been proposing for three decades the further development and improvement of railways in the country as well as the construction of HSR lines, investments remained extremely limited.

While the improvement, modernization and expansion of the conventional railway lines still remain limited, there has been a recent interest in HSR lines. After the Ankara-EskişehirHSR, which started to be constructed in 2003 and opened to service in 2009, Ankara-Konya and Konya-Eskişehir lines began to operate and Eskişehir-İstanbul section was opened in July 2014. In addition to these lines, there are numerous other HSR projects that are in planning stage.

This study aims to analyze four of these planned HSR lines by focusing on the possibility of passenger journey shifts from road to railway transportation. The shift is the most significant part of this study because if the expected ridership is not achieved for HSR projects, road oriented inter-city transportation remains the same and the amount of energy consumed and GHG emissions created by the

transport sector do not decrease. In addition, HSR investments are costly investments. If ridership levels remain less than projected, this would cause loss of money, loss of land and environmental damage. Furthermore, as mentioned above, the electricity consumed by railway operations also causes GHG emissions during its production. If the HSR lines are not likely to attract users, then the electricity used by the HSR operation will be a waste; and this would indicate both inefficiency in resource consumption and further environmental damage through the GHG emissions created during the production of this energy. Therefore, in this study, currently planned HSR lines will be evaluated from the user perspective.

In the scope of the study, after a review of Turkey's investment plans for HSR systems, two main research questions are to be answered:

1. What are the perceptions of potential users with regards to HSR:
    a. Are these planned railway systems likely to be used by inhabitants that currently use road transport?
    b. Under what conditions (price, time and other) are the users likely to prefer railway systems?
    c. Is a passenger shift from road to railways likely to happen as a result of these HSR investments?
2. In the light of answers to theabove questions, are HSR investments in Turkey likely to change passenger transportation patterns and mode choices and hence help mitigation of GHG emissions?

In order to have an understanding about past, current and future transport policies and HSR investments in Turkey, institutional sector reports have been analyzed. In addition, to have a better understanding of whether a passenger transport shift will occur from road to rail transport, a user questionnaire has been carried out with people living in close proximity to the planned HSR lines. The questionnaire

was conducted in the context of four planned HSR projects that are coded as Line 1, Line 2, Line 3 and Line 4:

Line 1: Sincan-Çayırhan-İstanbul HSR Line Ankara-Kocaeli Section
Line 2: Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line
Line 3:Kırşehir-Aksaray-UlukışlaHSR Line
Line 4: Erzincan-Diyarbakır-MardinHSR Line

In the next chapter, a brief review of the literature is presented with regards to sustainable development and the role that the transport sector plays in this. After that, current trends in passenger and freight transportation in the world are examined and then the environmental impacts of current transport modes are given. In order to provide a better understanding of global transportation policies and HSR investments, international policy documents are briefly reviewed.

In the third chapter, the transport sector in Turkey is reviewed in terms of current trends and mode shares, environmental impacts of current transportation modes and institutional framework for transport policies. Then Turkey's railway history and the current railway network are presented. In addition, recent plans and investments in HSR are discussed briefly.

In the fourth chapter, the methodology of the study is presented. Firstly, aims of the study and research questions are described. Then, the method of data collection and design of the questionnaire are given. After that the method of questionnaire evaluation is described.

Chapter 5 presents the evaluation of the questionnaire. Firstly, the results of the overall questionnaire are given, and then all four projects are evaluated separately by using descriptive statistical analysis. Since the study aims at determining the potential shift from road to railway transportation, the questions related with current choices of mode and price sensitivity are compared.

In the conclusion chapter, the main findings of the study are described. Recommendations are made as to what kind of policies should be implemented to encourage a modal shift from road to rail transportation. In addition, future research that could be based on this thesis is discussed.

CHAPTER 2

SUSTAINABLE DEVELOPMENT, THE TRANSPORT SECTOR, AND THE INCREASING EMPHASIS ON RAILWAYS

2.1. Sustainable Development and the Transport Sector

"Sustainable" implies forever, perpetuity, constant rebirth and renewal, an inexhaustible system whereas "development" implies change, growth, expansion, production and movement. "Sustainability and development" terms when used together connote balancing economic and social forces against the environmental imperatives of resource conservation and renewal for the world of tomorrow (Doğru, 2006). Sustainability is not against the concept of growth; it supports smart development and integrates the environment into all aspects of life and all aspects of government. In 1987, the Brundtland Report defined sustainable development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Nowak, 2012).In this definition, environmental awareness, inter-generational equity, and social-justice, as well as environmental awareness are emphasized as key concepts that are required for sustainable development (Piotrowicz&Cuthbertson, 2012). Therefore, sustainable development is a three dimensional concept that consists of three pillars, which are environment, economy and society.

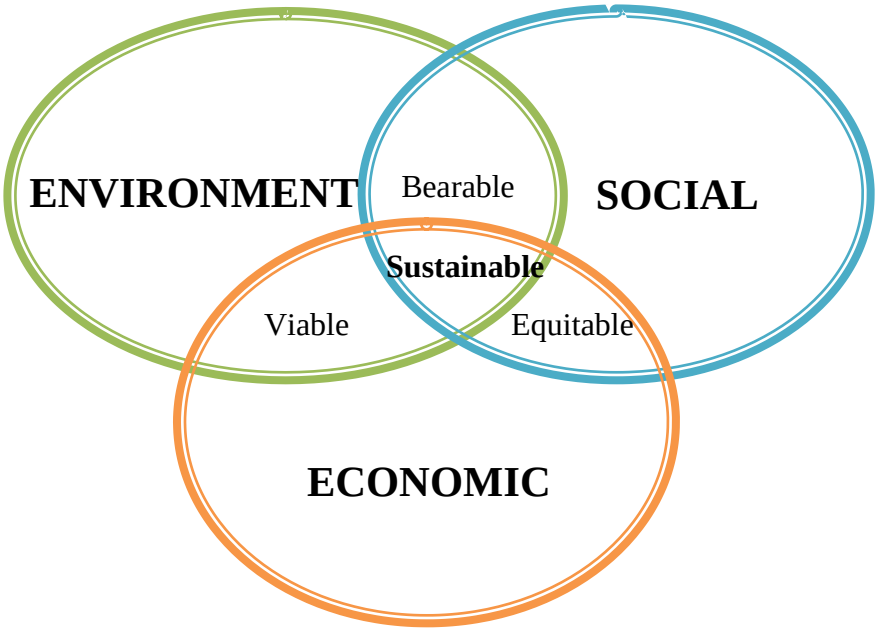


Figure 2.1. Pillars of Sustainable Development

The transport sector, which is one of the major consumers of land and energy, is seen as an obstacle to achieve sustainable development because increasing population and growing settlements make transport more indispensablerapidly (Black,1995). Mobility and traffic levels are continuously increasing, and travel distances are also increasing. This means that even though new technologies for energy-efficient vehicles are introduced, the massive growth in mobility offsets any reductions in energy consumption and emissionthat can be attained by such technologies (Golinska&Hajdul, 2012). Therefore, the transport sector is a major policy area for governments that aim to attain the goal of sustainable development.

According to the sustainable transport policy approach, the main target should be to provide secure, safe and environmentally friendly mobility. Therefore, it is important to increase proportions of passenger and freight transportation by environmentally less damaging modes and to use existing transport infrastructure efficiently. It takes long time to build appropriate transport infrastructure and it has many environmental, social and economic aspects. Therefore, it is important

to preserve existing transport infrastructure and rehabilitate it to prolong its life time(Royal Commission on Environmental Pollution (RCEP), 1995).

According to the European Union Council of Ministers of Transport, sustainable transport system should meet the needs of individuals, companies and society in a safe way and it should be consistent with human and ecosystem health and promote equity between generations (Goldman &Gorham, 2006). It should be affordable for all social groups and operate fairly and efficiently. Moreover, transport network should offer choice of transport mode and support a competitive economy, as well as balance regional development. Lastly, from an environmental perspective it should limit emissions, waste, use of land and noise and encourage renewable resource use.

There are many undesirable effects of transport that can be listed as; congestion, oil dependence, accidents, emissions of GHG and of other pollutants, noise, and land fragmentation caused by infrastructure (RCEP, 1995). Thus, sustainable transport oriented policies should provide solutions to these undesirable effects. In the sustainable development framework, the transport sector is reviewed in the next chapters in terms of climate change, energy consumption and societal challenges.

2.1.1. Transport Sector & Climate Change

Climate change is a multi-faceted phenomenon and the most prominent issue of the sustainable development agenda (Mega, 2005).Climate politics, which is an issue of interest for scientists, policy makers and citizens, have an importance in the global agenda, and the cost, benefit and impacts of actions are considered in relation to climate change in the policy making. The first attempt for global climate change awareness and policymaking is the United Nations Framework Convention on Climate Change (UNFCCC) which was ratified by one hundred and eighty nine nations in 1992 Rio Conference. Then, at the third Conference of

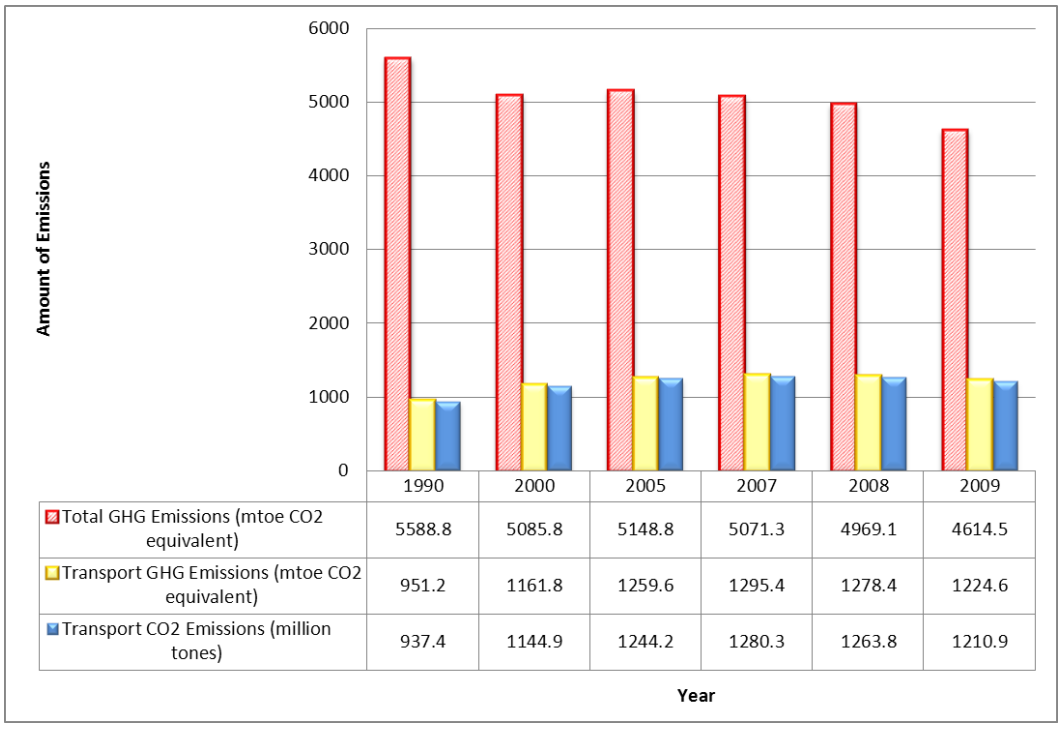
the signatories in Kyoto in 1997, the Kyoto Protocol, which led to industrialized countries to make commitments to emission reduction and introduced new flexible instruments including emission trading, joint implementation and the clean development mechanism, marked an important milestone. It was ratified by all European Union (EU) member states in 2002 and Russia joined in 2004. Turkey also joined in 2009. Currently, there are 192 parties and 83 signatories of Kyoto Protocol.

The primary indicator of climate change is air surface temperature rise. According to Intergovernmental Panel on Climate Change (IPCC), it is probable to see an increase of 1.4 to 5.8 degrees Celsius in temperature by 2100. Air surface temperature increase has many undesirable consequences. One of the major consequences is the sea level rise, which is expected to increase 9 to 88 cm by 2100 (Mega, 2005). Sea level rise is caused by the melting ice in the Polar Regions and ocean expansionbecause of the increasing air, sea andsurface temperature. Such environmental challenges are increasing and they are likely to have significant impacts on Earth. Extreme weather events that the world has been facing frequently in the past years are one of the evidences of climate change happening.

Greenhouse gas emissions (GHG), including carbon dioxide (CO_2), methane (CH_4) nitrous oxide (N_2O) and the three main fluorinated gases, hydrofluorocarbons (HFCs), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6) cause an increase in air temperatures (Mega, 2005). According to the IPCC Report (2013), there are striking findings about the surface temperature, sea level rise, glacier loss and GHG emissions. According to the Report, the globally average combined land and ocean surface temperature shows a warming of 0.85 °C over the period 1880 to 2012 and the sea level rise shows 3.2 mm between 1993 and 2010. In this report, it is firstly accepted that human activity is the reason of increased GHG emissions. It is stated that “the atmospheric concentrations of the GHG, carbon dioxide (CO_2), methane (CH_4), and nitrous

oxide (N_2O) have all increased since 1750 due to human activity. In 2011 the concentrations of these GHG were 391 ppm, 1803 ppb, and 324 ppb, and exceeded the pre-industrial levels by about 40%, 150%, and 20%, respectively." According to the ice core analysis in the same Report, CO_2, CH_4 and N_2O concentrations exceeded the records during the past 800,000 years.

Transportation, which is one of the sources of GHG in the atmosphere, has been increasingly contributing to the process especially since the 1990s. According to the EU Transport in Figures which is published by European Commission (2012), transport is accounted for about 17% of total GHG emissions in 1990 and this increased to 26.53 % of total GHG emissions in 2009 (see Figure 2.2).



	1990	2000	2005	2007	2008	2009
Total GHG Emissions (mtoe CO2 equivalent)	5588.8	5085.8	5148.8	5071.3	4969.1	4614.5
Transport GHG Emissions (mtoe CO2 equivalent)	951.2	1161.8	1259.6	1295.4	1278.4	1224.6
Transport CO2 Emissions (million tones)	937.4	1144.9	1244.2	1280.3	1263.8	1210.9

Figure 2.2. Total Emissions and Transport Related Emissions of EU 27 between 1990 and 2009 (EU Commission, 2012)

Table 2.1 shows GHG emission amount that is generated by different transport modes between 1990 and 2009 in the EU countries. It is seen that there is an

increasing trend in the share of GHG emissions of aviation and navigation sector. Furthermore, the road sector appears as the major contributor to GHG emissions, which is not surprising since it is the most commonly used mode, especially for passenger transport.

Table 2.1.GHG Emissions from Transport by Mode Shares for EU 27

	1990	**2000**	**2005**	**2007**	**2008**	**2009**
Total Aviation	8.7	11.7	12.0	12.5	12.7	12.3
Road Transportation	75.1	73.7	72.0	70.9	70.6	71.7
Railways	1.5	0.8	0.6	0.6	0.6	0.6
Total Navigation	13.5	13.0	14.6	15.2	15.3	14.6
Other Transportation	1.1	0.8	0.8	0.8	0.8	0.8

Source: EU Commission, 2012

Climate change mitigation strategies basically aim to reduce transport carbon footprint. However, transport decisions both for city and country level are related to land use, energy and economy policies of the country. Therefore, there is a complex relationship between land use, transport and climate change that needs to have a multi sectoral consideration combining both transportation policy and land use policy. Moreover, climate change oriented transport policy development requires multilevel governance arrangements that cover city, regional, national and global level. Developing countries face the challenge of both achieving reduction in GHG emissions and meeting increased population demand in a sustainable way.

2.1.2. Transport Sector & Energy Consumption

Energy has a crucial role to play for sustainable development in terms of socially integrated, environmentally sound and economically flourishing future (Mega, 2005). Energy is a necessity to provide a certain quality of living to citizens and it should be sustainable, competitive and affordable (Roseland, 2012). In the next decades, climate change and sustainable development strategies have pushed states to develop new technologies for energy efficiency and renewable energy sources. The sectors of industry, housing and transport are the main consumption areas of energy. Because of the population increase in the cities; energy consumption is rising every single day.

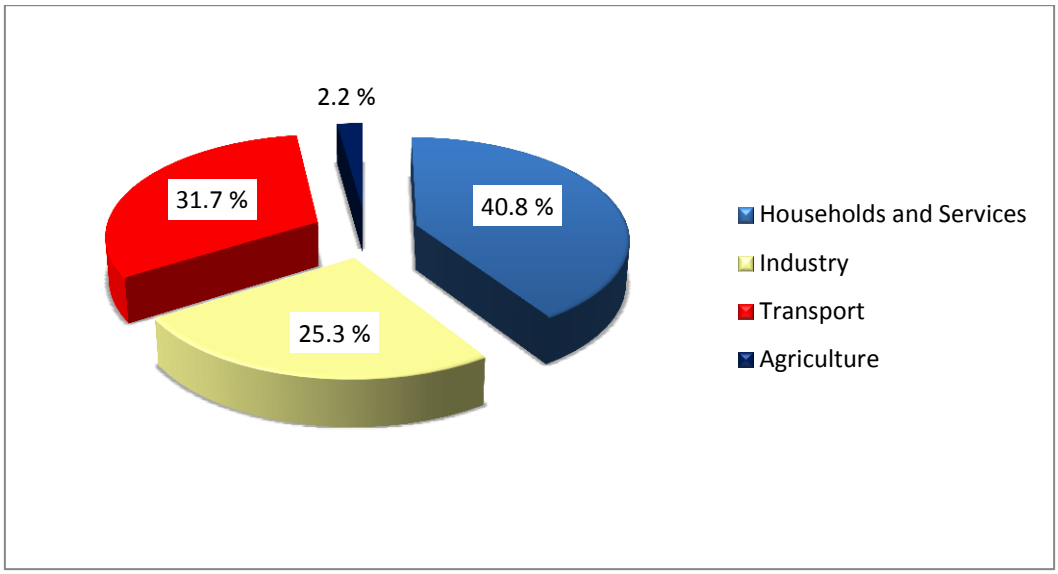
Transport is one of the fastest growing sectors of energy consumption that is affected by economic growth with the car ownership and new transport investments. Therefore, sustainable transport approach aims to switch from the use of private car usage to public transport systems. Fossil fuel still has a major share in transport energy sources and CO_2 emissions caused by fossil fuel combustion causes climate change. For example, European Union has 5% population of the world, but produces 14% of the global emissions (Mega, 2005). Therefore, it is crucial to improve energy efficiency in all energy consumer sectors and encourage sustainable use of energy.

In the short term, it is not expected that the transport sector reduce its fossil fuel dependence globally; however new technologies are being developed to provide an alternative to the fossil fuel vehicles.According to Zegras (2007) a combination of technological improvements and demand management will be required to reduce transport energy consumption.

In the EU White Paper, which was published in 2011 by European Commission, it is stated that "CO_2 emissions from transport would remain one third higher than their 1990 level by 2050". Thus, to reduce transport sector's dependence on oil

without compromising its efficiency and mobility, EU developed the Europe 2020 Strategy and the new Energy Efficiency Plan 2011 that aims to offer high quality mobility services while using resources more efficiently (EU Commission, 2011). According to the Europe 2020 Strategy, which is a 10-year strategy proposed by the European Commission on 3 March 2010, European Union countries have a binding target of having 10% share of renewable sources in transport.

According to the European Union statistical data about energy consumption of different sectors, transport sector is responsible for 31.7% of the total energy consumption(see Figure 2.3).This is a remarkable share that shows the importance of the transport sector in energy policies and in the attainment of strategies for energy efficiency.



Source: European Union Transport in Figures, 2012

Figure2.3. Final Energy Consumption by Sector (2010)

2.1.3. Transport Sector & Societal Challenges: Equity of Accessibility

Transport sector is seen as a show piece by national governments because especially automobile and aviation industries are important production area of a

strong economy that contributes significantly to employment (Giuliano& Gillespie, 1997). However, in the last years, both societal changes and the economic conditions have affected transport policy development. Growing concern about the environmental unsustainability of trends in human activity and transport's adverse environmental impact has orientated governments toward sustainable transport planning.

In the last decades, there has been an increase in the mobility of households and individuals. The reasons of the rising of mobility of households and individuals could be listed as individualization, living in sub-urban residential areas, economic and social changes in the society. These changes in the society structure and living styles bring major changes and increasing activities that are related to leisure, tourism and mobility patterns. In order to meet the travel demand, both short-distance (intra-city) and long-distance (inter-city) transport mode choices are often improved by national governments. However, increasing the mode choices or trip numbers are not enough alone because transport policy is directly related with the socio-economic structure of the society.

After "The Leadership Conference on Civil and Human Rights" that was organized by "The Leadership Conference Education Fund (LCEF)"in March 2011, a civil rights report "Where We Need to Go: A Civil Rights Roadmap for Transportation Equity" was published. In this report, it is emphasized that transportation is key to connecting the poor, seniors and those with disabilities to jobs, schools, health care and other resources. Thus it is crucial to expand opportunities of transport for all. There are millions of low-income and working class people, people with disabilities living in communities where quality transportation options are unaffordable, unreliable, or nonexistent(LCEF, 2011). Transportation policy has become one of the most pressing civil and human rights issues at a time of unemployment and unprecedented income inequality. It is important to consider the needs of low-income people, people with disabilities, seniors and poor rural communities to determine how best to rebuild and repair

roads, bridges, railways and ports and where/how to prioritize investments in transportation. So, policymakers should take into consideration the needs of all communities. According to the report, which considers United States of America, 33% percent of low-income African Americans, 22% percent of low-income Latinos, 12.1% percent of low-income Whites do not have access to automobiles, however 80% percent of federal transportation funding is dedicated to highways(LCEF,2011). There are many reasons related to transport systems that isolate low-income people from jobs and urban services such as the cost of car ownership, underinvestment in public transportation and a paucity of pedestrian and bicycle-accessible thoroughfares (LCEF, 2011). Besides these reasons, many people, and especially the disabled, have a lack of access to public transport and do not have the option to drive a private car. Similarly, people in rural areas have limited transportation options.

Transport infrastructure investments often result in economic and social segregation in the cities. Generally over ground transport projects like highways, bicycle ways, light rail transit, etc. create spatial segregation in the affected areas (Odeleye,2001). In these areas, it is inevitable to conserve existing settlement areas, agricultural areas, natural conservation areas, forests and pastures. Especially public transport investments that create positive or negative externalities for the people living in the impacted area, directly affect communities. For the people having a property in the construction area, expropriation process is often practiced by the government authorities to initiate construction of transport infrastructure. However, expropriation process does not always work for the benefit of property owner because property is a general term; for instance it could be either a house used as shelter or agricultural field for earning a living. Thus the economic valuation of a property and expropriation process may not satisfy the property owner. In addition, positive externality could be created by the new public transport investment as well. This is generally called as the rent which implies additional economic value. For example, newly built rail station in the vicinity of a property increases the value of it. HSR which is the

focus of the study has both positive and negative externalities in terms of expropriation process and the socio-spatial impact. However, in the scope of the study these impacts will not be analyzed in detail.

In terms of HSR investments, because of the high technical standards (ie. bend is minimum 3500 m. radius), it is not possible to revise the design of line. For example, it may damage agricultural land of inhabitants unintentionally. Also, in order to operate a HSR, stations are not designed close to each other. Therefore, for many small settlements, stations are not planned. These settlements that are close to the line are affected from the project but they do not benefit from it because of their distance to the system's stations. Thus, it could be inferred that HSR serves mostly to the inhabitants in cities in terms of accessibility to the station (Salzberg, Bullock, Jin, &Fang, 2013).

In order to provide equitable transport opportunity to everyone, priority of the governments should be to create economically affordable and physically accessible transportation options. Within the context of the study, the affordability of HSR investments, which are planned in many cities, are partially analyzed by the help of a survey that is given in the following chapters.

2.2. Current Trends in Passenger and Freight Transport in the World

2.2.1. Transport Systems and Their Modal Shares in Transportation

According to Babalık (2007), a policy shift towards more sustainable modes has already started in most countries and it has taken part in their national policy agendas. As sustainable transport policies are being increasingly adopted all over the world, the share of transport modes change for passenger and freight transport. Highway transport has a major share in every country for both passenger and freight transport; and traffic volumes show an increasing trend. However, emission reduction strategies that are implemented for climate change mitigation require reducing the share of road transport and the amount of oil consumption. It

is not easy to reduce road transport usage in the short term, but it seems possible to create a shift from road transport to railways and sea transport with the help of applicable strategies on transport sector. In this chapter, major transport systems and modes will be evaluated in terms of their usage shares.

Road Transportation

Most of the surface transport emissions are predominantly created by road transportation in developed and developing countries. Rapid increase in the private car ownership that is expected to double to 2 billion by the middle of the century is one of the causes of increasing GHG emissions' globally (IEA, 2009). Road transport is responsible for about 17 % of the energy and overall CO_2 emissions and it is increasing every day. According to the International Energy Agency, global car park could triple to 2 billion (Gainsborough, 2012). Therefore, as sustainable development policies require, governments around the world are working on developing policies about energy and energy related sectors such as transport. Countries aim to reduce their fossil fuel dependency. For example, in the fuel sector the European Union Renewable Energy Directive requires 10% (energy basis) of road vehicle fuel from renewable sources by 2020, the USA Energy Independence and Security Act 2007 requires 36 billion gallons of renewable road transport fuels by 2022 and in California, the Low Carbon Fuel Standard calls for a reduction of 10% in the carbon intensity of California's transport fuels by 2020 (Gainsborough,2012). In addition, when the number of cars per person for different countries is analyzed, EU-27 countries have the motorization rate of 477 cars per 1000 people while USA has 763 cars per 1000 people and Japan has 542 cars per 1000 people. China has the lowest motorization rate among these countries with 30 cars per 1000 people. Table 2.2 shows the passenger cars stock, motorization and commercial freight vehicle numbers for EU-27, USA, Japan, China and Russia.

Table 2.2. Vehicle Stock of the Countries

	EU-27	**USA**	**JAPAN**	**CHINA**	**RUSSIA**
YEAR	**2010**	**2009**	**2010**	**2010**	**2010**
Passenger Cars Stock (million)	238.8	234	69.2	40.3	32.6
Motorization (cars/1000 person)	477	763	542	30	228
Commercial Freight Vehicles (million)	34.09	10.97	6.22	13.69	5.41

Source:EU Commission, 2012

In the last 20 years trucking and freight movement has been one of the fastest growing activities in most countries. Economic growth coming from the gross domestic product (GDP) has a significant effect on this mobility because import and export issues require transporting goods from one place to another in both short and long distances. For freight transport, it is possible to increase efficiency through better technologies such as advanced engines, light weighting, improved aerodynamics, better tires that are expected to provide about 30 % to 40% efficiency by 2030 (EU Commission, 2012).

However, in order to reduce the share of road transportation for both passenger and freight, modal shift to rail is seen as an alternative option to save energy and CO_2 emissions. For many countries that do not have sufficient infrastructure for railway its share is extremely low when compared to highway transportation; and therefore investments in rail and intermodal systems are required in order to create a shift from road to rail (EU Commission, 2012).

In Turkey road transportation has a major share both for intra-city transport and intercity transport. According to the Ministry of Transport, Maritime Affairs and Communications (MoT) Strategic Plan for 2014-2018 period (MoT, 2013), 90.5

% of the intercity passenger transport and 87.4 % of the freight transport have taken place on roads. In recent years, there has been an increase in the number of privately owned automobiles. There has been a rapid increase in the number of motorized vehicles especially between 1990 and 2010. In 1990, the number of private cars was 1,649,879; however in 2013 it increased to 9,283,923. It means that car ownership level has increased from 29 cars per 1000 people to 121 cars per 1000 people (TUIK, 2013).

Railway Transportation

After its introduction in the 19th century, railway transportation became popular in the world for intercity transport. Rail technology also started to be adopted for urban transport with the emergence of electric trams, and underground or elevated urban rail systems. Although, 19th century was more class stratified than today, all classes used railway for their mobility. However, after the invention of the diesel engine, which led to widespread use of buses as well as increased private car ownership, railways partially lost its popularity and road traffic volume increased (Cahill, 2010).

In the last decades, there has been a return to railway oriented transport investments because of supra-national policies that focus on climate change and sustainable development(Wright & Fulton, 2007). Railway is seen as an economic, environmental and high-quality solution for reducing oil dependency in freight and passenger transportation because of its energy consumption and emission generation amounts. For instance, European Union has a target about completing the European High Speed Rail network by 2050 and tripling the length of the existing high speed rail network by 2030. Thus, majority of medium-distance passenger transport is expected to be provided by HSRs by 2050 (EU Commission, 2012).

In Turkey, after the 2000s sustainable development came into the national policy agenda and integrating national rail network to Trans-European Railway Network was seen as a significant action to connect physically and economically into Europe (Babalık-Sutcliffe, 2007).Therefore, HSR investments became an important area in the transport policy of Turkey in recent years. In the forthcoming chapter, current railway network and the planned HSR investments will be given in more detail.

Air Transportation

Air transportation is the fastest growing transportation system of the last decades because of the increase in recreation and business trips and reductions in ticket prices. It is clear that air traffic will continue to grow in the future too. It is expected that air passenger kilometers will increase by a factor of four between 2005 and 2050(IEA, 2009). Consequently, the high rate growth in the aviation sector will cause a significant increase in energy use and CO_2 emissions: both are expected to be tripled by 2050 (IEA, 2009).

Although aircraft manufacturers work on efficiency improvements, such as weight reduction, aerodynamic improvements, and engine efficiency, more work is needed to decelerate the growth in energy consumption and CO_2 emissions. According to International Energy Agency(IEA, 2009), modal shift and general reduction in aviation travel growth could help to reduce the CO_2 emissions. In this respect, development of new alternatives such as high speed rail systems may help contribute to the reduction in aviation traffic growth.

Sea Transportation

Sea transport has a place in shipping, which has grown very rapidly in recent years. Tesfay (2014) stated that "Maritime transportation is the most effective mode to move large quantities of cargo such as steel, crude oil, aluminum".

.Especially growth in Asian manufacturing and exports to other countries triggered the sea transport. According to the International Energy Agency, international water-borne shipping represents about 90 % of all shipping energy use (IEA, 2009). In the recent years, the average size of ships has been increasing, making shipping more efficient per ton kilometer moved. When ship engines are compared with aircrafts, they are more capable of using a wide range of fuels and it is expected that by 2050 30 % of ship fuel will be low GHG bio-fuel (IEA, 2009).

2.2.2. Comparison of Transport Modes With Respect to Their Environmental Externalities

2.2.2.1. Energy Consumption

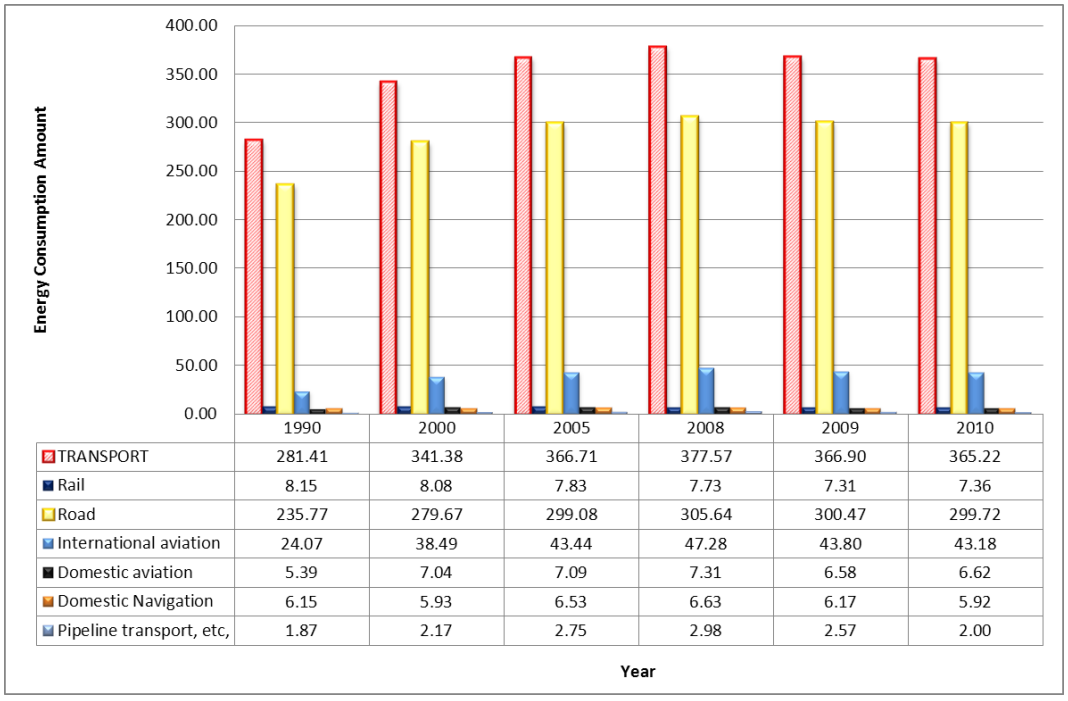
Transport sector is one of the most energy dependent sectors that consume very large portion of oil and oil products. Because of the high energy density and easy handling characteristics, oil and oil products are quite effective as energy sources for transportation. According to the International Energy Agency (2009), more than 60 % of the petroleum products that have been used in OECD countries were used as transportation fuel. In this respect, the growth rate of transportation systems' energy consumption is analyzed. According to Table 2.3, while air transport energy consumption growth rate is larger than the other transport systems in OECD countries, road transport's growth rate is larger than others in Non-OECD countries.

Energy consumption amounts show variety between different transport systems. Figure 2.4 shows the European Union transport sector's energy consumption since 1990: total energy consumption of transport dramatically increased between 1990 and 2010 (RCEP,1995).

Table 2.3. Growth Rates of Transport Energy Use 1990-2006

	OECD				NON OECD			
Year Period	**90-95**	**95-00**	**00-06**	**90-06**	**90-95**	**95-00**	**00-06**	**90-06**
International Aviation	4.4	5.0	1.2	3.4	-0.6	1.7	4.7	2.1
Domestic Aviation	-0.2	2.5	-0.3	0.6	-0.5	4.9	3.0	2.5
Road	2.3	2.1	1.4	1.9	2.5	2.9	4.2	3.3
Rail	-0.1	-0.3	2.3	0.7	-4.4	2.9	2.3	0.3
International Marine Bunkers	1.1	2.3	2.5	2.0	4.6	3.9	5.4	4.7
Domestic Navigation	0.8	0.5	-1.0	0.0	-2.6	6.5	4.0	2.6
Transport Sector	2.1	2.1	1.2	1.8	1.1	2.6	4.3	2.8

Source: RCEP, 1995



	1990	2000	2005	2008	2009	2010
TRANSPORT	281.41	341.38	366.71	377.57	366.90	365.22
Rail	8.15	8.08	7.83	7.73	7.31	7.36
Road	235.77	279.67	299.08	305.64	300.47	299.72
International aviation	24.07	38.49	43.44	47.28	43.80	43.18
Domestic aviation	5.39	7.04	7.09	7.31	6.58	6.62
Domestic Navigation	6.15	5.93	6.53	6.63	6.17	5.92
Pipeline transport, etc,	1.87	2.17	2.75	2.98	2.57	2.00

Source: RCEP,1995

Figure 2.4. Energy Consumption Amounts of Transport Modes in EU

As mentioned before, the transport sector is responsible for a large portion of the total energy consumption and road transport has a major share among different modes. Also international aviation nearly doubled its energy consumption between 1990 and 2010. When transport modes are compared, it is seen that water

transport has the lowest primary energy consumption although rail produces lower emissions of some pollutants per ton kilometer (RCEP, 1995).

In order to decrease CO_2 emissions, railway transportation is a good alternative that creates a shift from oil usage to electricity. In terms of environment, electricity is considered more environmentally friendly when compared to energy made from fossil fuels, although it is also important to consider whether the electricity is produced from renewable or non-renewable sources.

2.2.2.2. Air quality (GHG emissions)

Combustion of fossil fuels in the form of petroleum products results in an increase of carbon emissions in the atmosphere. Therefore, air quality is directly related with the emissions from the transport sector. In the First Assessment Report of the Urban Climate Change Research Network, it is stated that GHG emission amount from transport shows variety between different modes and types of uses. Different motorized transportation modes –automobile, transit or two wheelers – have different carbon footprints which are measured in tons of emitted carbon per passenger mile, or per ton-miles, respectively depending on whether people or goods are transported (Rosenzweig, Solecki, Hammer, Mehrotra, 2011, p.147). Therefore, mitigation policies vary depending on how passengers and freight are transported. Table 2.4 presents aviation transport CO_2 emissions variation according to domestic, short haul and long haul flights. This data implies that long haul flights produce fewer CO_2 emissions because of large amounts of fuel are consumed during take-off and landing. According to Table 2.5,air travel is not an environmentally unfriendly mode in terms of CO_2 emission production per passenger kilometer (Beggs, 2012). However, the above information about the emission impact of short-haul flights indicates that it is crucial to provide relatively shorter journeys by surface transportation rather than aviation. As mentioned before, among surface transportation modes, railways create the lowest emissions per passengers carried.

Table 2.4. Comparison of the 'Real-Life' Carbon Dioxide Produced per Kilometer Travelled for Various Vehicle Types

Vehicle Type	**Engine Size**	**Miles per gallon**	**Grams of CO_2 produced per km**
Petrol car	<1.4	35.5	183.1
	1.4-2.0	30.1	216.2
	>2.0	21.9	296.4
Diesel car	<1.7	49.3	150.7
	1.7-2.0	39.5	188.1
	>2.0	28.2	263.5
Hybrid petrol-Electric Car	Medium	51.5	126.2
Motorbike	<0.125	89.2	72.9
	0.125-0.5	69.2	93.9
	>0.5	50.6	128.6

Source: Beggs, 2012, Energy and Transport, p.77

Table 2.5. Comparison of the 'Real-Life' Carbon Dioxide Produced per Passenger-Kilometer Travelled for Various Aviation Flights

Flight Type	**Example Flight**	**Load Factor**	**Grams of CO_2 produced per passenger km**
Domestic	London to Edinburgh	65.0	158.0
Short-haul international	London to Central Europe	65.0	130.4
Long-haul international	London to New York	79.7	105.6

Source: Beggs, 2012, Energy and Transport, p.77

Air pollution is not only a factor of climate change and ozone layer depletion, but it also has negative impacts on health, environment and city structures. Transport related pollutants may damage buildings; change the sensitiveness of the trees. Critical levels for nitrogen oxides and ozone may have effects on receptors such as plants and ecosystems(Gilbert and Perl, 2010).

In addition low air quality leads to many health problems, such as mortality, non-allergic respiratory morbidity, allergic illness and symptoms (such as asthma),

cardiovascular morbidity, cancer, and male fertility (Gilbert and Perl, 2010). Thus, in order to reduce emissions, improve air quality as well as the quality of life, it is important to change transport policies towards sustainable modes. Both inter-city and intra-city transport alternatives should be developed to reduce emissions, which have so far been mostly caused by road transport although air transport and emissions it causes are also on the increase.

There has been a rapid increase in emissions in Turkey parallel to the economic growth. According to Environmental Situation Report (ESR) of Turkey which is prepared by Ministry of Environment and Urbanization (MEU) total GHG emissions between 1990 and 2009 are shown in Table 2.6. As it is seen in the table, there has been an increase of 198 % in the total GHG emissions. In addition, Table 2.7 shows that CO_2 emissions per person increased from 2.56 to 4.16 tons (162.5%) between 1990 and 2009 (MEU, 2011).

Table 2.6. GHG Emission Amounts Between 1990-2009 (mtoe, CO_2 equivalent)

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Amount	187.0	190.1	210.2	221.6	217.1	237.5	258.6	271.8	274.0	274.7
YEAR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Amount	297.0	278.1	286.2	302.7	312.2	329.9	349.6	379.9	366.5	369.6

Source: MEU, 2011

Table 2.7. CO_2 Emission Amounts Change Between 1990-2009 (tone per person)

YEAR	**1990**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
CO_2 Amount	2.56	3.51	3.21	3.30	3.48	3.59	3.79	3.99	4.38	4.18	4.16

Source: MEU, 2011

According to the Climate Change National Action Plan (MEU, 2011) of Turkey, transport related emissions in 2009 made up 17% of total GHG emissions. Road transport which is the most popular mode of passenger and freight transport in

Turkey is responsible for 85 % of transport related emissions. In order to reduce emissions in the transport sector, the government set some goals for the period of 2010-2020. According to these targets, railway usage share will be increased to 15% for freight transport (from 5% in 2009) and to 10% for passenger transport (from 2% in 2009). Furthermore, road transport share will be reduced to 60% for freight transport (from 80.63 % in 2009) and to 72% for passenger transport (from 89.59 % in 2009). In addition to these numerical targets, to implement sustainable transport planning approach in cities, legal revisions are proposed in the Action Plan and encouragement of alternative fuel and clean car technologies are stressed.

2.2.2.3. Noise and Vibration

Noise and vibration are mostly seen as insignificant impacts of transport systems by investors and governments even though transport is one of the main source of noise in the community (Ivanov, Samoylov, Tyurina, &Shachnev, 2000). However, noise and vibration has negative impacts on people and animals and these impacts are evaluated in the Environmental Impact Assessment (EIA) reports that are prepared for the transportation infrastructure projects (applicable for the countries that EIA procedure is legally compulsory). Noise and vibration effects of transport systems may trigger social and ecological problems, such as community health problems and psychological and behavioral problems for animals living in the affected ecosystem (RCEP, 1995).

Noise, particularly from road traffic and aircraft movement, is usually the source of acoustic nuisance in urban and rural areas. It is supposed that 75 % of the acoustical pollution is produced by road transportation, 10 % is produced by railway transportation and about 5 % is by aviation. About 10 % of the acoustical pollution is produced by industrial plants, during construction works (Ivanov, Samoylov, Tyurina, &Shachnev, 2000). These values are acceptable for average sized cities and the ratios could vary in certain range

In terms of the transportation sector, noise is created in both construction and operation stage. It could be below or above the determined noise levels by legislations. Since the 1960s, noise norms have been revised by most of the countries in a limited way and new developments in noise control measures have been adopted to reduce transportation noise (Ivanov, Samoylov, Tyurina, &Shachnev, 2000).

Noise level should be kept below 55 decibels in day time and 45 decibels in night time according to World Health Organization (Gilbert and Perl, 2010). High level of noise may cause health problems, such as sleep loss, disturbed sleep, high blood pressure and cardiovascular diseases (EPA, 1996). According to the CE Delft Study on Traffic Noise Reduction in Europe (Boer & Schroten,2007), "…some 210 million Europeans are regularly exposed to road traffic noise levels exceeding 55 decibels and 35 million are exposed to similar levels of rail noise." Furthermore, it is stated that around 50,000 people die prematurely because of heart attacks and 200,000 people exposed to cardiovascular disease are linked to traffic noise(Boer & Schroten,2007).

Although European legislation set limits for various types of vehicles aiming to control noise pollution, growing air traffic is a remaining concern for policy makers. This is a valid situation for the other countries too because air traffic is increasing all over the world as a result of the increase in business and tourism trips in the last decades.

According to Elbers (2000), it is important to set noise control measures to provide environmental benefit however it creates extra cost for railway sector. Therefore, optimization of noise control strategy is needed. As one of the noise control measures, acoustical barriers are most popular, cheap and effective (Ivanov, Samoylov, Tyurina, &Shachnev, 2000).

2.2.2.4. Building materials (finite resources of critical materials like rock mines)

Each transport system has different infrastructure and construction materials. However, in general, stone and mineral mines are required for the construction of infrastructure (EPA, 1996). These are natural materials and finite resources. Mining activities that are required for construction have environmental impacts and these impacts could be hazardous for the existing ecosystem and settlements. Effects of the mining activities could be listed as degraded air quality because of the dust created, decreasing surface and groundwater quality, noise created by blasting, aesthetic degradation etc (Kitula, 2006).In the construction stage, the closest mines that appropriate construction material are chosen in order to reduce the cost of material transportation and construction. For example, sand and gravel mines are opened close to highway or railway projects and then abandoned once the project is completed. Mining activities are generally involved in the list of the projects that are subjected to environmental impact assessment.

Building materials' impact on the environment was less noticeable in the past because population was less than now and there were lower levels of development (EPA, 1996). However, with the population increase, the necessity for transportation infrastructure projects has grown and many mining activity has increased. Thus, regulation of the cumulative environmental impact of mining is harder than before for governments.

2.2.2.5. Nature Destruction and Land use impacts

Use of land for transport can be a factor that contributes to the environmental stress. Transport infrastructure covers a large portion of the land depending on the transport mode. For example, roads cover 25-30% of land in urban areas and almost 10% in rural areas in OECD countries. In European Union, road network covers 93%, rail network 4 % and airports less than 1 % of the total land area used

for transport (OECD, 2006). Surface transport projects like highway and railway may damage existing areas, such as natural preservation areas (national parks, wild life preservation and development areas, environmental protection areas), forests, agricultural areas and pastures. In terms of destruction, the way of transition (above ground, underground, tunnel, viaduct, etc.) and the coverage area that depends on the number of lanes are important factors (EPA,1996).

Although environmental and structural measures are considered in the planning stage of transport projects, in the construction and operation stage many environmental impacts occur. The development of new transport infrastructure requires compaction, soil sealing, cutting and filling operations. Thus, existing ecosystem is damaged and habitat destruction occurs (EPA, 1996). Furthermore, existing development plans should be taken into consideration in the planning stage of new transportation infrastructure. There could be new property rights given to the citizens and depending on the project's priority, expropriation methods may be implemented to the impacted area. This process may create economic and social problems for the people living in that area. Local governments have an important responsibility in this process management (Chen & Yeh, 2013).

2.3. Contemporary Transport Policy: The Increasing Role of Railways for Environmentally Sustainable Transport

2.3.1. International Policy Documents: Shifting Transport to Railways

In this chapter, European Union, United States and China are studied in terms of their transport policies with the help of national policy documents. In this respect European Commission White Paper, which was published in 2011, and United States High Speed Rail Strategic Plan (Vision for High Speed Rail in America), which was published in 2009, are analyzed to provide a better understanding of the contemporary transport policy in these two leading geographies, Europe and

North America. Also, as an Asian country China is analyzed in terms of its transportation policy and especially rapidly developing HSR network.

European Union

Maastricht Treaty, which was signed on 7 February 1992 by the members of European Community, underlined the importance of transport and in particular of the European network. Articles 75 to 81 of the treaty extended the competencies of governments to create common regulations for international transport, market access, transport safety, fiscal harmonization, transport pricing and state subsidies. According to the framework established by the guiding principle "subsidiarity", European Union should promote the interconnection and interoperability of national transport networks as well as the access to that network (Giorgi and Pohoryles, 2001).

According to the European Commission data, White Papers have been published since 1985 in order to structure the transportation policy. In this study, the most recent Transport White Paper, which was published in 2011, is analyzed. Climate change related environmental policies have been developed in European Union and these policies directly affect the transport sector. It is stated in the Transport White Paper that inorder to create a more sustainable and energy efficient transport system, firstly it is important to break transport system's dependence on oil. "Resource efficient Europe" that is set up in Europe 2020 Strategy and the new Energy Efficiency Plan of 2011 aim to establish a system enhancing competitive and high quality service while using resources more efficiently. According to the Transport White Paper (EC, 2011) "in practice, transport has to use less and cleaner energy, better exploit a modern infrastructure and reduce its negative impact on the environment and key natural assets like water, land and ecosystems." Thus, in order to reduce oil dependency, railway is seen as one of the modes that provides economic and efficient solution for freight transport. The target is to reduce emissions by 60% and ten goals are set in the White Paperto

achieve this. In these goals, railway has a major role to play. It is aimed to triple the length of the existing high speed rail network by 2030 and complete the European High-Speed Rail Network by 2050. After that, all core network airports will be connected to the rail network and all core seaports will be connected to the rail freight to provide intermodal transport. As a result, in 2050 the majority of medium-distance passenger transport and freight transport will be provided by railways.

United States

United States is one of the countries that introduce railway policy into their transport agenda in the late 20th Century. Before that railwayswere not emphasized in policy documents and they play a minor role in intercity passenger travel. In United States, intercity passenger transport is mostly dependent on air transport, however in recent years railways have come to the national policy agenda and new railway investments have gained priority.

In United States, the transport system, which depends on highway and air transportation, consumes 70 % of oil demand mostly provided from overseas sources. Furthermore, it constitutes 28 % of the GHG emissions. In High Speed Rail Strategic Plan which is prepared by US Department of Transportation (DoT), it is emphasized that existing transport infrastructure will be inefficient for the future passenger and freight mobility demands and a new transport policy approach, which gives importance to the contemporary economic, energy and environmental challenges, is needed. Thus, some goals were determined for the new transport policy approach:

- Ensure safe and efficient transportation choices
- Build a foundation for economic competitiveness
- Promote energy efficiency and environmental quality

- Support interconnected livable communities(DoT, 2009)

Furthermore, it is stated that in order to create clean, energy-efficient transport, high speed passenger rail network will be provided efficiently for 100 to 600 mile distance. $8 billion down payment is provided in the American Recovery and Reinvestment Act (ARRA) and a high-speed rail grant program of $1 billion per year (proposed in the fiscal year 2010 budget) was committed to start the process.

China

Before the 1980's railway was the dominant inter-city transportation mode of China. At this time transport demand and supply was at equilibrium however in the beginning of 1980's, economic growth has increased the traffic volumes (Mao & Chen, 2001). As transport demand increased, local and central governments began to invest for highway development. Thus, there has been an increase in length of national highways and expressways.

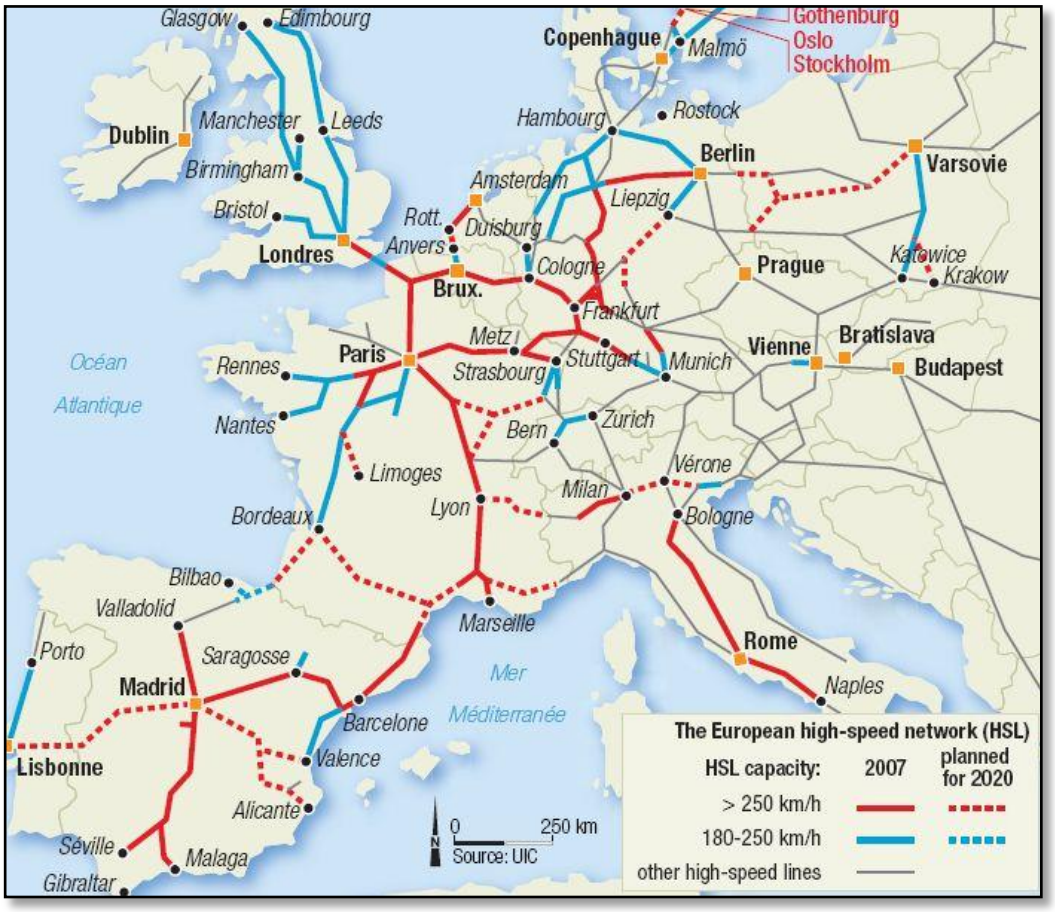
In 1990s, inter-city transportation policy which hasstrengthened by road investments has shifted to railways again. In the 1997 Ninth Five-Year Plan it was planned to strengthen the existing lines to reach higher speeds (160 km/h for passenger trains) and to increase its capacity. The speed of existing commercial train lines were increased six times from 1997 to 2007 (Xu & Gui, 2011).

After 2004, there has been an attempt to develop HSR and mid-to-long-term plan was announced for the HSR investments(Takagi, 2011). By 2013, it has about 10,000 kilometers of HSR network which is larger than the entire European Union HSR network (Ollivier, Sondhi, & Zhou, 2014). It is expected to have 30,000 kilometers of HSR that will connect 250 cities having about 700 million population (Lou & Gui, 2011). Improving HSR network is important to reach strategical targets in many industries such as tourism, logistics for China and it is

believed that many cities in west and central China revitalized by the impact that is created by HSR network (Lou & Gui, 2011).

2.3.2. Investment in Railways in the World

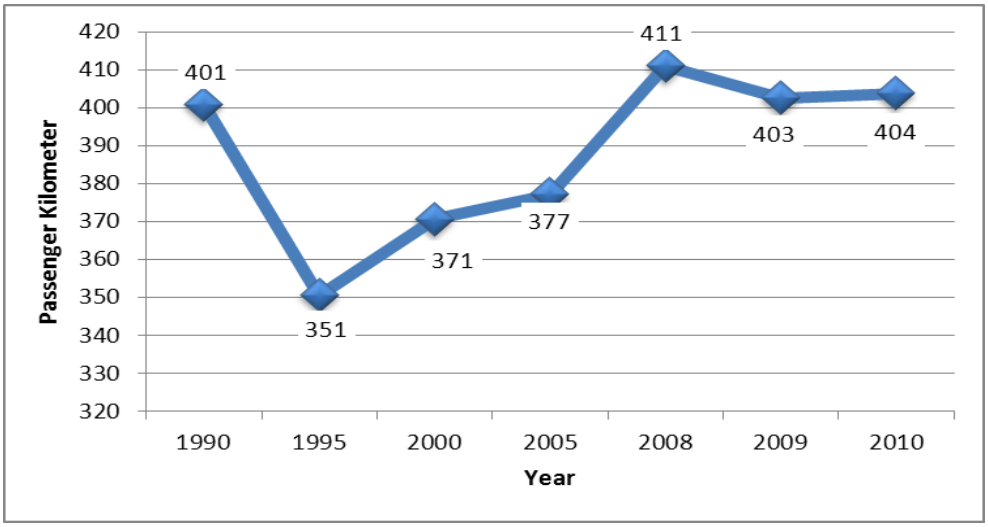
As it was mentioned before, one of the leading investment on railway development have been experienced in Europe. European Commission approved the first action plan about Trans-European Networks (TENs) in 1990. TENs aim at creating a set of road, rail, air and water transport network for promoting growth and competitiveness across member states. The establishment of this network is seen as a requirement of "European Single Market". The Trans-European Transport Network was a component of the Trans-European Network including the communication sector as well. The main aim of the Trans European Transport Network is to create a modal shift from road to rail in order to provide sustainable mobility. Thus it is important to encourage railway and increase the share of it among other modes. Transforming East-West connections, removing bottlenecks and enhancing existing infrastructure are proposed in order to create a modal shift for sustainable transport system. Trans European Transport Network will connect 94 main European ports with rail and road links, and 38 key airports with rail connections into major cities (EC, 2013). According to European Commission (2013), existing railway lines (about 15000 km) will be upgraded to high speed and 35 cross border projects will be implemented. Furthermore, connections between different modes of transport will be improved and this will contribute to the EU'sobjectives on climate change. It is planned to invest €26 billion for the transport infrastructure in 2014-2020. Figure 2.5 shows the existing and planned HSR network in the European Union countries.



Source: Retrieved from http://www.iau-idf.fr/fileadmin/Etudes/etude_718/the_european_high_speed_rail_network_of_the_future.jpg on 24.08.2014.

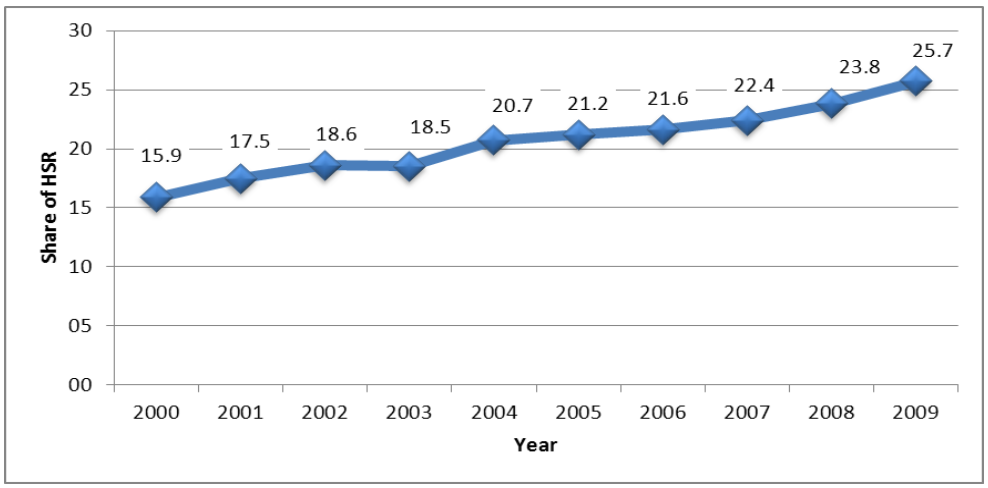
Figure 2.5. HSR Network in European Union Countries

When passenger transport which is realized by railway is analyzed for EU-27 countries, it could be stated that there has been a decrease in passenger kilometers in 1995. However, between 1995 and 2010 years, there has been an increase in the passenger kilometers (see Figure 2.6). In addition, the share of high speed rail transport in total passenger kilometers in rail transport is analyzed (see Figure 2.7). Since 2000, every year the share of HSR has increased and in 2009, its ratio has reached 25.7%.



Source: European Commission, 2012

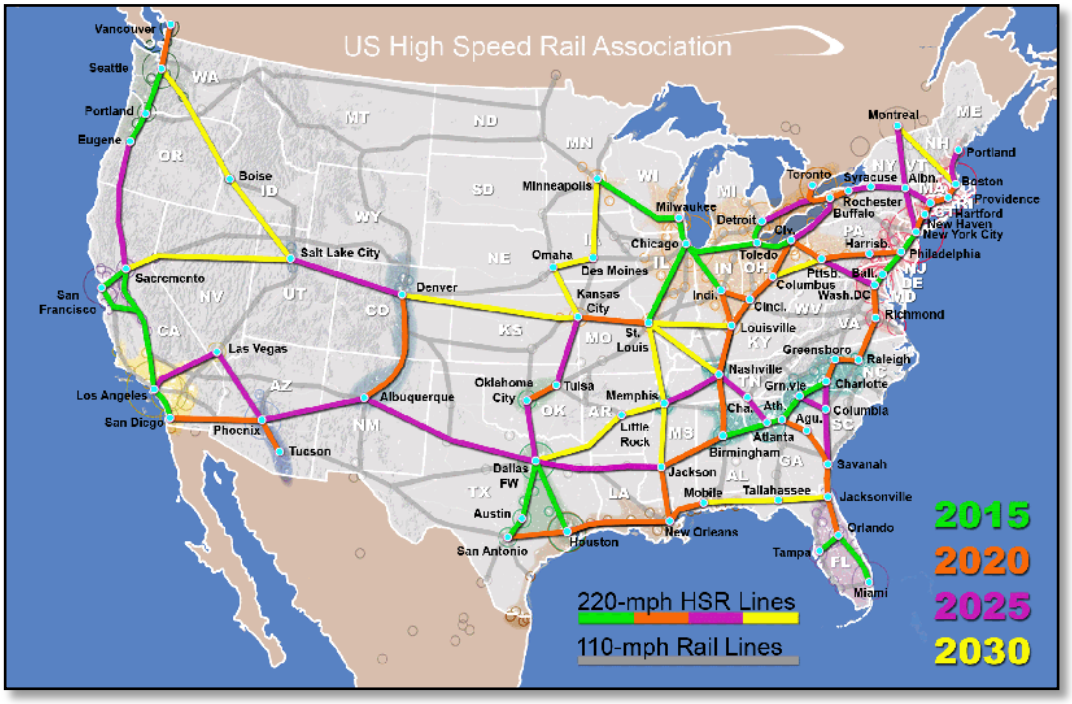
Figure 2.6. Passenger Transport Expressed in Passenger Kilometers



Source: European Commission, 2012

Figure 2.7. Share of High Speed Rail Transport in Total Passenger Kilometers in Rail Transport (%)

Although United States failed to invest in railway network in the past, the government has an attempt to develop HSR network for especially 100 to 600 miles distance intercity transportation. According to the High Speed Strategic Plan of America new express high-speed corridor services will be advanced, regional high-speed corridor services will be developed. As it is seen in Figure 2.8, there is a HSR development which is to be implemented in stages for every 5 years.



Source:Retrieved from http://www.ushsr.com/phasingplan.html on 24.08.2014.

Figure 2.8. Planned HSR Network in USA

In addition to EU and USA that have railway investments described above, there are ongoing investments in Japan, China, Iran and Saudi Arabia. In China, the existing HSR network is 947 kilometers length and it is planned to increase it to 8311 kilometers with the railways that are in construction and planning phase. Also Japan has remarkable investment on HSR construction. The existing railway network is 2452 kilometers length and 590 kilometers of HSR is under construction. In addition 583 kilometers of HSR is in planning phase. According to International Energy Agency (2009) Saudi Arabia has no HSR network however, 550 kilometers of HSR is in planning phase.

Currently, more than 75 % of the world's HSR network is located in Japan, France, Spain, Germany and Italy. According to European Commission, by 2020, it is expected that existing length of HSR network in the world will be tripled. Table 2.8 shows the high speed rail lines, existing and planned by country.

Table 2.8. High Speed Rail Lines Existing or Planned by Country (kilometers of track)

	In operation	**Under construction**	**Planned**	**Total**
EUROPE				
Belgium	137	72	0	209
France	1872	299	2616	4787
Germany	1 285	378	670	2333
Italy	744	132	395	1271
The Netherlands	0	120	0	120
Poland	0	0	712	712
Portugal	0	0	1006	1006
Russia	0	0	650	650
Spain	1599	2219	1702	5520
Sweden	0	0	750	750
Switzerland	35	72	0	107
United Kingdom	113	0	0	113
TOTAL	5785	3292	8501	17578
ASIA				
China	947	3289	4075	8311
Chinese Taipei	345	0	0	345
India	0	0	495	495
Iran	0	0	475	475
Japan	2452	590	583	3625
Saudi Arabia	0	0	550	550

Source: IEA, 2009

Table 2.8. (continued) High Speed Rail Lines Existing or Planned by Country (kilometers of track)

Korea	330	82	0	412
Turkey	0	745	1679	2424
TOTAL ASIA	4074	4706	7857	16637
OTHER COUNTRIES				
Morocco	0	0	680	680
Argentina	0	0	315	315
Brazil	0	0	500	500
United States	362	0	900	1262
TOTAL	362	0	2395	2757
TOTAL WORLD	10221	7998	18 753	36972

Source: IEA, 2009

2.4. Summary & Concluding Remarks

There is a significant trend for railway development in the world and railways are receiving more focus in many country's transport policy agenda. Especially in European Union countries, railways are increasingly being given a dominant role to play in transport policies. In addition, there is an emphasis on HSR development in national policy documents. Parallel to these developments all over the world, there is a tendency to develop HSRs in Turkey too. In the next chapter, Turkey's current and future transport policies will be discussed with relation to national development plans and strategic policy documents, and railway projects will be analyzed in detail.

CHAPTER 3

THE TRANSPORT SECTOR IN TURKEY, CONTEMPORARY POLICIES AND RECENT INVESTMENTS IN HIGH-SPEED RAILWAY

3.1. A Historical Overview to the Railway Development

In 1890, under the Ottoman Empire there was an attempt to develop railway lines for agricultural, military, defense and economic reasons; and consequently privileges were given by the Ottoman Empire to countries such as England, France and Germany to develop railways in the country. Countries that undertook the construction of railways had an opportunity to construct and operate the railway system and if the profit was less than expected, the Ottoman Empire would compensate this (Yıldırım, 2001). Furthermore, Ottoman Empire gave the right of cutting trees for 20 km width in the construction area and mining research permit. According to General Directorate of State Railways Administrationdatabase, between 1856 and 1922, the lines listed below were constructed.

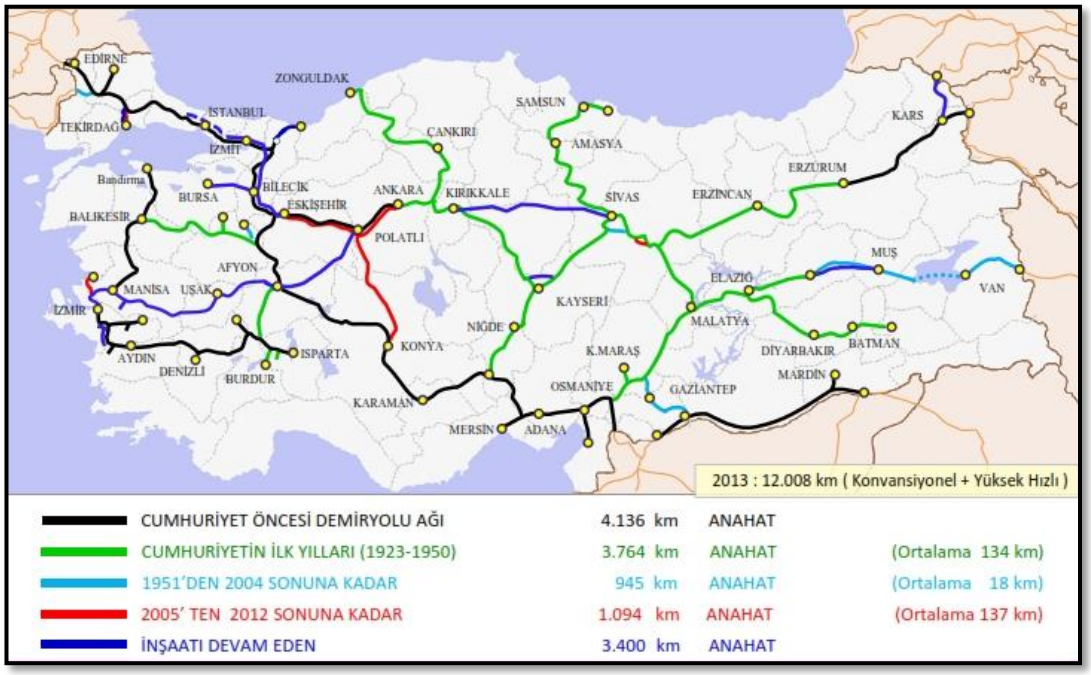
- Rumelian Railways
- Anadolu-Bagdat Railway
- İzmir –Kasaba Railway and offset
- İzmir -Aydın Railway
- Damascus-Hama Railway and offset
- Yafa-Jerusalem Railway
- Bursa-Mudanya Railway
- Ankara-Yahşihan Railway

Before the War of Independence, there was 4112 kilometers of railways in Turkey, which were mostly developed by other countries. There were 118 locomotives, 203 passenger and 1983 freight wagons in 1923. After the establishment of the Republic of Turkey, between 1923 and 1948, the government gave priority to railway construction to increase the length of railways, provide national security and increase social and economic growth. In 1924, government policies aimed at nationalizing the existing railways and constructing new lines. The first decision was to complete the Ankara-Sivas Railway and then to construct the Samsun-Sivas Railway (Yıldırım, 2001). A Turkish company won the tenders of Sivas-Erzurum and Malatya-Çetinkaya Railways in 1934 for the first time (Yıldırım, 2001). Budget that was attributed to the railway construction was much more than the highway budget between 1923 and 1933, since the latter was a newly emerging transport technology and hence there was not much highway investment. "State Railways and Harbors Headship" was established in 1927 and 13.98 % of the budget was allocated for railway development. Although railway construction was important in this period, operation was not that advanced. In 1934, the government purchased 172 new locomotives, 110 passenger and 2323 freight wagons (Yıldırım, 2001).

Between 1940 and 1950, railway construction decelerated because of the 2nd World War. 3208 kilometers of the 3578 kilometer rail road was constructed between 1923 and 1940. In 1953, "State Railways and Harbors Headship" was transformed into "General Directorate of State Railways Administration". After the 2nd World War, investments on railway development decelerated and between 1951 and 2002, 17 kilometers new railway constructed each year. The 1950s is often considered as a turning point in transport policy in Turkey since it marks the start of a road oriented policy for the country, which is still prevalent today. This was a period that witnessed technological advances in road and car industry; and a US Federal Government aid that was received to invest in the development of the road network resulted in a vigorous road programme for the next decades. "While it was necessary to develop the road network, the subsequent road

programmes created an extremely road-based transport policy, and eventually an infrastructure dependent on a single mode" (Babalık-Sutcliffe, 2007, p.488).

Because of inadequate investment in railway development, quality and usage declined and most of the railways remained in physically old standards. Figure 3.1 shows the railway network development since the pre-republic era. It is indicated in the Figure that, after 2002, there is an increase in railway network development. It is stated that 137 kilometers of HSR has constructed each year.



Source:General Directorate of State Railways Administration, 2012

Figure 3.1. Railway Development in Turkey

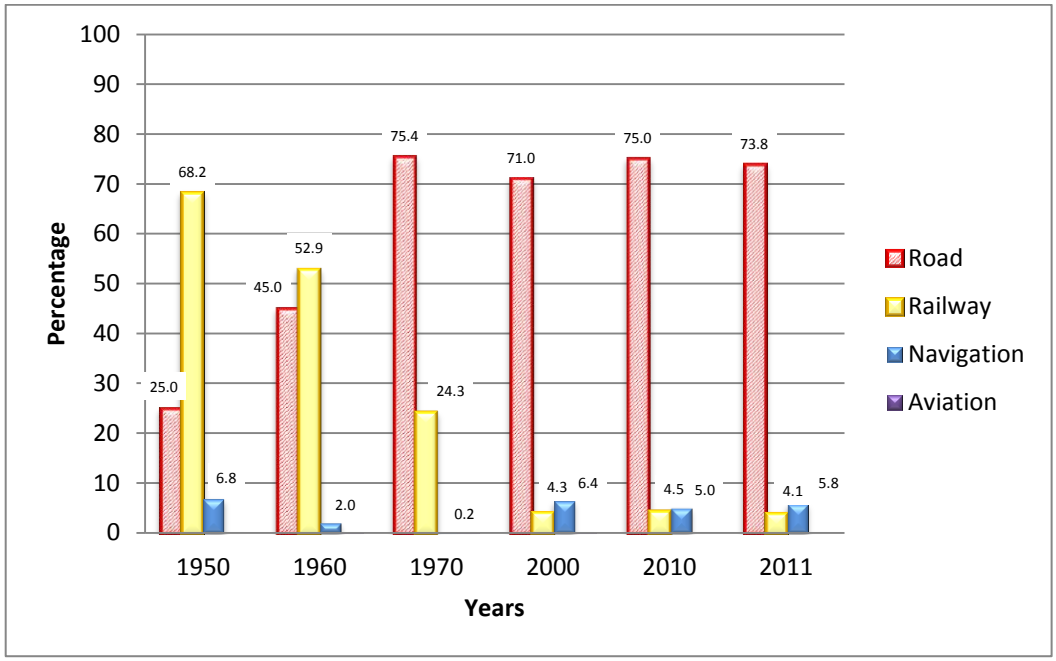
Transport policies are analyzed in the next sections to provide the recent and contemporary transport policy agenda. As illustrated in these upcoming sections, the dominance of road transport and its repercussions in terms of petroleum consumption, dependency on foreign resources, traffic safety and accidents have always been highlighted as main concerns in the Five-Year Development Plans of Turkey in the 1970s, 1980s and 1990s too. These plans too advocated the

improvement and development of railways in order to create a more balanced usage of transport modes. The plans from the 2000s onwards, however, seem to have an even stronger emphasis on railways because they also resulted in an increase in the funds allocated for railways. This may be due to the increasing urgency of sustainability debates, environmental concerns, as well as the will to integrate into the Trans European Rail Network. In addition, energy security has become an important issue because of political and economic reasons in recent years. The current state of the transport sector and a review of transport policies in the country are provided below in the next sections.

3.2. General Overview of the Transport Sector in Turkey

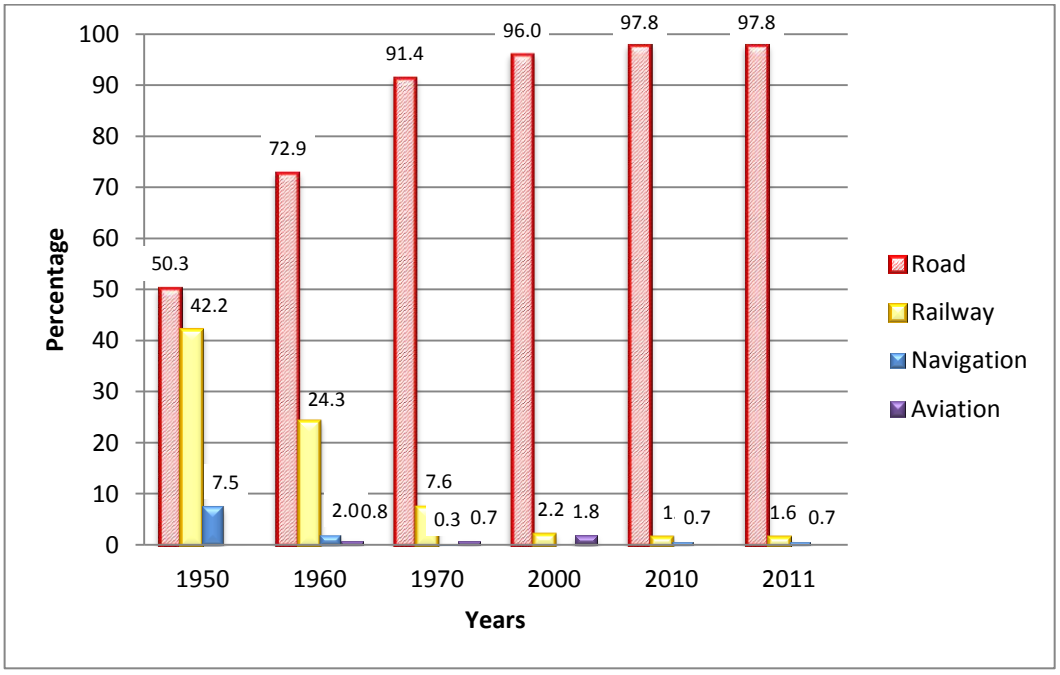
3.2.1. Transportation Trends and Share of Modes in Turkey

In Turkey, road transport has been the predominant mode of both intra-city and inter-city transportation for the last 50 years. Modal split in intercity transportation in Turkey is given in Figure 3.2 and Figure 3.3. As the figures show, there has been a sharp decrease in the share of railways in both passenger and freight transportation after 1950. Reasons of the decrease in railway share will be covered in more detail in the forthcoming sections of this study.



Source: General Directorate of State Railways Administration, 2012

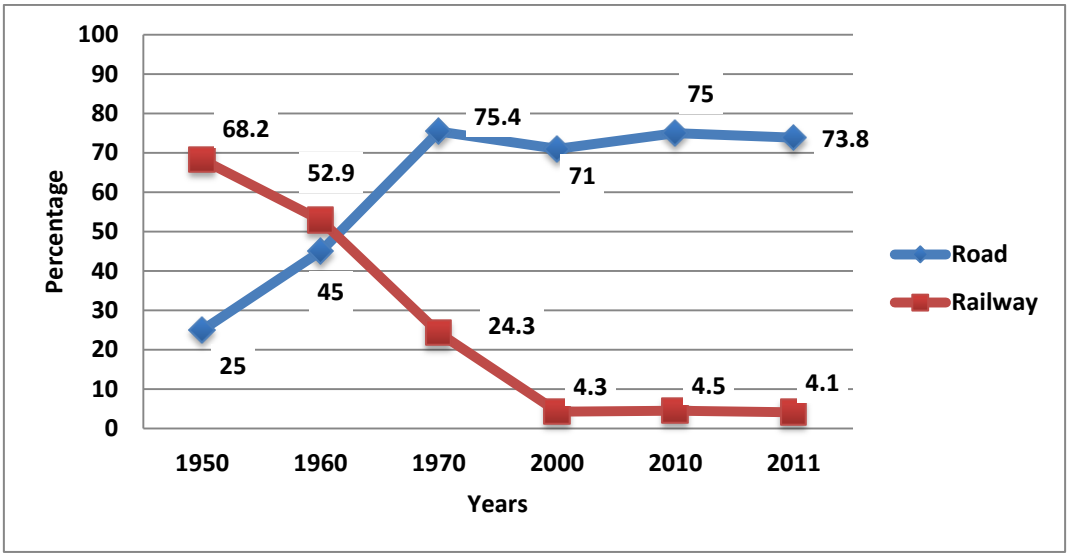
Figure 3.2. Freight Transportation ModalShares (1950-2011)



Source: General Directorate of State Railways Administration, 2012

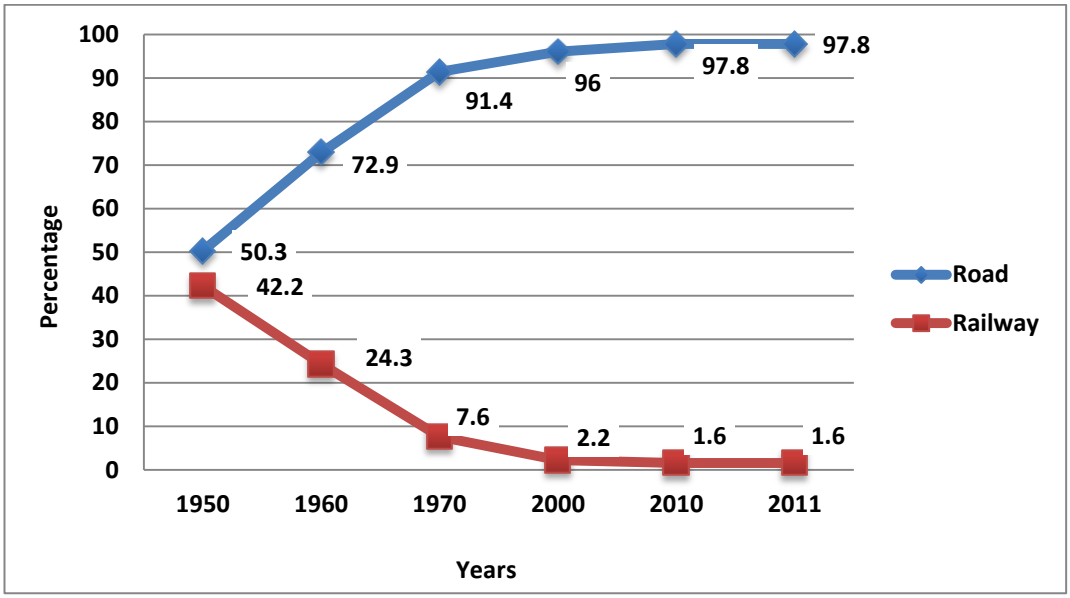
Figure 3.3. Passenger Transportation Modal Share (1950-2011)

Figure3.4and Figure3.5show how road and railway transportation shares have changed in the last decades. For freight movement, road transport has increased its share from 25% to 73.8% between 1950 and 2011. In the 1950s, railway's share in freight transport was quite high when compared with road transport because road transport infrastructure was inadequate and services provided by motorized road vehicles were few. In terms of passenger transportation, road and railway transportation shares were close to each other in 1950; however, since then the share of railways has begun to decrease and the gap between road and rail shares has increased.



Source: General Directorate of State Railways Administration, 2012

Figure 3.4. Change in Modal Share of Freight Transportation Between 1950 and 2011



Source: General Directorate of State Railways Administration, 2012

Figure 3.5. Change in Modal Share of Passenger Transportation between 1950 and 2011

Since the 1970s, railway development has been stressed in policy documents (Five Year Development Plans) as vital for economic and social development of Turkey. In addition, particularly since the 1990s there has been a particular emphasis on the integration of the country's railway network to Trans European Transportation network. With increasing emphasis on sustainable development in the transport sector, which can be seen in policy documents in the late 1990s and early 2000s, the shift in transport policy towards railway development can be seen in the funds allocated to railway development (Babalık-Sutcliffe, 2007). This trend continued throughout the 2000s as these funds increased from 75 Million Turkish Liras in 2000 to 4.1 Billion Turkish Liras in 2012. This renewed interest in railways appears to be partly motivated by the policies to integrate into EU and partly stimulated with the increasing popularity of high-speed rail technology in the world. As a result of the policies that aimed at introducing HSRs into the current network and inclusion of private operators into the sector, railway development has entered a new process. According to the General Directorate of State Railways Administration Sector Report (2012), 11.000 kilometers rail road

has been renewed; Ankara-Konya and Ankara-Eskişehir HSR Projects have been completed and began to operate.

3.2.2. Environmental Impacts of Current Transport Network

In **Chapter 2,** environmental impacts of various transportation modes were given in general. In addition, Turkey's transportation mode share was given in detail in the previous section. It is seen that the current transportation system highly depends on road transportation. Although, there is an effort for developing the railway network by introducing new HSR lines, the infrastructure and its usage are still limited to have any effect on the reduction of the share of road transportation. Adding to this, airway transportation is increasing its popularity for intercity transport. Especially, flexibility of the price in air transportation and the private companies' campaigns make air transport attractive. All of these increase the environmental impacts of transportation, which can be evaluated in terms of energy consumption, greenhouse gas emissions, noise, vibration, land coverage, contribution to the soil and water pollution, etc.

Turkey has a high dependence (71.5%) on imports to meet energy demand for all sectors. 90.3 % of the primary energy consumption consists of fossil fuels and the total primary energy consumption of Turkey was 114,480 mtoe in 2011. According to Figure 3.6, the transport sector was responsible for 14 % of the primary energy consumption in 2011.

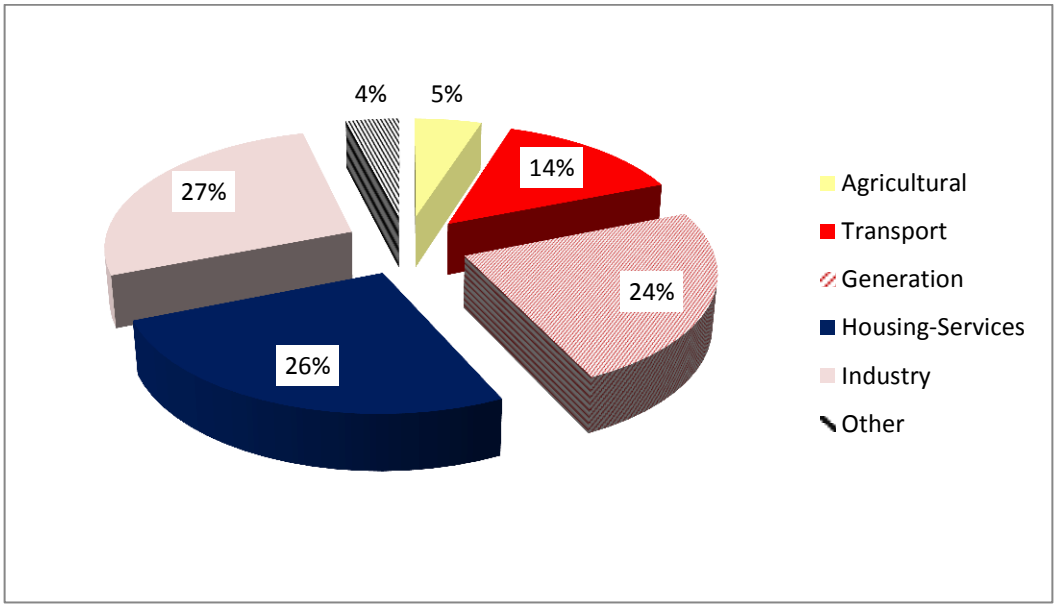


Figure 3.6. Share of the Primary Energy Consumption among Sectors

According to the Turkish State Railway's Strategic Plan (2012), railway is responsible for 5 % of air pollution while road transportation is responsible for 85 %. According to the emission inventory of Turkey (MoE, 2011), transportation is responsible for the 17 % of the overall GHG emissions; and road transport, which has the highest, is responsible for the %85 of the CO_2 emissions originated from the transport sector.

Currently, road is the major transportation mode and it consumes too much energy while at the same time producing greenhouse gas emissions. Therefore, the contribution to the air pollution is more than railway. Indeed, railway's impact on air pollution is less than other motorized transportation modes because it consumes electricity that does not directly produce emission. Therefore, the contribution of road transportation to the climate change and air pollution is relatively higher than other modes in Turkey. When the land coverage is analyzed, a railway line, which is constructed as two lanes (about 13.7 m in width), is equivalent to a highway with 6 lanes(about 30 m in width) in terms of capacity. In this regard too, railway has a comparative advantage to the road transportation since it has a higher carrying capacity per area that it occupies.

3.2.3. Transport policy-making in Turkey: Institutional Framework and National Development Plans

Ministry of Transport established in 1949,is the main government agency for developing transport policies in Turkey. General Directorate of State Railways Administration which is subjected to Decree Law no: 233 on the State Economic and State Owned Enterprises, is also under this Ministry and is mainly responsible for the construction, operation and renovation of railways (both conventional and high-speed railways), and coordination and cooperation between enterprises. The supervision, coordination and relations of Turkish State Railways at the government level are executed by the Ministry of Transport, Maritime and Communication.

Turkey's status as a candidate country of the European Union affects the country's national policies. In the accession process, it is important to develop economical and physical infrastructure to integrate in to the European Union. Therefore, transportation has an important position in terms of physical integration that brings with it increasing economic activities, such as commerce and tourism.

It is not intended to review all of the Development Plans of the country to present the contemporary policy agenda of the country. In fact many development plans emphasized the ever-increasing road transport and the need to support railways too. This emphasis increased with the 7th Development Plan, prepared in 1995, which was the first one to clearly stress the negative environmental consequences of the transport sector (Babalık-Sutcliffe, 2007). Then the 8th Development Plan in 2001 became the first one to include the term sustainability for the transport sector. Therefore, in order to analyze the recent and present policies, the 8th, 9th and 10th Development Plans are reviewed here. In addition 2011 Action Report published by the Ministry of Transport, Maritime and Communication, and the

Transport Congress Report prepared after the National Transport Congress of the Ministry in 2009 are analyzed in the scope of this study.

The 8th Development Plan (2001-2005) is the first development plan of the country that featured the concept of "sustainability" in relation with the transport sector and emphasized the importance of sustainable development of transport infrastructure and activities. In this plan, there are many suggestions about minimizing the negative impact of transport on the environment and promoting policies that will help to reduce greenhouse gas emissions. In order to provide a sustainable transportation system, the plan proposed to develop a comprehensive framework to evaluate externalities of transport investments ,and to create a multimodal integrated and interconnected transport infrastructure to establish a continuous rail corridor across Europe and Middle Asia (Babalık-Sutcliffe, 2007). In addition, the development plan has significantly altered the fund allocation between transport modes: when compared with previous plan proposals, the 8th Development Plan proposed a higher share of funds to be allocated for railways. Funds proposed for the railway investment increased to one-fifth of all transport expenditures.

In the 9th Development Plan (2007-2013), the transportation sector received the biggest share of fundsin the public investments and increased its share to about one-third of total expenditure. The importance of strengthening the network with Trans European Transport Network, Caucasian Countries ,Middle Asia and Middle East was emphasized in the transportation policies.

In the 10th Development Plan (2014-2018), 34 % of the national budget was allocated for transportation projects. In this plan period, developing transportation infrastructure to connect production and consumption centers in the country and overseas has been proposed as a significant national policy. In line with this, projects that strengthened Trans-European Transport Network, Caucasian Countries and Middle East were proposed.

When the Development Plans are analyzed in terms of the transport sector, it is seen that there has been an increase in the share of funds allocated for the transport sector and that the share of funds proposed for railways also increased. This parallels the arguments presented in the policies of the Development Plans since railways have received increasing emphasis as an instrument to make the transport sector more sustainable. In addition, in three development plans, the significance of the integration of all transport modes and networks is emphasized.

According to the 2011 Action Report of the Ministry of Transport, Maritime and Communication too, the shift from road to rail for freight transportation is stated as a strategic goal and in the report it is emphasized that the role of private sector in rail freight transportation should be increased to meet this purpose. Also, as it was stated in the development plans, it is emphasized that projects strengthening the integration to Trans-European Railway Network should be given priority and developed urgently.

3.2.4. Review of Railway Policies and Railway Investment Proposals in the National Development Plans of Turkey

In the 8th Development Plan (2001-2005), railway infrastructure is proposed to be developed with particular emphasis on international corridors. It is stated that Turkey-Georgia (Kars-Tbilisi) Railway Project construction will begin. In addition, the Bosporus Railway Tube Transition and Gebze-Halkalı Suburban Railway Rehabilitation Project are stressed as crucial investments to be completed.

In the 9th Development Plan (2007-2013), it is stated that 938 kilometers of new railway lines will be constructed, 1000 kilometers railway will be renewed and freight transportation by railway will increase its share to12 %. However, when General Directorate of State Railways AdministrationAnnual Statistics(2013) is analyzed, it is seen that, this aim has not been reached in 2007-2013 period; in

2012 the share of freight transportation was around 4.1%. In addition, for the plan period it was aimed that İstanbul-Ankara-Sivas, Ankara-Afyon-İzmir and Ankara-Konya HSR projects would be constructed and that they would begin to operate for passenger transportation. However, this goal has not been attained in this period either.

In the 10th Development Plan (2014-2018),a comprehensive HSR network was planned with Ankara as the center of the network: İstanbul-Ankara-Sivas, Ankara-Afyon-İzmir, Ankara-Konya and İstanbul-Eskişehir-Antalya high speed rail corridors were proposed. It was planned to complete Gebze-Eskişehir Railway in orderto start operation in the Ankara-İstanbul line in 2013; however, this deadline could not be met and the line opened to service in 2014 July. Until the end of the plan period (2018), Ankara-Sivas (393 km) and Ankara (Polatlı)-Afyonkarahisar (167 km) lines are planned to be completed to start operation. After the completion of the planned railway network it is expected that the share of railway will be 13 %in freight transportation and7 % in passenger transportation (MoE, 2011). This indicates an increase from the current levels, which are 4.1 % in freight transportation and 1.6 % in passenger transportation.

In the National Transport Congress Report (2011), which is an outcome of a large congress and study carried out with the participation of policymakers and experts from ministries and the academy; many new transport investment proposals have been made. It was suggested to build new conventional railways (about 4700 km length) with the standard of 100 km/h speed and it was planned to integrate commercial harbors and railway stations to provide an efficient freight transportation network. Another suggestion was to build a railway on to the 3rdBosphorus Bridge in Istanbul that is under construction. The3rd Bosphorus Bridge project, which is planned by the General Directorate of Highways, will be the third road bridge connection between Asian and European sides of Istanbul and is planned as part of a wider motorway project. The railway component of the project will be a part of the Sincan-Çayırhan-İstanbul HSR Project, which will be

analyzed in detail in this study in the next chapters. The other projects can be listed as İstanbul-Basra Railway Project, Turkey-Iran Railway Project, Arabian-African Railway Project and HSR projects all across Turkey.

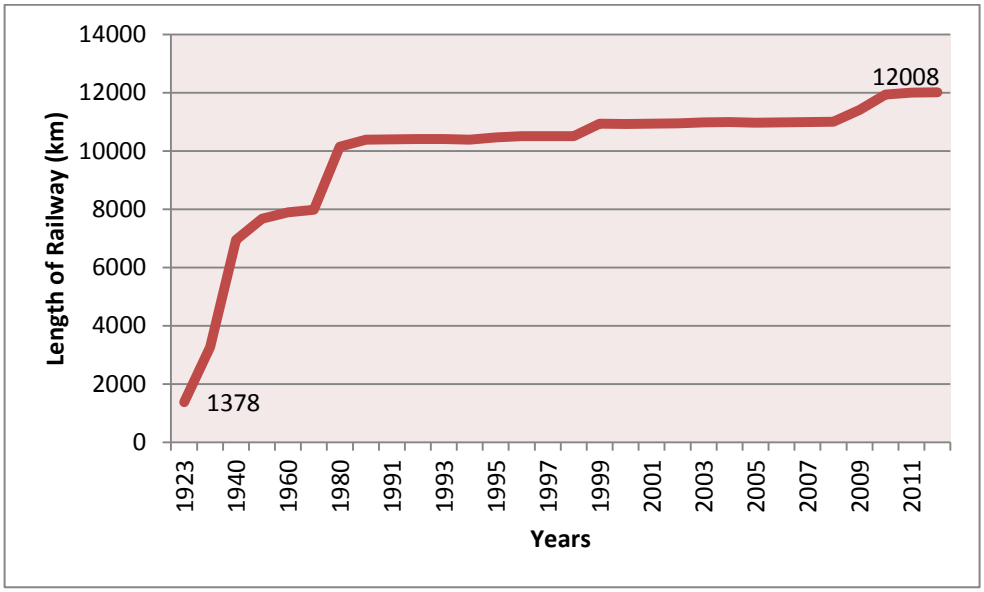
As a result of policies for more railway development, funds that were allocated for railways increased in order to achieve the targets presented above. However, it should be noted that while funds were allocated in investment programmes, these were not fully spent. The actual expenditure on railway development often stayed behind the proposed funds that were allocated to railways. Babalık-Sutcliffe (2007) stated that "In fact, actual investment throughout the 2000s remained below 40% of what was proposed". Therefore, it could be stated that proposals in policy documents were not implemented fully. The following sections present the current network of railways in Turkey and existing and planned high-speed rail lines.

3.3. Development of the Railway Sector in Turkey

3.3.1. The Current Railway Network in Turkey

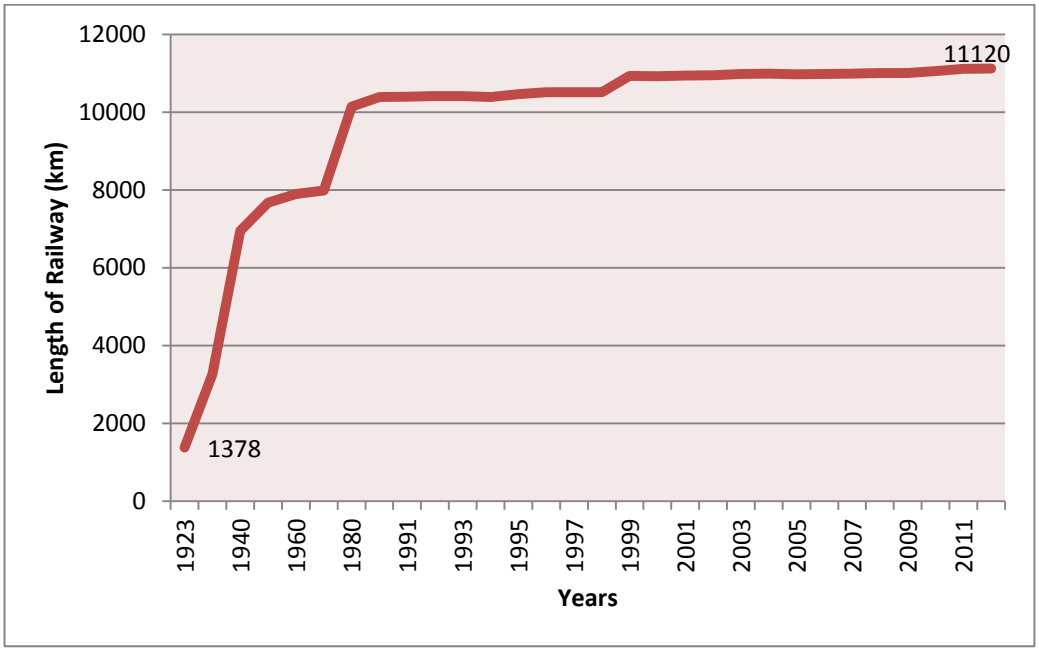
Turkey has 12,008 kilometers of railway network including conventional and HSRs. 2328 kilometers of the railway network is electrified while 888 kilometers of it is HSR (TCDD, 2012). In addition, According to the Sector Report (TCDD, 2011), 91 % of the railway network is single-line, 26.8 % is electrified and 33.4 % is signalized.

These all indicate the need for vigorous work to improve the conventional railway systems if a high quality service levels is to be attained. Electrification and signalization rates are quite low; and many policy documents, which were reviewed in the previous sections, highlight the need for developing them and increasing the rate of signalized and electrified lines. Figure 3.7 and Figure 3.8 shows the development of railway network in Turkey between 1923 and 2012.



Source: General Directorate of State Railways Administration,2014, statistics provided on the internet site

Figure 3.1. Total Length of Railways including HSR (and branch and station lines)



Source: General Directorate of State Railways Administration,2014, statistics provided on the internet site

Figure3.8. Total Length of Railways HSR (including branch and station lines exluding HSR)

The above graphics show the stagnation in railway development in the 1950s and 1960s, which changed in the 1970s with some 2000km of new lines being built. Since then no significant expansion has been made in the railway network except for the increase seen in 2009 and onwards in the first graph that includes the HSR (HSR) lines. When the second graph, which excludes HSR, is observed, it is clearly seen that the increase in the network is only due to the new HSR lines and investment made to expand the conventional lines has remained insignificant for decades.

Ankara-Eskişehir HSR Project is the first HSR line that has been operating in Turkey since 13 March 2009. Its construction began in 2003 and was finished in 6 years. Secondly built high speed rail line is Ankara-Konya, which has been operating since 24 August 2011. The number of passengers transported by HSRs increased by 31% from 2011 to 2012, as would be expected: high-speed railway has been operating since 2009, and 2011 marks the opening of the second line, Ankara-Konya. Unfortunately, when the total number of passengers transported is analyzed, it is seen that there has been a decrease between 2011 and 2012 (see Table3.1).

Table 3.1. Total Number of Passenger Transportation on Main Lines

Main Line Passenger Transport (*1000)	**2009**	**2011**	**2012**
Domestic (Conventional)	21,656	23,588	16,449
HSR	942	2.557	3.350
International	241	181	125
Total	22,839	26,326	19,924

Source: General Directorate of State Railways Administration Annual Statistics 2005- 2009 and 2008-2012

3.3.2. HSR Projects: Current and Future HSR Investments

High speed rail is a type of railway transportation that allows 250 km/h or faster transportation and uses an integrated system of specialized rolling stock and dedicated tracks. It competes with road and air in medium-range distances. Turkey has experienced its first HSR trip in 2009 by the launching of Ankara-Eskişehir line. After that Ankara-Konya, which is the second line, opened to service in 2011. Between March 2009 and December 2012,a total of 8,741,921passengers were transported and 31,320 trips were made. The number of passengers transported increased by 35% in 2011 and by 31% (3,353,399 people) from 2011 to 2012 (TCDD, 2012).

In this section of the study, both current and planned HSR lines will be analyzed in detail. First, operating characteristics of Ankara-Eskişehir and Ankara-Konya High Speed Lines will be given. Then, four HSR projects that are in planning stage will be presented in detail.

3.3.2.1. Current HSR Lines and Their Impact on CO_2 Reduction in the Corridors

Ankara-Eskişehir-İstanbul HSR

Ankara-İstanbul HSR Project consists of two sections that are Ankara-Eskişehir and Eskişehir-İstanbul HSRs and it aims to connect Ankara and İstanbul, which is a high demand transport corridor. Ankara-Eskişehirsection is the first high-speed rail line to be constructed and operated by the Turkish State Railways. It has been operating since 13 March 2009. The second section has been under construction and its Eskişehir-Gebze section opened to service in July 2014.

This project has also provided benefits to the surrounding cities like Bursa and Kütahya because modal integration has been implemented in the Eskişehir rail station. For the Ankara-Kütahya corridor, HSR+conventional railway, for

Ankara-Bursa corridor HSR+bus alternatives have been developed and project catchment areas have been enlarged. In the Ankara-Kütahya corridor 70,273 passengers, in the Ankara-Bursa corridor 146,087 passengers used these combined transport alternatives in 2012 (TCDD, 2012). According to Table 3.3, 36% of the combined trips are realized in Eskişehir-Kütahya corridor. 60% of the total trips that are generated and produced in Eskişehir are combined trips that provide transportation to Kütahya and Bursa.

Table 3.2. Ankara-Eskişehir Line Combined Transportation Share

	Combined	**Total**	**%**
Eskişehir-Kütahya Corridor	66,634	185,956	36
HSR+Bus (Ankara-Bursa)	146,087	146,087	100
Eskişehir Combine Total	216,360	362,922	60

Source: General Directorate of State Railways Administration,2012

Assessment of CO_2 Reduction in the Ankara-Eskişehir CorridorAfter the HSR

As it was emphasized in the previous chapters, HSR lines are seen as one of the important component of CO_2 reduction strategy because of their potential impact on the shift from carbon intensive road and air transportation to HSR. In order to calculate the reduction in carbon dioxide emissions in this corridor, modal split data that belongs to before and after HSR is used.

Before the HSR was constructed, there was a conventional railway line in this corridor; however, private car and bus transportation have been the major transport alternatives for the Ankara-İstanbul journeys. Ankara-Eskişehir road is

approximately 233 km and travel time is about 3 hours by bus. After HSR began to operate, travel time has decreased to 1.5 hours and hence when compared with bus and car transportation it provides significant time saving and a more comfortable journey. According to General Directorate of State Railways AdministrationAction Report (2012), currently, there are 10 trips per day operating on both directions (in total 20 trips per day), andcarrying6000 to 7500 passengers daily. In addition, railway share has increased from 8% to 72% in the Ankara-Eskişehir corridor with the opening of the HSR here. Bus share has dropped from 55% to 10% and private car decreased its share from 37 % to 18 % (see Table 3.3).

Table 3.3. Ankara-Eskişehir Line Modal Split Evaluation in Terms of Passenger Transportation

The Number of Passenger (daily)	**Before HSR**	**Share (%)**	**After HSR**	**Share (%)**
Bus	1,463,650	55	292,000	10
Conventional Railway	208,780	8	49,275	2
HSR	0	0	2,117,000	70
Private Car	1,000,000	37	547,500	18
TOTAL	2,672,480	100	3,005,775	100

Source: General Directorate of State Railways Administration,2012

As seen in Table 3.3, 2,117,000 passengers were carried by HSR in 2012. If there was no HSR line in the corridor, these passengers would be carried by bus, conventional railway line and private car. Thus, for the no HSR line scenario in Ankara-Eskişehir corridor, 2,117,000 passengers are distributed to other transportation modes according to the shares presented in Table 3.4.

In this calculation, following assumptions are made;

- An intercity bus has an average occupation rate of 46 passengers,
- A conventional train set has an occupation rate of 310 passengers,
- A private car has an occupation rate of 2 passengers in Turkey for intercity trips.

Based on these assumptions, number of trips that would have been generated by 2,117,000 passengers in case there was no HSR line is calculated by taking the average occupation rates of bus; conventional train and private car (see Table 3.4).

Table 3.4. Passengers Distribution according to Modal Split Data before HSR for Ankara-Eskişehir Corridor

Transportation Mode	**Share (%)**	**Number of Passengers (p)**	**Average Occupation Rate (r)**	**Number of Trips(p/r)**
Bus	55	1,164,350	46	25,312
Conventional Railway	8	169,360	310	546
Private Car[1]	37	783,290	2	391,645
TOTAL	100	2,117,000	-	-

According to Table 3.5, if there was no HSR line in Ankara-Eskişehir corridor, there would be 25,312 bus trips resulting in 5,897,696 vehicle kilometers, 546 conventional railway trips resulting in 136,500vehicle kilometers and 261,096 private car trips resulting in 60,835,368 vehicle kilometers.

Table 3.5. Total Vehicle Kilometers for Ankara-Eskişehir Corridor

Transportation Mode	**Number of Trips (t)**	**Length of line (kilometers-k)**	**Total Vehicle Kilometers (t*k)**
Bus	25,312	233	5,897,696
Conventional Railway	546	250	136,500
Private Car	391,645	233	91,253,285

[1]Average occupancy rate is taken from the report on "Environmental Aspects of Inter-City Passenger Transport" of OECD,2009

In order to calculate carbon emissions generated by trips in no HSR line scenario, carbon emission factor values (kg CO_2/kilometer) are used and multiplied by total vehicle kilometers (see Table 3.6). The total amount of CO_2 emissions in no HSR line scenario is calculated as 22,900 tons.

Table 3.6. Total CO_2Emissions for Ankara-Eskişehir Corridor before HSR

Transportation Mode	**Total Vehicle Kilometers (km)**	**Emission Factor[2] (kg CO_2/km)**	**Total Emission Amount (kg CO_2)**
Bus	5,897,696	0.13552	799,255.8
Conventional Railway	136,500	0.06715	9,166.0
Private Car	91,253,285	0.24234	22,114,321.0
Total	-	-	22,922,742.8

In order to compare pre-HSR and after-HSR emissions, it is needed to calculate HSR emission amount that is produced in Ankara-Eskişehir corridor. Emission factor for high speed rail transportation is taken as 0.048 kg CO_2/kilometer and number of passengers per train set is accepted as 412in average. Additionally, Ankara-Eskişehir HSR line is 218 kilometers in length. The total amount of CO_2 emissions generated by the HSR is calculated as 54 tons.

Table 3.7. Number of Trips made by Ankara-Eskişehir HSR

Number of Passengers (p)	**Average Occupation Rate (r)**	**The number of Trips (p/r)**
2,117,000	412	5138

Table 3.8. Total CO_2Emissionsgenerated by Ankara-Eskişehir HSR

Number of Trips (t)	**Length of line (km)**	**Total Vehicle Kilometers (t*k) (km)**	**Emission Factor[3] (kg CO_2/km)**	**Total Emissions (kg CO_2)**
5138	218	1,120,084	0.048	53,764.032

[2]http://www.carbonneutralcalculator.com/Carbon%20Offset%20Factors.pdf
[3]Tanaka et al. (2010), Thompson, Schipper, Kosinski &Deakin, 2010, Analysis of High-Speed Rail's Potential to Reduce CO_2 Emissions from Transportation in the United States

In order to assess the impact of HSR on emission reduction, the results of before and after HSR situations should be compared. In the case that HSR does not operate in Ankara-Eskişehir corridor, 22,900 tons of CO_2 emission would be emitted due to use of private cars, buses and conventional trains. However, after HSR began to operate in the same corridor, CO_2 emissions are found to reduce to 54 tons of CO_2, showing a significant reduction potential more or less equal to22,850 tons.

Ankara-Konya HSR

Ankara-Konya HSR is the second high-speed line of Turkey after Ankara-Eskişehir and it has been operating since 24 August 2011. Before the HSR began to operate, bus and private car were the two major alternatives for this corridor too and travel time by these modes is about 3 hours. Conventional railway also exists in this corridor but it has low standards and travel time is more than 3 hours.

Currently, it takes about 2 hours to travel between Ankara and Konya by HSR. According to General Directorate of State Railways AdministrationSector Report (2012), there are 8 daily trips operating on both directions and totally 16 trips are realized in one day. There is high-speed railway and conventional railway integration in stations for this line and bus transfer will also be added to enlarge the service area. It is planned to add bus connection in order to provide transportation to Antalya, Manavgat, Alanya, Silifke, Mut, etc.

Assessment of CO_2 Reduction in the Ankara-Konya Corridor After the HSR

After the Ankara-Konya HSR began to operate, there has been a decrease in the shares of buses from 70% to 18%, and private car from 30% to 17% whereas the railway share has increased to 65% (see Table 3.9). In 2012, 1,778,148 passengers were carried by Ankara-Konya line.

Table 3.9. Ankara-Konya Line Modal Split Evaluation in Terms of Passenger Transportation

The Number of Passenger (daily)	Before HSR Share (%)	After HSR Share (%)
Bus	70	18
HSR	0	65
Private Car	30	17
TOTAL	100	100

According to Table 3.10 and Table 3.11, if there were not HSR line in Ankara-Konya corridor, there will be 27,059 bus trips that result with 7,062,399 vehicle kilometers and 177,815 private car trips with 49,409,715 vehicle kilometers.

Table 3.10. Passengers Distribution according to Modal Split Data before HSR for Ankara-Konya Corridor

Transportation Mode	Share (%)	The Number of Passengers (p)	Average Occupation Rate (r)	The number of Trips (p/r=t)
Bus	70	1,244,703.6	46	27,059.0
Conventional Railway	0	0	310	0.0
Private Car[4]	30	533,444.4	2	266,722
TOTAL	100	1,778,148	-	-

Table 3.11. Total Vehicle Kilometers for Ankara-Konya Corridor

Transportation Mode	The number of Trips (p/r=t)	Kilometers of line (k)	Total Vehicle Kilometers (t*k)
Bus	27,059	261	7,062,399
Private Car	266,722	261	69,614,442

[4]Average occupancy rate is taken from the report on "Environmental Aspects of Inter-City Passenger Transport" of OECD,2009

In order to calculate carbon emission reduction amount in this corridor, carbon emission factor values are taken and multiplied by the total vehicle kilometers.

Table 3.12. Total CO_2 Emissions for Ankara-Konya Corridor before HSR

Transportation Mode	**Total Vehicle Kilometers (L=t*k)**	**Emission Factor (f)**	**Total Emission Amount (CO_2 per km)**
Bus	7,062,399	0.13552	957,096.312
Private Car	69,614,442	0.24234	16870363.874
Total	-	-	17,827,460.186

In order to compare pre-HSR and after-HSR emission amounts, it is needed to calculate HSR emission amount that is produced in Ankara-Konya corridor. Therefore HSR emission factor is taken as 0.048 kg CO_2 per kilometer and passenger per train set is accepted as 412 in average as in Ankara-Konya corridor CO_2 reduction assessment which is above. Additionally, Ankara-Konya HSR line is 213 kilometers of length.

Table 3.13. The Number of Trips Made by Ankara-Konya HSR

The Number of Passengers (p)	**Average Occupation Rate (r)**	**The number of Trips (p/r=t)**
1,778,148	412	4316

Table 3.14. Total CO_2 Emissions generated by Ankara-Konya HSR

The number of Trip (p/r=t)	**Kilometers of line (k)**	**Total Vehicle Kilometers (t*k)**	**Emission Factor (f)**	**Total Emission Amount (kg CO_2)**
4316	213	919,308	0.048	44,126.784

As it is stated in Table 3.12, 17,820 tons of CO_2 emission would be emitted due to use of private cars and busses in the case that HSR does not operate in Ankara-Konya corridor. However, after HSR began to operate in the same corridor, CO_2 emissions are found to reduce to44 tons of CO_2 that shows significant decrease in the CO_2emissions.When CO_2 emissions in the both conditions are compared, it is seen that there is about 17,776 tons reduction in CO_2 emissions.

3.3.2.2. Future HSR Investments

Currently there are many projects that are in planning stages. These projects are planned to integrate into each other in certain cities. Integration of different projects will expand the high-speed rail network service area and create hubs that focus on railway transportation. Feasibility and route studies are conducted in this stage and 1/5000 plans are prepared to identify physical, social and environmental impacts of the projects. Table 3.15shows the list of HSR projects that are in planning stage. In this chapter, four of them will be analyzed in detail because in the upcoming chapters questionnaire analysis will be given related to these projects.

Table 3.15. List of HSR Projects in Planning Phase

NO	PROJECT
1	Ankara-İzmir HSR Project
2	Halkalı-Kapıkule HSR Project
3	Ankara-Sivas HSR Project
4	Sivas-Erzincan-Erzurum-Kars HSR Project
5	Eskişehir-Antalya HSR Project
6	Konya-Karaman-Ulukışla-Mersin HSR Project
7	Bandırma-İzmir HSR Project
8	Bandırma-Bursa HSR Project
9	Yerköy-Şefaatli-Kayseri HSR Project
10	Kırıkkale-Çorum-Samsun HSR Project
11	Trabzon-Erzincan HSR Line Project
12	Erzincan-Diyarbakır-Mardin HSR Project
13	Sincan-Çayırhan-İstanbul HSR Project
14	Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Project
15	Diyarbakır-ŞanlıurfaHSR Project
16	Kırşehir-Aksaray-Ulukışla HSR Project

The analysis presented in the thesis is based on four HSR projects that are:

- Line 1: Sincan (Ankara)-Çayırhan-İstanbul HSR Line
- Line 2: Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line
- Line 3: Kırşehir-Aksaray-Ulukışla (Niğde) HSR Line
- Line 4: Erzincan-Diyarbakır-Mardin HSR Line

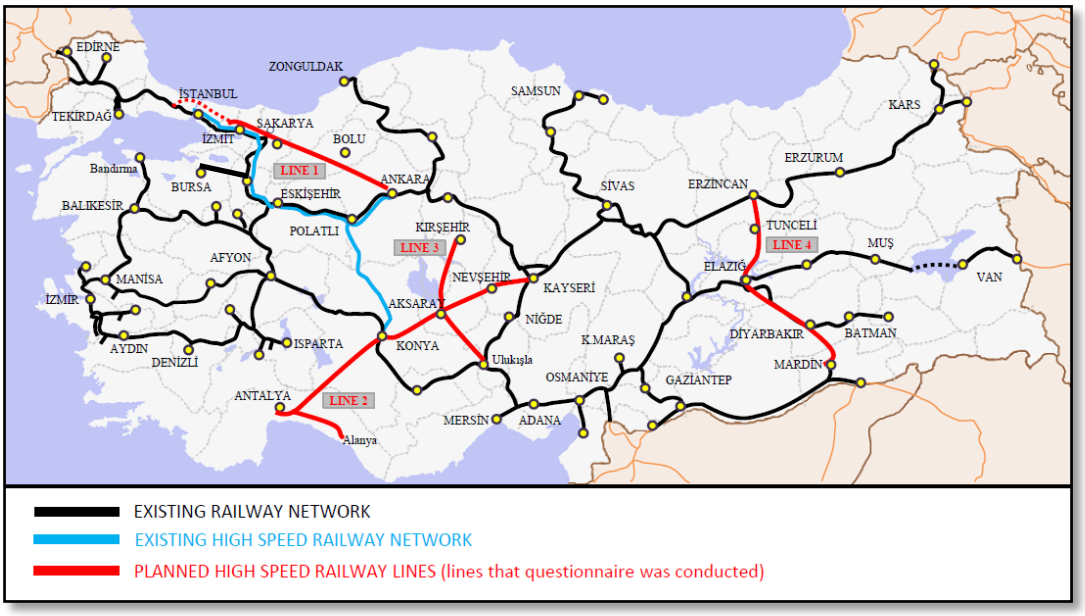


Figure 3.9. Railway Network in Turkey Including Studied HSR Lines

Line 1: Sincan-Çayırhan-İstanbul HSR Line

Sincan-Çayırhan-İstanbul HSR Line (Line 1) aims to create a new high-speed railway line between Ankara and İstanbul with a high standard infrastructure. This project has a route different than the Ankara-Eskişehir-İstanbul HSR that was mentioned in the previous section. The planned route begins in Sincan (Ankara) as an expansion of the existing HSR infrastructure and passes through Mudurnu (Bolu), Sakarya, Kocaeli and finishes in İstanbul (European Side). The project was planned to have 3 sections. The first section includes Ankara-Kocaeli line; the second section is Kocaeli-İstanbul Anatolian Side connection; and the last section is from İstanbul Anatolian Side to Küçükçekmece on the İstanbul European Side with the link of the 3rd Bosphorus Bridge which is in construction phase. In the following chapters, the analysis will be made for Ankara-Kocaeli Section of this HSR line.

The geometrical characteristics of the project are rather different when compared to other planned high-speed railways because it aims to reach 350 km/h speed that will be the fastest railway system in Turkey. Because of its high physical

standards that are required to reach such a high speed, it is not convenient for freight transportation. Ankara and İstanbul are the cities that attract and product highest levels of passenger trips. Therefore, it is crucial to provide efficient transportation in this corridor. Air, road and rail transportation are the current alternatives for Ankara-İstanbul transportation however in the last years conventional rail transportation has not been operated because of the construction of the Ankara-İstanbul HSR, described in the previous section. Therefore, currently air and road transportations are the only alternatives.

Air transportation is the fastest transport mode however in large metropolitan cities like İstanbul and Ankara, arriving to the airport takes time. Also, airport traffic has increased in recent years and airport capacities become inadequate in some cities like İstanbul. Thus, departure and landing times are often not reliable due to delays. Urban transportation and waiting times may decrease the attraction of air transport especially for short-distance travels. For example, it takes 3 to 3.5 hours to go from Ankara to İstanbul by air (from the city center to city center, i.e. considering airport access times as well); 5 to 6 hours by bus; and 4 to 5 hours by private car. Thus, there is not much time saving provided by air transportation for this corridor. Sincan-Çayırhan-İstanbul HSR line aims to reduce travel time to 2 to 2.5 hours. In some cities, railway stations are located in city centers or there can be public transportation service to the station. It creates an advantage for HSR transportation.

Line 2: Antalya-Konya-Aksaray-Nevşehir-Kayseri Railway Project

Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line (Line 2) is another line that is in planning stage. It aims to connect the Mediterranean Region with the Middle Anatolian Region and to enhance tourism potential. Antalya and Nevşehir are two leading tourism centers in Turkey and road transport is the single alternative to connect these cities. Line 2 which is planned to operate with a speed of 250 km/h

speed will reduce the travel time. In Konya Station, it is planned to integrate into the Ankara-Konya HSR.

Line 3: Kırşehir-Aksaray-Ulukışla Railway Project

Kırşehir-Aksaray-Ulukışla HSR Line (Line 3) is another link of the planned railway network. This project is planned in the boundaries of Kırşehir, Aksaray, Konya and Niğde. Currently, road is the main transportation mode in this region and between Kırşehir and Aksaray there is no direct road connection. The shortest road goes through Ortaköy and it takes about 3 hours to go by car or bus. Besides this, the project is designed to create a link between different regions and Central Anatolia. As mentioned in the previous section, there are many HSR projects that are currently in construction, planning or operation stages. Thus, in order to create an integrated railway network it is necessary to build connecter railroads. It is planned to integrate Kırşehir-Aksaray-Ulukışla HSR Line to;

- Ankara-Sivas HSR Line (by the Kırşehir-Yerköy Connector Railway)
- Kırıkkale-Samsun HSR Line (by the Yerköy-Sungurlu Connector Railway)
- Konya-Mersin HSR Line (Integration on Ulukışla Station)

The above links will result in the connection of Samsun Harbor and Mersin Harbor, hence a line in the north-south direction. Furthermore, there will be HSR connection to many cities such as Ankara, Sivas, Konya, Mersin, Kırıkkale, Çorum, and Samsun.

Line 4: Erzincan-Diyarbakır-Mardin Railway Project

Erzincan-Diyarbakır-Mardin Railway Project (Line 4) is planned in the boundaries of five cities; Erzincan, Tunceli,Elazığ, Diyarbakır and Mardin. In small scale, this project aims to connect East Anatolian Cities and South East Anatolian Cities. However, when all the projects that are in planning stage are analyzed, Diyarbakır will be a transportation hub for the region and high-speed rail transportation both to Anatolian cities and the Black Sea Region will be provided. In four of the five cities that the project is planned, there are airports. Air travel is also a considerable alternative in this region because of geographical reasons. It takes a long time to reach central Anatolian and western cities by road transportation from this region.

3.4. Summary & Discussion

The analysis of past and current policies, as well as passenger and freight transport trends point to the dominance of road transportation in Turkey. Currently the share of private car and bus usage in passenger transport is extremely high, which is a result of road oriented transport policies that have been implemented since the 1950s. For decades, national transport policies of the country proposed to reduce the dominance of roads and develop railways. In recent years, the focus on railways became stronger and particularly supportive of HSR development, which may be seen as a trend that is parallel to the development of this technology in the world.

It is seen that in the lines that already started to operate, high-speed rail systems attract users from roads and increase their modal shares for that particular corridor. Before Ankara-Eskişehir HSR began to operate, road transportation was the major transport mode although there was a conventional railway network between Ankara and Eskişehir. It could be stated that Ankara and Eskişehir are the cities that attracts and produces daily tourism and work trips because of the

distance between them is 3 hour drive. After Ankara-Eskişehir HSR began to operate, there has been a significant increase in the railway share and modal share of railway increased to 70% in this corridor. Similarly, after Ankara-Konya HSR began to operate, modal share of railway increased to 65%. It is not expected to see similar demand and modal share increase in railway in every corridor that HSR is planned however. In longer distances air transport may be preferred. In addition, for certain corridors and certain users, road transport, i.e. car usage and bus transport, may continue to be chosen. When the transportation shares of the whole country are considered, it is seen that in spite of the efforts of HSR development, the modal shares of road and air systems are on the increase at the national level.

There are many HSR investments being planned and constructed in Turkey; however, it is uncertain to what extent they will be preferred and used by the passengers. It depends on both travel demand in that corridor and traveler's perception about HSR usage. It is also related with the income level, cost and travel time. The factors that affect mode choice will be detailed in further chapters. It is therefore important to know traveler's perceptions about new HSR lines that are being planned. In which conditions people use HSR is an important issue to analyze because if the expected usage is not realized, then benefits expected from HSR projects, such as environmental benefits, cannot be achieved. In the following chapters, the potential usage of newly planned HSRs will be analyzed with a view to provide a better understanding of possible shifts -and factors that may foster or hinder such shifts- from road to railway transportation.

CHAPTER 4

METHODOLOGY

4.1. Context and Aim of the Study

The transport sector is responsible for 26.53% of greenhouse gas emissions in the world (EC, 2012). While in most other sectors, such as industry, energy production, and residential uses, reductions could be achieved in greenhouse gas emissions through energy-efficient technologies; this does not seem to be the case in the transport sector. Mobility, i.e. number of trips made and the average distance of trips are continuously increasing. Furthermore these trips are increasingly taking place in energy-intensive and polluting modes, i.e. road and air transport. Therefore, in the context of sustainable development policies, the transport sector has become an important area that should be interfered and restructured by governments. In this respect, many countries have committed themselves to reduce fossil fuel combustion and increase the share of more sustainable modes in transportation. Railways are generally considered to be a more environmentally friendly mode, and hence it has become a universal policy to shift transport to railways from road and air transport, which are carbon dependent modes. Due to its relatively lower emission impact and energy consumption, railways receive increasing emphasis that has resulted in extensive investment in rail networks. HSR (HSR), as the fastest mode of railway systems, has received particular emphasis in the recent decades. HSR is seen as an effective alternative for both passenger and freight transport in order to reduce carbon intensive long-distance travel. It is expected that when HSRs are introduced, there will be a shift from road and air to rail.

Turkey has also invested in HSR systems in the recent years, and has extensive plans to expand its HSR network. Considering the extremely road-based transport system of the country, HSR investments are introduced with a view to increase intercity transport alternatives and create shift from roads to railways. These systems are expected to decrease the dependency on road transport and provide an alternative for air transportation in long-distance travel. Therefore, the research, on which this thesis is based, aims to analyze high-speed railway investments in Turkey and whether they can help fulfill these expectations. The main idea behind this analysis is to emphasize that there cannot be any positive impact of planned investments without usage targets are not reached.

Therefore, in this study, the aim is to evaluate currently planned HSR projects in Turkey from the user perspective. Four of the planned HSR projects are analyzed by focusing on the possibility of passenger journey shifts from road to railway transportation. The shift is the most significant part of this study because if the expected ridership is not achieved for HSR projects, road oriented intercity transportation remains the same and the amount of energy consumed and GHG emissions created by the transport sector do not decrease. In addition, HSR investments are costly investments. If ridership levels remain less than projected, this would cause loss of money, loss of land and environmental damage. Furthermore, although railways are considered environmentally friendly as they use electricity for power source, the electricity consumed by railway operations also causes GHG emissions during its production. As a result, if the HSR lines are not likely to attract users, then the electricity used by the HSR operation will be a waste; and this would indicate both inefficiency in resource consumption and further environmental damage through the GHG emissions created during the production of this energy.

4.1. Research Questions

The study is expected to contribute to our understanding of the newly planned HSR investments from the user perspective and it is expected to reveal a set of objectives for the policies about HSR operations. The analysis which will be explained in the following chapters aims at revealing the perceptions, preferences, and travel behaviour and choices of potential HSR users. Currently, because there is an only 11 years (including planning stage) of experience for HSR in Turkey, there are no comprehensive studies on HSR investments except for the state documents and statistics.

Following the main aim of the study described above, research questions to be answered are as follows:

1. What are the perceptions of potential users with regards to HSR:
    a. Are the planned railway systems likely to be used by inhabitants that currently use road transport?
    b. Under what conditions (price, time and other) are the users likely to prefer railway systems?
    c. Is a passenger shift from road to railways likely to happen as a result of these HSR investments?
2. In the light of the answers to the above questions, are HSR investments in Turkey likely to change passenger transportation patterns and mode choices and hence help mitigation of climate change?

In the scope of the study, institutional sector reports have been analyzed to understand the transportation sector and HSR investments in Turkey. In addition, in order to provide a better understanding of whether a passenger transport shift will occur from road and air transport to rail transport, a user questionnaire has been carried out with people living in close proximity to the investments. Detailed information about the method of analysis will be given in the next section.

4.2. Method of Analysis

4.2.1. Method of Data Collection

Information about the HSR investments in Turkey was obtained through the environmental impact assessment process of the projects which were carried out by me within the body of MGS Project, Consulting, Engineering Company between 2012 and 2014. In this process, I had the opportunity to be involved in both route planning studies and environmental impact assessment processes. In both the institutional meetings held at the Ministry of Transport, Maritime Affairs and Communications and the public consultation meetings carried out in the cities that the investments are planned in, information about the investments have been gathered. Dates of the public consultation meetings are given in the following section in Table 4.1.

Additionally, in April 2014 there has been a consultation meeting with experts from the Turkish State Railways in order to understand the latest progress in HSR investments. In addition, technical reports and maps were obtained from the Ministry in order to have detailed information about the investments.

4.2.2. Selection of Cases and Research Area

In order to identify the possible shift from road and air transportation to rail, a sample group was selected among the cities which has HSR project in planning stage. During the environmental impact assessment process, which was conducted by the Ministry of Environment and Urbanization, public participation meetings were organized in each city where a HSR investment was being planned. These meetings provided an opportunity to carry out a questionnaire with the potential users of the HSR. In the scope of the public participation procedure of these 4 projects, announcements were made with the help of written and visual media tools such as newspapers and internet. Then, during the meeting, questionnaires were distributed to the participants who attended the meetings. Projects that are

included in this study and the cities that the survey was conducted are listed in the table below.

Table 4.1.HSR Linesthat the Questionnaire was Implemented for

Number	HSR Line	Cities that the questionnaire was conducted	Dates of Public Participation Meetings
1	**Line 1:**Sincan Çayırhan-İstanbul HSR Line (questionnaire was conducted for Ankara-Kocaeli Section of the line)	Ankara, Sakarya, Bolu, Kocaeli	19/02/2013 20/02/2013
2	**Line 2:**Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line	Antalya, Konya, Aksaray, Nevşehir, Kayseri	20/11/2012 21/11/2012 22/11/2012
3	**Line 3:**Kırşehir-Aksaray-Ulukışla HSR Line	Kırşehir, Aksaray, Konya, Niğde	27/11/2012 28/11/2012
4	**Line 4:** Erzincan-Diyarbakır-MardinHSR Line	Erzincan, Tunceli, Elazığ, Diyarbakır, Mardin	07/05/2013 08/05/2013 09/05/2013

4.2.3. Questionnaire Design

The questionnaire, which was designed to understand the potential HSR users' travel behaviour and preferences, is given as Appendix 1. The questions were designed to reveal how people perceive the high-speed railway and how their travel behaviors are likely to change with respect to their attitude to travel time savings and monetary costs associated with different modes of transport. In the scope of the questionnaire, the following information was tried to be obtained:

1. Current transport behaviors in terms of travel time, cost, reliability, punctuality and comfort
2. Mode choices according to different transport purposes
3. Experience of using HSR previously
4. Willingness to pay for HSR

In order to gather information about the topics that are given above, the questionnaire was designed in two sections:personal and socio-demographic characteristics and intercity travel evaluation. The first section includes questions that gather information about the potential passenger's personal and socio-economical characteristics. These include the city that the person lives in, occupation, age, gender and monthly income level (see Figure 4.1).

Figure 4.1. Socio-Demographic Qustions (1st Section of the Questionnaire)

In the second section of the questionnaire 5 questions were asked. The questions are given as Figure 4.2.

1. Could you please indicate which of the following criteria are important for you in intercity transportation by marking the degree of importance?

	Very Important	Relatively Important	Not Very Important	Not Important at all
Travel Time				
Cost				
Safety				
Punctuality				
Comfort				
Environmental Sensitivity				

2. Can you please indicate the modes that you use for intercity transportation according to purpose/type?

Work	Tourism/Recreation	Other
a. Private Car b. Bus c. Railway d. Airway	a. Private Car b. Bus c. Railway d. Airway	a. Private Car b. Bus c. Railway d. Airway

3. Did you ever travel by high speed railway Eskişehir-Ankara and Ankara-Konya) which have been currently operating?

a. Yes
b. No

4. If a high speed railway system begin to operate in the city that you are living in, would you use it for intercity transportation? (provided that it goes to your destination)

a. Yes
b. No

5. Under which of the following pricing conditions would you prefer using high speed railways?

	Prefer	Not Sure	Not Prefer
If high speed railway price is more than bus , do you prefer high speed railway instead of bus?			
If high speed railway price is equal to bus , do you prefer high speed railway instead of bus?			
If high speed railway price is less than bus , do you prefer high speed railway instead of bus?			

Figure 4.2. Intercity Transportation Related Questions (2nd Section of Questionnaire)

In the survey study, a sample size of 212 participants among people living in close proximity to the HSR investments reached.

4.2.4. Assessment of the Questionnaire Responses

In order to evaluate questionnaire responses, each question and answer in both two sections are coded to ease the evaluation. For example, gender question's answer was coded with code 1 given to the answer "Female" and code 2 to "Male".

Questionnaire results were analyzed using SPSS. Descriptive analysis; frequency and cross-tabs are used to analyze questionnaire outcomes. It was aimed to generate analysis of frequencies and percentages of responses and finding the relationships between different responses.

In the scope of the study, perceptions of potential users about the new HSR investments and the likelihood of changing transportation patterns and mode choices toward HSRs are evaluated. In the following chapter all the questions' results will be given by implementing descriptive analysis. Especially, in order to determine possible modal shifts, the questions related with current mode of choices and price sensitivity will be compared with socio-demographic characteristics.

CHAPTER 5

ANALYSIS OF HSR INVESTMENTS IN TURKEY FROM THE PERSPECTIVE OF POTENTIAL USERS: QUESTIONNAIRE RESULTS

As described in the previous chapters, a questionnaire was designed for potential HSR users and conducted to 212 people, who live in the cities in close proximity to the planned HSR investments. This chapter is dedicated to the analysis of the survey results, and it is divided into three main sections. Firstly, participant profile and their general travel behavior characteristics will be presented. Secondly, an overall evaluation of the responses of the participants from all four HSR project areas will be made. Finally, evaluation for each HSR project will be made separately. In the latter section, only those project-specific issues will be given in detail.

5.1.Participant Profile and General Travel Behavior

5.1.1. Participant Profile

The questionnaire was conducted with 166 male and 46 female respondents, a total of 212 people, where majority of the participants were male (78%).As described in Chapter 4, respondents were grouped according to their monthly income levels as:

- "very low" for the interval of 500TL-1000TL,
- "low" for the interval of 1000TL-2000TL, and
- "middle" for monthly incomes more than 2000TL.

Assuming a currency rate of 2.1304 USD/TL (Central Bank of the Republic of Turkey,18/07/2014), these intervals correspond approximately to:

- "very low" income level of 236-471
- "low" income level of about 471-943, and
- "middle" income level as more than about 943$.

According to this classification, 52 (24.5%) of the respondents are in very low income group whereas 40 (18.9%) are in low income group, and the remaining majority 120 (56.6%) are in the middle income group (see Table 5.1).

The distribution of the participants by the HSR lines was almost equal, except for the Line 3 for which there were only 26 people interviewed. As it was explained in detail in Chapter 4, one of the main limitations of this survey study is dependence on the public participation meetings where people were invited to be informed about the HSR project. In the meeting for Line 3, the number of participation was very low (see Table 5.1).

Questionnaires were conducted in 16 cities. Two meetings for Konya and Aksaray were organized because they were the cities that two different HSR projects (Line 2 and Line 3) were planned. As the environmental impact assessment procedure requires, for each different project, it is obligatory to organize independent public participant meetings. There was a higher representation from the cities of Elazığ, Konya, Ankara and Bolu in the survey sample. It depends on the number of attendees in the public participation meetings. In addition, for Konya it was expected to be higher because of the reason explained above.

In terms of previous HSR experience, 36 respondents had prior HSR experience, while 176 (83%) did not. In the cities that the questionnaire was conducted, only Ankara and Konya have existing HSR lines. Therefore, in these areas it is expected to reach people who had previous HSR experience (see Table 5.1).

Table 5.1. Socio-Demographic Profile of Respondents

	Number	**%**
Total no. of participants	**212**	**100.00**
By Gender		
Male	166	78.3
Female	46	21.7
By Income Level		
(500TL-1000TL)Very Low	52	24.5
(1000TL-2000TL)Low	40	18.9
(>2000TL)Middle	120	56.6
By HSR Line		
Line 1	57	26.7
Line 2	64	30.1
Line 3	26	12.6
Line 4	65	30.6
By City		
Ankara	22	10.4
Bolu	21	10.0
Sakarya	10	4.7
Kocaeli	8	3.8
Antalya	19	9.0
Konya	24	11.3
Aksaray	8	3.8
Nevşehir	11	5.1
Kayseri	3	1.4
Kırşehir	14	6.6
Niğde	7	3.3
Erzincan	1	0.5
Tunceli	9	4.2
Elazığ	31	14.6
Diyarbakır	15	7.0
Mardin	9	4.2
By HSR Experience		
Previous experience	36	17.0
No experience	176	83.0

5.1.2. Personal Priorities for Travel Characteristics among the Respondents

As this thesis aims to evaluate potential shifts to rail from road transport, mode choice behavior is an important part of the evaluation of the potential users. A better understanding of the factors behind mode choice requires having information about socio-demographic characteristics of the traveler, their trip purpose, as well as travel time and costs because the expected shift from road transportation to railway is directly related with travel behavior of the passenger (Corpuz, 2007).Therefore, to understand the effect of mode-specific characteristics on intercity travel behavior of people, questions regarding the following issues were asked:

- travel time,
- cost,
- safety,
- punctuality,
- comfort and
- environmental sensitivity

The respondents were requested to rank these aspects by degree of importance:

1. “very important”,
2. “relatively important”,
3. “not much important” and
4. “not important at all”.

Analysis of the results (see Figure 5.1) showed that for each one of these aspects, the majority of the respondents (with at least 55.2% for the cost of the mode) chose the option of “very important”, but for some aspects, the percentage of those who find it very important is higher than for others. Safety of the transportation mode is the most important concern for83.5% of the respondents. Secondly, travel time is the aspect found very important by 77.4 % while comfort

is also considered very important by 70.3%. Punctuality is seen as very important by 66.5%. Lastly 62.7% of the respondents stated that it is very important that a transport mode is environmentally sensitive.

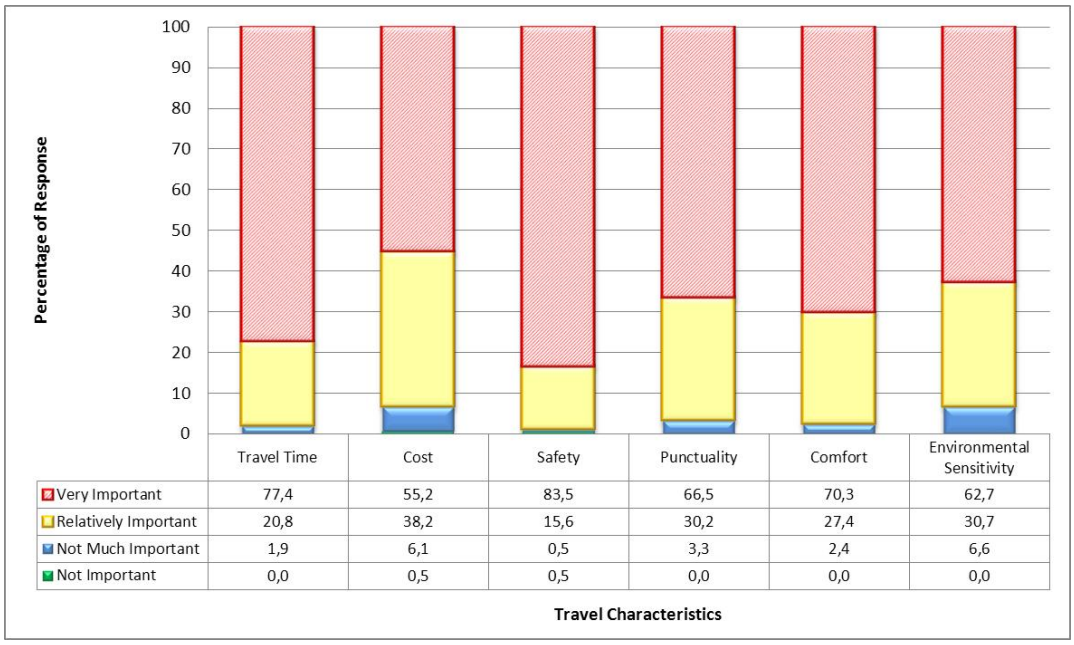


Figure 5.1. Percentage of Personal Priorities for Travel Characteristics

The same analyses were also performed for respondents from each HSR project, for which the results are presented below:

Analysis of Respondents from Line 1: Sincan-Çayırhan-İstanbul HSR Line

According to the questionnaire results, as in overall analysis covering all four projects' questionnaires, safety is a major concern for respondents from Line 1 too. 82.5% of the respondents stated that safety is a very important characteristic for intercity trips. Respectively, travel time, comfort, environmental sensitivity, punctuality and lastly the aspect of cost follow up the concern of safety. Compared to other aspects, only 56.1% of the respondents found cost as a very important aspect in their intercity trips (see Figure 5.2).

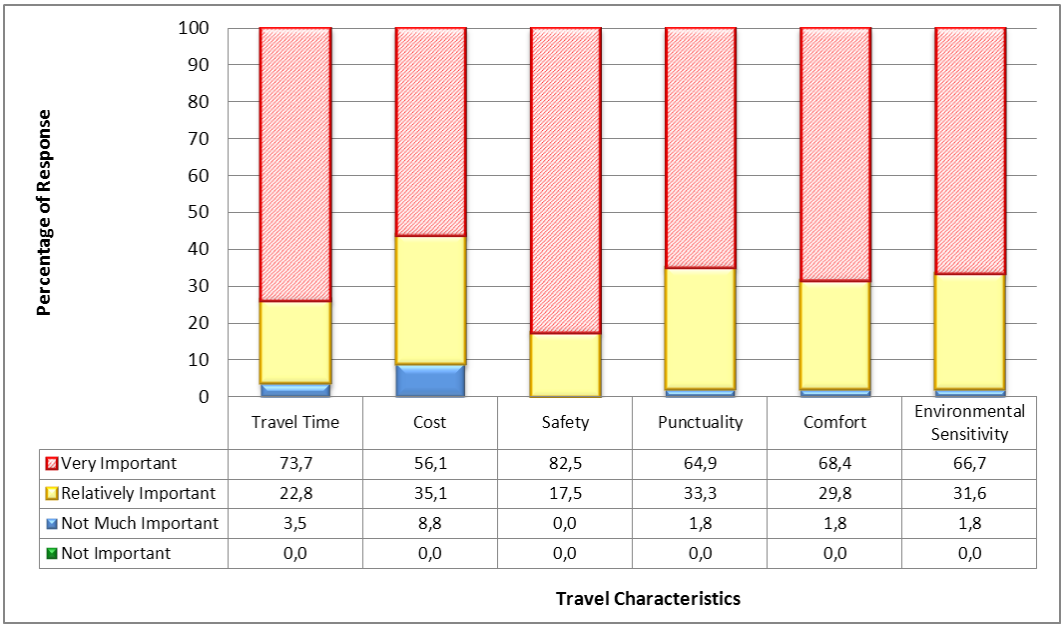


Figure 5.2. Percentage of Personal Priorities for Travel Characteristics (Line 1)

Analysis of Respondents from Line2: Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line

In the analysis performed for Line 2, safety is the major concern similar to the overall evaluation. However, the share of those who stated that a transport mode's being environmentally sensitive is very important (53.1%) is relatively low when compared with the overall analysis results. Consequently the share of those who said that a mode's being environmentally sensitive is not much important (18.8%) is higher when compared with overall results (see Figure 5.3).

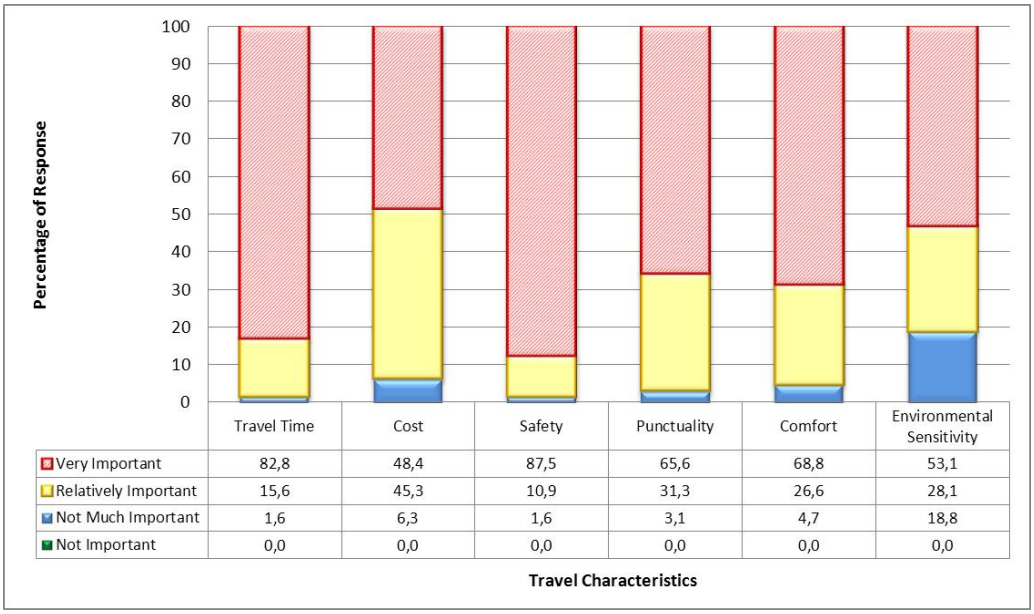


Figure 5.3. Percentage of Personal Priorities for Travel Characteristics (Line 2)

Analysis of Respondents from Line3: Kırşehir-Aksaray-Ulukışla HSR Line

For Line 3, the most striking result is that the share of those who state that a transport mode's being environmentally sensitive is less than both the overall evaluation and the other projects. 50% of the respondents said that a mode's being environmentally sensitive was "very important" while in the overall analysis this share was 62.7% (see Figure 5.4).

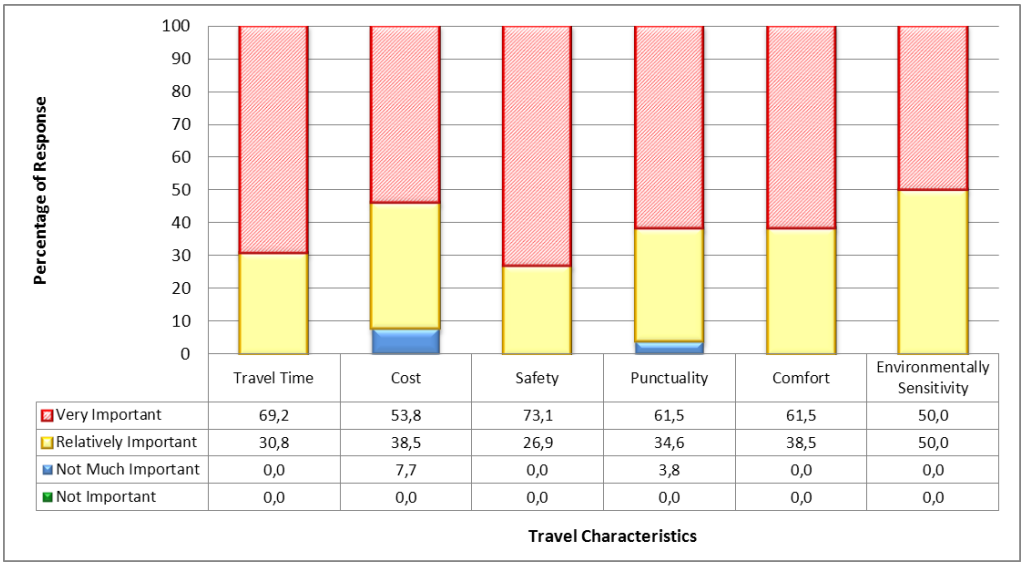


Figure 5.4. Percentage of Personal Priorities for Travel Characteristics (Line 3)

Analysis of Respondents from Line4: Erzincan-Diyarbakır-Mardin HSR Line

When the responses that are given to the 1st question are analyzed, there are similar results in comparison to the overall analysis(see Figure 5.5).While safety is found very important by 84.6% of respondents, a relatively lower ratio (61.5%) of the respondents stated that cost is very important.

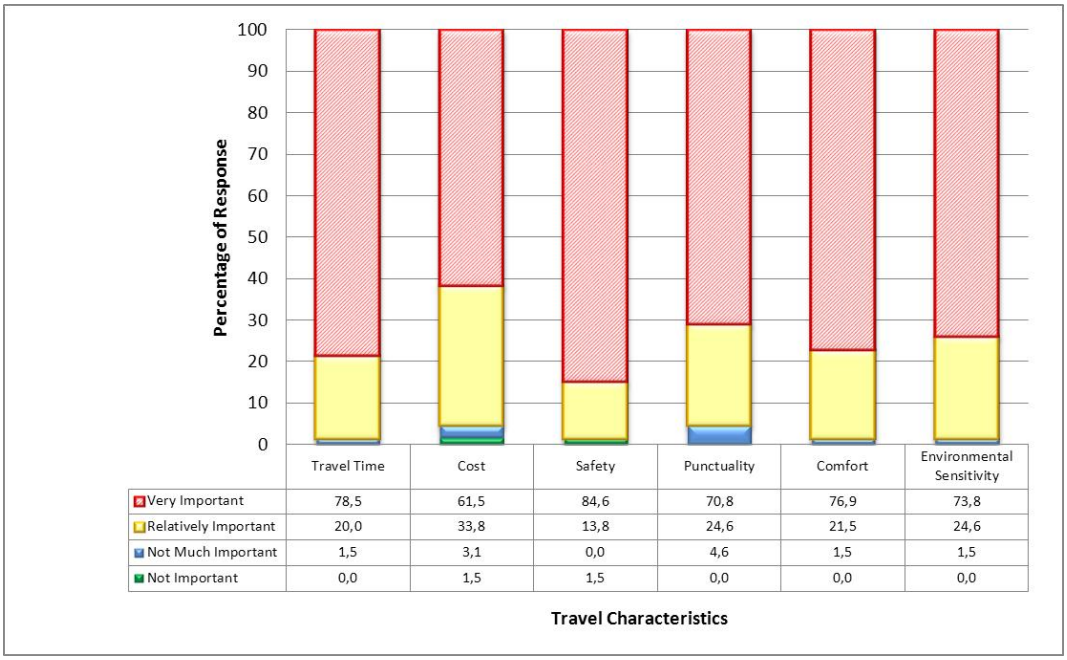


Figure 5.5. Percentage of Personal Priorities for Travel Characteristics (Line 4)

5.1.3. Variation of Travel Characteristics based on Income Level

While "safety" was stated to be the most important factor by more correspondents when compared to "cost", the significance of cost parameter in intercity travel may also be related to the income level of the population. For a more in-depth analysis, the variation of the importance of "cost" parameter according to different levels of income is evaluated by using the overall data (see Figure 5.6). As can be expected from the participant profile (with majority of them in the middle-high

income level), the relatively higher income level people found the cost parameter "not important".

In order to understand the relationship between income and travel time, variation of "travel time" parameter according to different income levels is analyzed. As the amount of monthly income that the respondents get increases, the importance of travel time for intercity trips increases. As it is seen in the Figure 5.7, 52% of the respondents who stated that travel time is "very important" are in middle income level whereas 17% of them in low income and 31% of them in very low income.

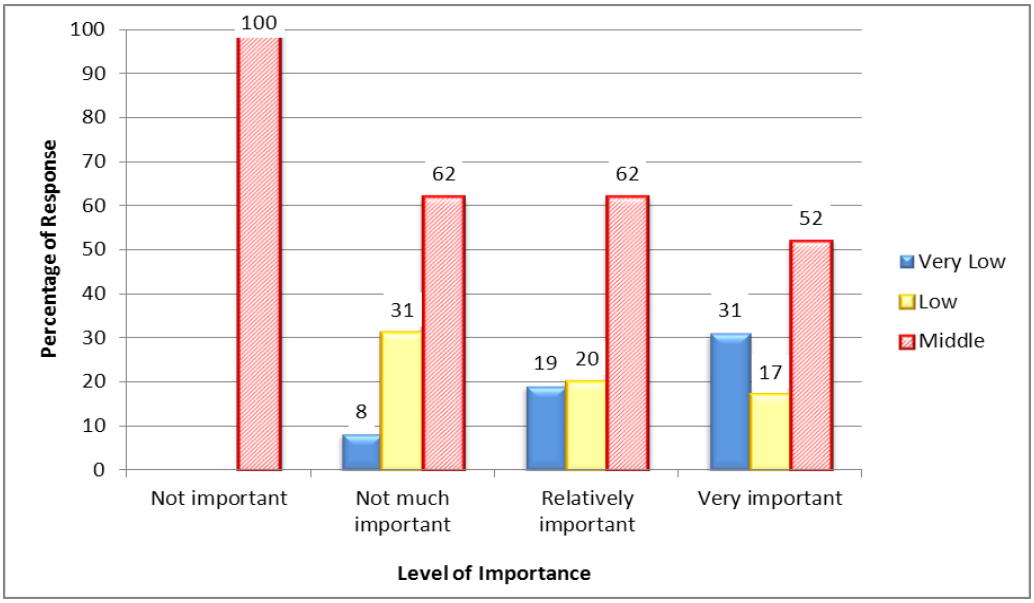


Figure 5.6. Variation of Importance of Cost Aspect among Different Income Levels

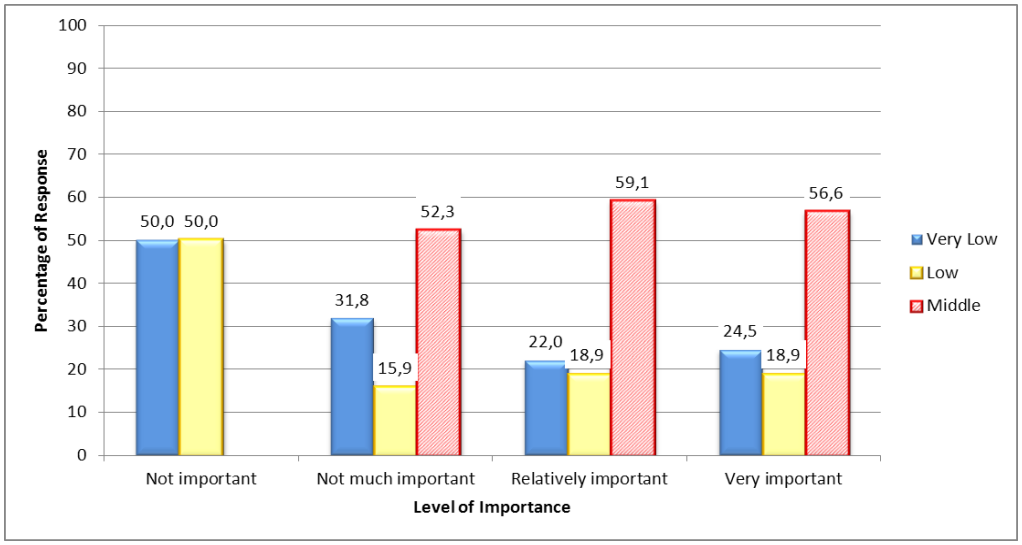


Figure 5.7. Variation of Importance of Travel Time Aspect among Different Income Levels

When the relationship between income level of respondents and their responses to the importance of environmental sensitivity is analyzed, it is seen that nobody claimed that environmental sensitivity is "not important". In addition, it can be stated that middle income level people are more sensitive to transport being environmentally not damaging (see Figure 5.8). This might be due to education and awareness level.

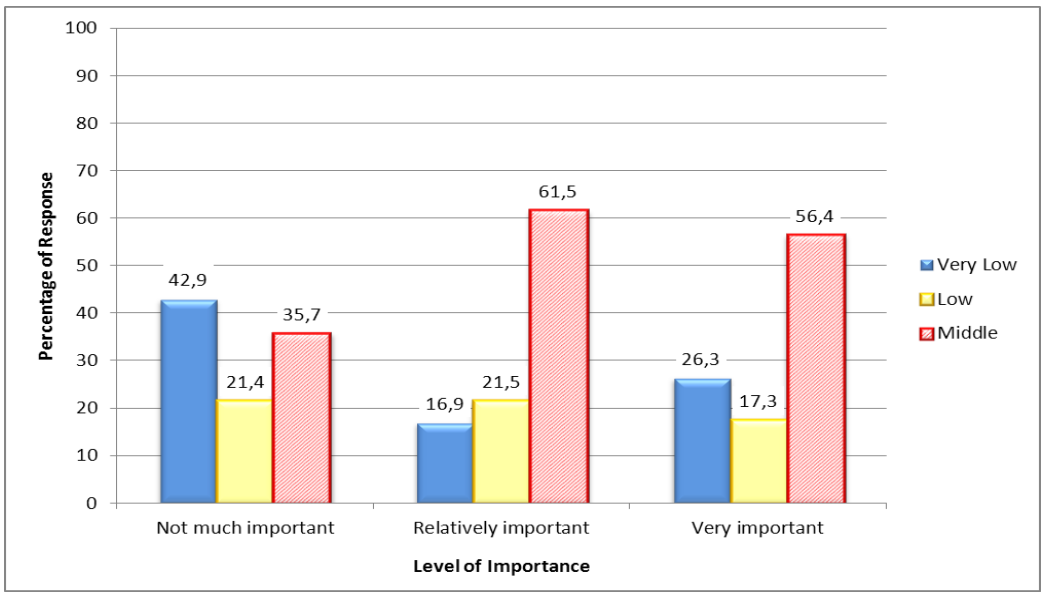


Figure 5.8. Variation of Importance of Environmental Sensitivity Aspect among Different Income Levels

5.1.4. Mode Choice Characteristics of the Respondents

Respondents were also asked to state their mode choice for their intercity trips. Three different trip purpose categories were given:

- work/business,
- tourism and
- other (which is further detailed by the respondent).

Other category is answered by almost all the respondents; some gave further explanation for other trip purposes such as visiting relatives/friends. Although visiting a friend could be accepted as a type of a "tourism" trip, the responses revealed that people used the "tourism" in a narrower meaning where they go to a place for sightseeing and vacation.

For each category, respondents were asked to choose only one mode from the options of:

- private car
- bus
- railway
- airway

At this point, it is important to look at the availability of these modes in the studied cities. Intercity buses and private cars are available modes in all the cities. There are 10 airports in the 16 cities included in the case study areas. Considering the proximity to an existing airport (up to 2 hour drive), 14 cities could be assumed to have airway option too. The 28 respondents from the remaining 2 cities (Bolu and Niğde) may not have airway options, but due to their small share in the sample, they are not studied separately. In terms of railway option of respondents, 11 cities have an existing railway infrastructure while 2 of them (Ankara and Konya) have currently operating HSR lines. The 71 respondents could be assumed not to have railway option. It should be noted that, as it was

mentioned in previous chapters there is a very limited railway network in Turkey. The existence of railway network in the city does not mean that it could be an alternative for travelers because current railway network is not sufficient to meet the demand in terms of providing opportunity to reach all desired destinations.

For the intercity work/business trips, the majority (41.5%) of people preferred intercity bus transportation, and 28.8% of people use private car. It is clear that road transportation is the most dominant transportation system in intercity tripsfor work purpose. Airways also have an important share (20.8%) in intercity trips forwork/business purpose.

As for tourism trips, the usage of intercity buses and private cars are equal with 38.7% shares. Usage of airways for tourism trips (13.7%) is less than that for work/business trips (20,8%). As it is seen, private car share is more than that in work/business purpose trips, possibly because those kinds of trips are planned according to the business type and working conditions. For the tourism trips, people are free to choose their trip modes by themselves and it seen that (see Figure 5.9) tourism trips are mostly performed by road transportation (private car and bus).

Railway transportation has a share of 9%for both tourism and work trips, which is very low compared to other available modes. As it is mentioned in previous chapters, railway has a share of 3% for passenger transport in Turkey which has been declining since the 1950s. Furthermore, current railway network is not well maintained, frequent, fast and comfortable enough, so all these result in people choosing to use other transport modes. Thus, it could be stated that the low share of railway for the study area is an expected result. According to the figure, bus and private car shares for the trips that are not included in work or tourism categories are relatively high compared to railway and air transport (see Figure 5.9).

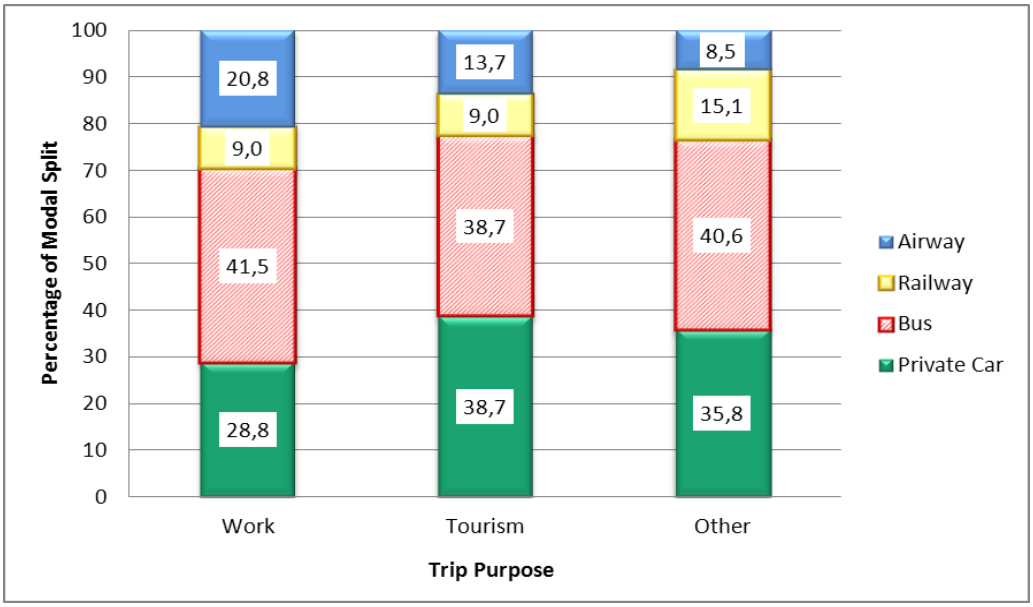


Figure 5.9. Modal Split for Each Different Trip Purposes

Analysis of Respondents from Line 1: Sincan-Çayırhan-İstanbul HSR Line

According to Figure 5.10which shows the modal share of respondents, bus transportation has a remarkable share among other modes. In contrast to the overall evaluation, air transportation has a share of only 3.5% for all trip purposes, which is not a remarkable share among other modes. Especially in metropolitan cities like Ankara and İstanbul, accessibility to the airports which are located in the periphery of cities takes time and it has an extra cost for passengers. For example, between Ankara and İstanbul travel time is 1hour (in-vehicle time) by air and it increases to 4 or 4.5 hours when accessing the airports and waiting at the airports are included.

In this particular region, the share of those who stated that they use private cars for their inter-city travel is slightly higher than those found in the overall analysis. This is particularly the case for work/business trips. Share of railway usage is low when compared to road transport usage. Currently there is an existing conventional railway between Ankara and İstanbul. However, it has not been operated for 2 years because of the construction of Ankara-İstanbul HSR, which is

the extension of the current Ankara-Eskişehir High Speed Rail line. After Ankara-Eskişehir-İstanbul HSR is completed, for which the Eskişehir-Gebze section is opened recently in July 2014, the share of railway may be expected to increase.

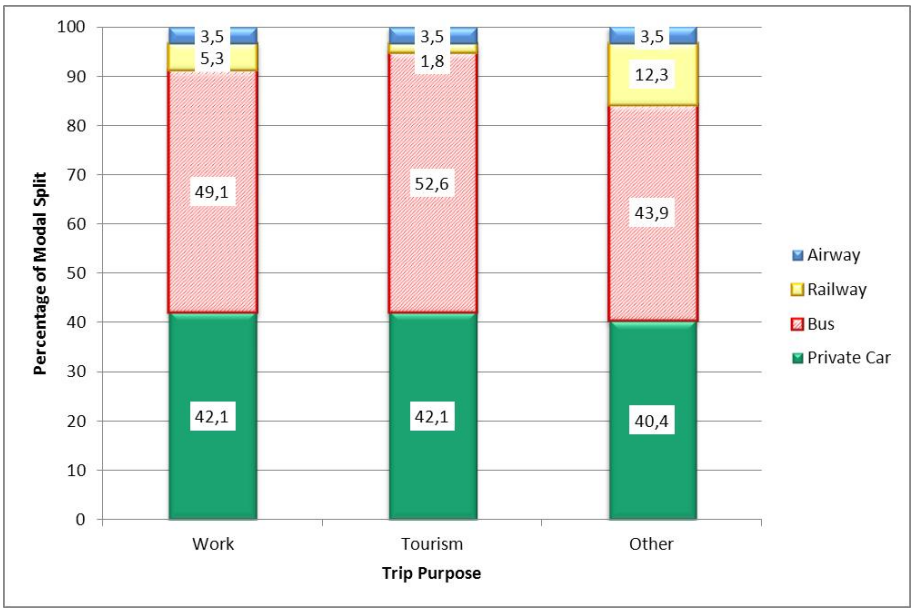


Figure 5.10. Modal Split for Each Different Trip Purposes (Line 1)

Analysis of Respondents from Line2: Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line

As Figure 5.11 shows, mode choice of the respondents living in these cities shows similar characteristics with the overall evaluation. While, bus is the most preferred mode in work/business trips, private car has a remarkable share in tourism trips. Share of work/business trips made by airways is lower in this region when compared with the overall sample.

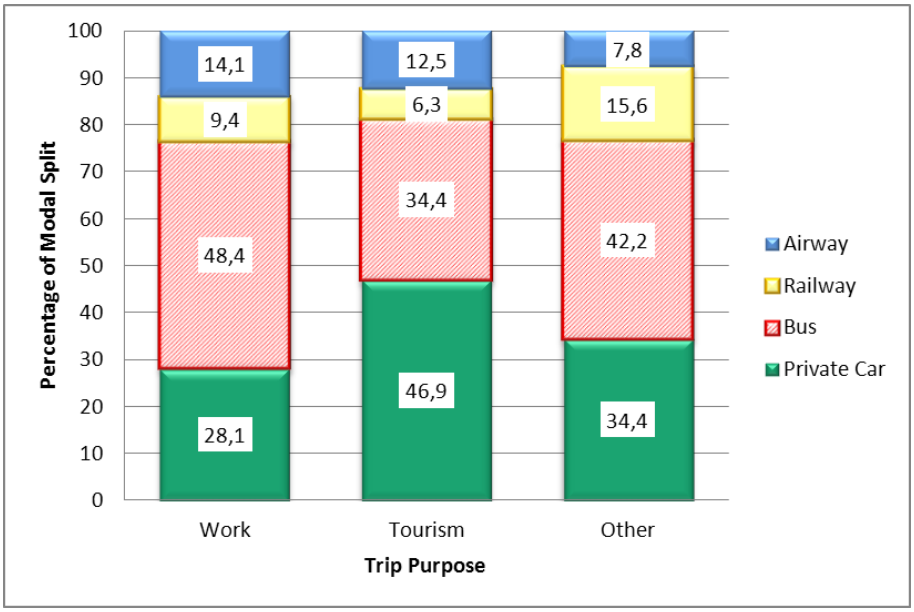


Figure 5.11. Modal Split for Each Different Trip Purposes (Line 2)

Analysis of Respondents from Line3: Kırşehir-Aksaray-Ulukışla HSR Line

In the region that the questionnaires were conducted, there are conventional railway lines that currently operate. Therefore, the share of railway usage is relatively high when compared with the overall analysis and the evaluation results of other projects (seeFigure5.12). However, despite the existing airports in the region, airway usage share is "0" for tourism and other trips. For work trips, however, 23.1% of the people travel by air.

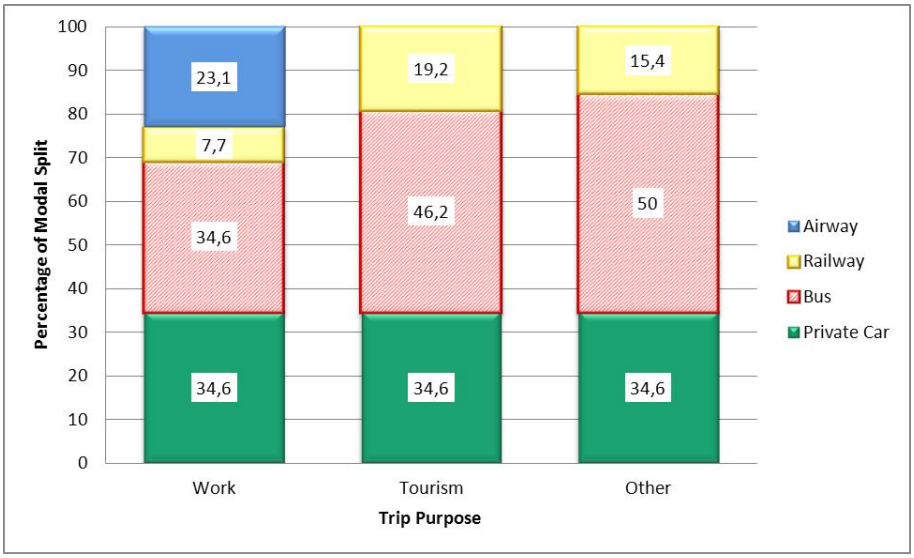


Figure 5.12. Modal Split for Each Different Trip Purposes (Line 3)

Analysis of Respondents from Line 4: Erzincan-Diyarbakır-Mardin HSR Line

In the region that the railway line is planned, trip purpose has a significant role in mode choice. When Figure 5.13 is analyzed, it is seen that airway is the dominant mode for work/business and tourism trips while private car is prevalent for other trips. One of the reasons for airway's being popular in this region may be the geographic location of the cities. Unlike in Middle Anatolian Region, it takes long time to travel to many cities of Turkey by road transportation from the East and Southeast side of the country. For example; if it is assumed that Ankara and İstanbul are major business centers, trip time exceeds 10 hours by road transportation. In contrast to the overall evaluation, railway has a considerable share in this project area because of the existing conventional lines operating in this region.

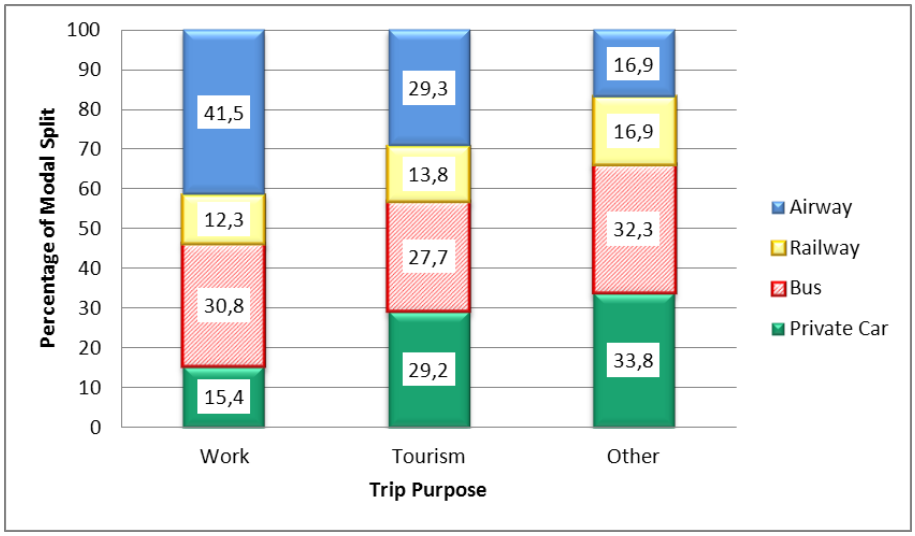


Figure 5.13. Modal Split for Each Different Trip Purposes (Line 4)

5.2.Overall Evaluation of HSR Potential Usage

In the questionnaire, the respondents were asked whether they have ever travelled by the HSR systems; Eskişehir-Ankara, Ankara-Konya and Konya Eskişehir which are currently operating**.** According to the results, the majority of people (83%) have not used the HSR as a mode in their intercity trips (see Table 5.2). Amongst the places where the questionnaires were conducted, only Ankara and Konya have an option to use HSR for intercity transport mode. Therefore, it could be said that the outcome of this question is not surprising.

The respondents were also asked the following question:**"If a HSR system begins to operate in the city that you are living in, would you use it for intercity transportation? (Provided that it goes to your destination)"**.99.1% of the respondents is willing to use HSR if there is that option in their cities (see Table 5.2).

Table 5.2. Potential Usage of HSR

Total participant	**Number**	**%**				
	212	**100.00**				
Potential HRS Usage						
	Previous Experience (N=36)		**No Previous Experience (N=176)**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Yes	35	16.7	175	83.3	210	100.0
No	1	50.0	1	50.0	2	100.0

The above question showed that the respondents have a positive perception for high speed rail system and almost all of them would use this system if there was a connection in close proximity to where they live, provided that the system offers access to their desired destination. Because of this result, no comparisons are necessary with other information, such as those who use air transport for example. It is clear that almost all respondents would generally be willing to use high speed rail systems.

This is a general statement however; and it may change according to the pricing policy for high speed rail systems. It is necessary therefore to understand travel patterns and its variation according to economic factors in order to forecast future travel decisions and mode choice of travelers. For decision makers pricing decision of the new transport alternative is one of the most important parts of the operation process and it is a crucial factor to create a shift from other modes. Therefore, as another question the respondents were asked under which pricing condition they were most likely to use HSR systems. This was asked to determine the price impact on the usage of HSR. The question was divided into three parts in terms of price levels. The levels were set so that people can compare with HSR price and bus price. Therefore, all HSR price levels are relative to bus ticket price. In addition, in the graphical representations HSR ticket price is defined as “P”.

According to the results of the questionnaires, 53.8% of the people said that they would prefer HSR even if its ticket price is more than bus ticket prices while 17.9% of them stated that they would not prefer it under those conditions. About 28% were not sure. This means that if HSRs are more expensive than buses, then almost half of the respondents may not consider using this system.

In the case of HSR ticket prices and bus ticket prices being equal to each other, 86.8% of the people said that they would prefer HSR. If railway ticket price is less than that of the bus, 99% of the people stated that they would prefer railway (see Figure 5.14). Although, in the first question, which was about the importance of different travel parameters, the parameter of cost has been seen as "very important" by only 55.2% of the respondents, replies to this question shows that cost parameter has an impact on mode choice.

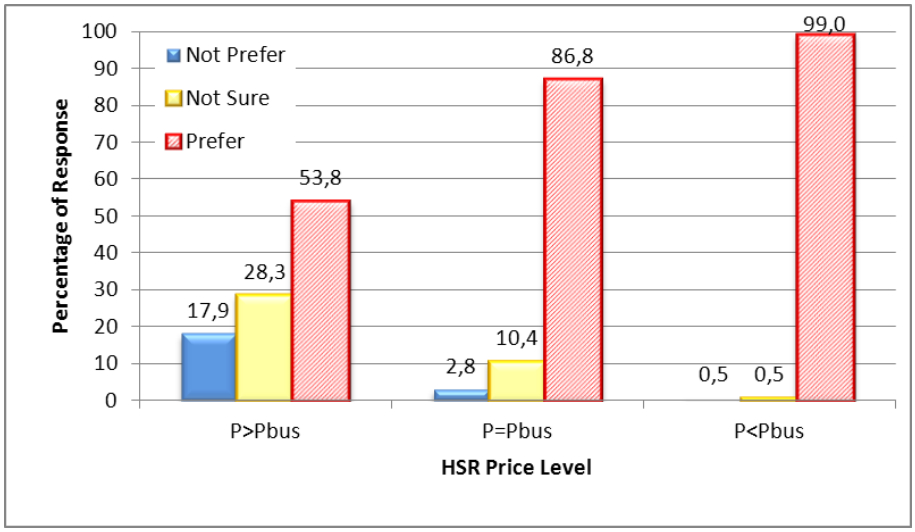
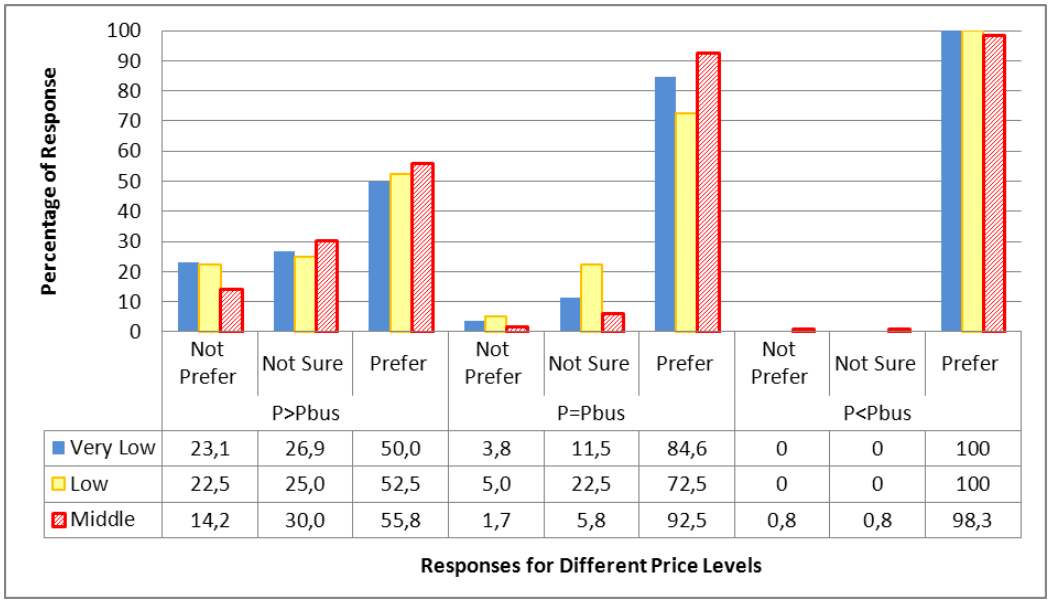


Figure 5.14. Preferability of HSR for Different Price Levels (P_{HSR}/P_{Bus})

According to the results, cost may be a significant parameter which affects the mode choice in travel; however, it is important to see its relation with different income levels as well as the past experiences of people regarding their usage of a HSR system in the past. In order to understand the influence of different income levels on the stated preference of modes with regards to their relative costs, a number of cross tabulation analyses were made between the replies to "income"

and “pricing conditions”. Clearly, income factor influences mode choice and as it is mentioned above, cost of the new alternative will affect the decision about it. If the price which is set for HSR is more than the bus price, 23.1% of the respondents who have very low income claimed that they will not prefer it. In addition, 22.5% of the low income and 14.2% of middle income respondents said that they would not prefer it. The finding shows that if high speed rail tickets are more expensive than bus tickets, then almost one fourth of the lower income users may not prefer this. When those who stated that they were not sure are added to this, the ratio increases (see Figure 5.15).



	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer
	P>Pbus			P=Pbus			P<Pbus		
Very Low	23,1	26,9	50,0	3,8	11,5	84,6	0	0	100
Low	22,5	25,0	52,5	5,0	22,5	72,5	0	0	100
Middle	14,2	30,0	55,8	1,7	5,8	92,5	0,8	0,8	98,3

Figure 5.15. Preferability of HSR for Different Income and Price Levels (P_{HSR}/P_{Bus})

According to Figure 5.16**,** only a small percentage of respondents said that they would not prefer HSR if its price is equal to the bus price. The analysis shows that there is not much difference in this result when a comparison is made between different levels of income groups. Bus is one of the conventional transportation modes that serve almost every city and town. Therefore, for those who do not have a private car, it is already an intercity transportation mode alternative that has the least cost among other alternatives. Therefore, the result, which is shown in the figure, is expected because, if prices are equal, people tend to think that

railway will be a good choice in terms of travel time concern. If the HSR ticket price is less than the bus ticket price, it is seen that almost 100% of the respondents would prefer HSR.

As mentioned before, it was considered important to look at the impact of previous HSR experience on the cost-related preferences. HSR is considered as a new alternative for Turkey and currently it operates just in few cities. Therefore, the number of people who had an opportunity to experience is still low throughout Turkey. However, according to the outcome that was created with cross tabulation, there is not much difference between the people who have experienced HSR in the past and those who have not experienced it before (see Figure 5.16). The results are very close to each other and it appears that regardless of whether or not they used HSRs before, about half of the respondents would prefer using railways even if it is more expensive than buses, whereas the remaining half is either not sure or not keen on using it in such a pricing condition.

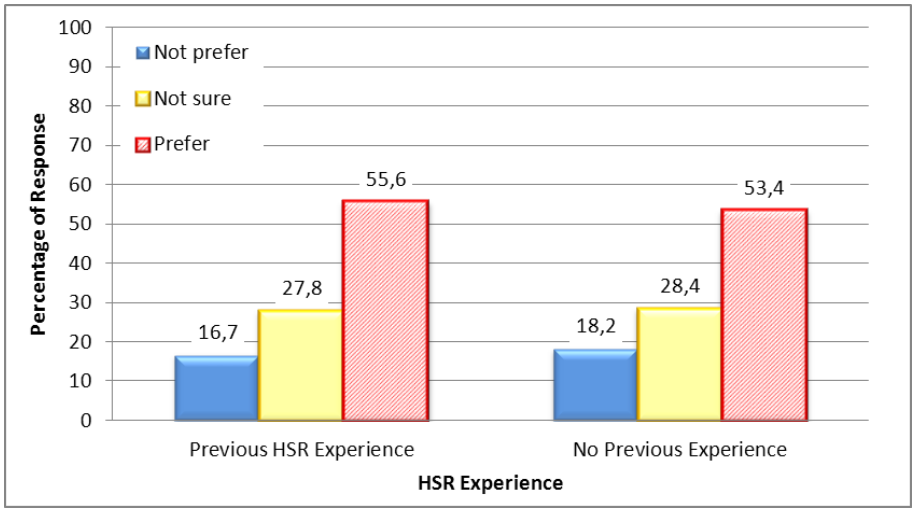


Figure 5.16. Impact of the Previous HSR Experience on Potential HSR Usage, if P_{HSR}/P_{Bus}

As it was mentioned before, road transport is the dominant sector in passenger transport in Turkey and therefore any high-speed railway investment must help attract users from road transport to railways. In other words, the study aims to

analyze the potential shifts from road transport to HSR, and hence road transport users' point of view in terms of the pricing of HSR is seen as significant to evaluate. In which pricing condition the shift could be successfully achieved is a main question that is tried to be answered in the scope of this study. Therefore, the cross tabulation analysis is made between road transport users for different purposes and pricing conditions.

In the questionnaire, there were private car and bus as alternatives for road transportation. People who currently use road transport for work, tourism and other purposes are analyzed to determine whether or not they will change their travel behavior towards HSRs and under what pricing conditions this is more likely to happen. Table 5.3 and Figure 5.17show the percentages of road transport users HSR preference for different price levels. About half of the bus users said that they would prefer HSRs if its ticket price was higher than the bus, indicating that the other half is reluctant to use HSRs if its price is higher than bus tickets. The shares of those who are reluctant are slightly more in the case of private car users.

The majority of private car and bus users (more than 80%) state that they would prefer using HSR if HSR ticket price and bus price are equal to each other. Private car users are slightly more supportive of high speed rail systems in this pricing scenario, indicating that if the prices are equal, a private car user would rather make a trip with HSRs than with inter-city buses. In the case that the price of HSR is less than bus ticket prices, it is seen that almost all private car and bus users state that they would prefer HSRs over buses (see Table 5.3 and Figure 5.17).

Table 5.3. Percentage of Road Transport User's HSR Preference for Different Price Levels

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$					
Work	Private Car	21.3	29.5	49.2	100.0
	Bus	20.5	28.4	51.1	100.0
Tourism	Private Car	19.5	35.4	45.1	100.0
	Bus	22.0	24.4	53.7	100.0
Other	Private Car	21.1	31.6	47.4	100.0
	Bus	19.8	30.2	50.0	100.0
$P=P_{bus}$					
Work	Private Car	1.6	9.8	88.5	100.0
	Bus	3.4	12.5	84.1	100.0
Tourism	Private Car	4.9	7.3	87.8	100.0
	Bus	2.4	13.4	84.1	100.0
Other	Private Car	2.6	9.2	88.2	100.0
	Bus	2.3	11.6	86.0	100.0
$P<P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	1.1	0.0	98.9	100.0
Tourism	Private Car	0.0	1.2	98.8	100.0
	Bus	1.2	0.0	98.8	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	1.2	1.1	97.7	100.0

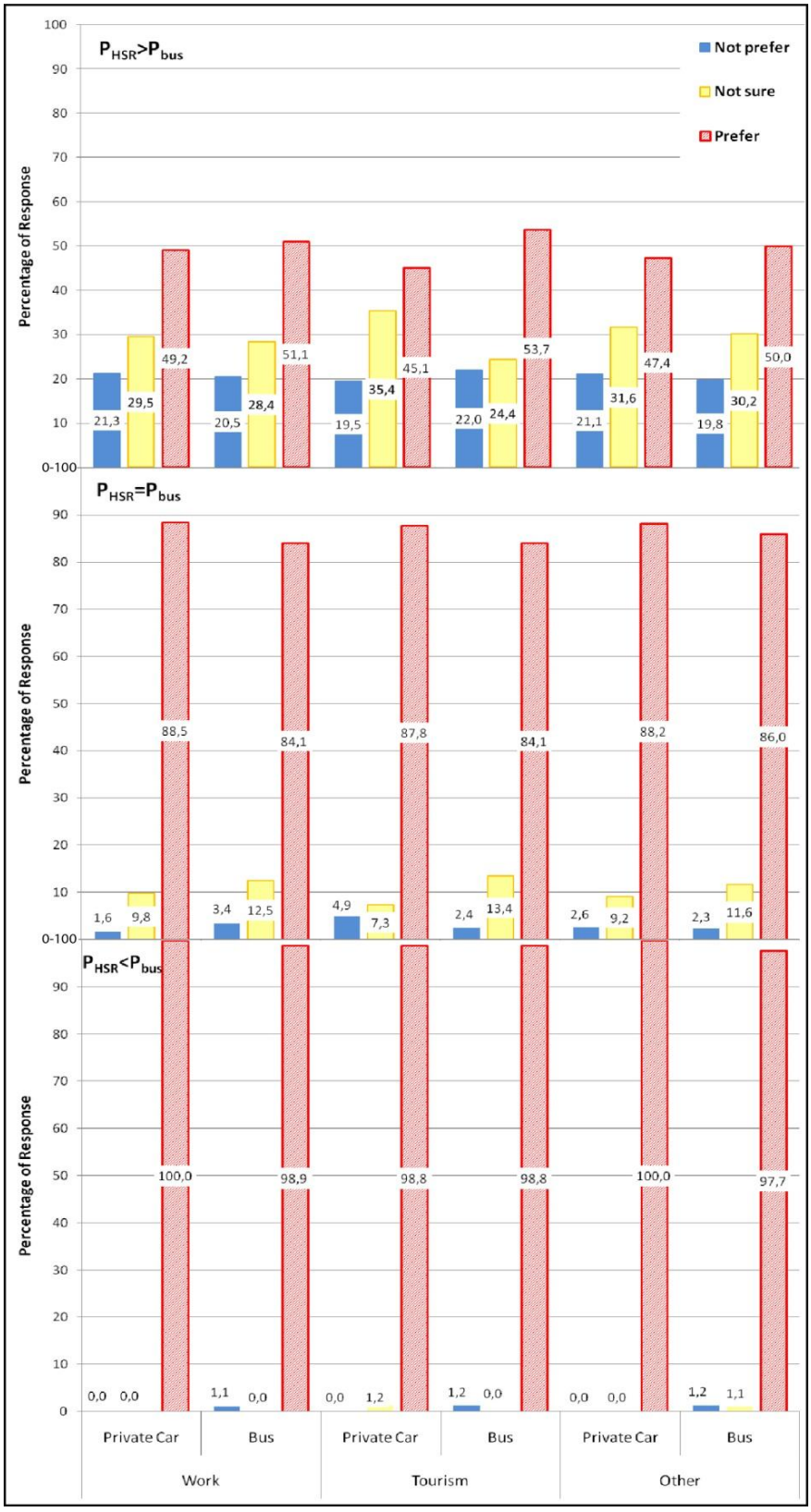


Figure 5.17. Preference Percentage of Road Transport (Bus & Private Car) Users for Different HSR Price Levels

5.3.Project Based Evaluation of Potential HSR Usage

In this section, questionnaire results, which were conducted for four different railway projects, will be given separately. However, the results that give similar inference with the overall analysis are excluded in this section. Instead, only those project-specific findings that significantly differ from the overall analysis are highlighted here.

5.3.1. Potential HSR Usage for Line 1

Sincan-Çayırhan-İstanbul Railway Project which is called as Line 1 is planned in the boundaries of five cities; Ankara, Bolu, Sakarya, Kocaeli and İstanbul. The cities are located in Middle Anatolian Region and Marmara Region. Questionnaires were conducted for Ankara-Kocaeli Section of the project and to 57 people in Ankara, Bolu, Sakarya and Kocaeli. One of the interesting outcomes in this analysis is that the share of people who traveled by HSRs in the past is lower than the expected share. This project area includes Ankara, which has two different HSR line connections that are currently operated. However, only 8.8% percent of the respondents have had a trip experience by HSR (see Table 5.4).

Table 5.4. Percentage of Potential HSR Usage and Previous HSR Experience for Line 1

Total participant	**Number**	**%**				
	57	**100.00**				
Potential HRS Usage						
	Previous Experience (N=36)		**No Previous Experience (N=176)**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Yes	5	8.8	52	91.2	57	100.0
No	0	0	0	0	0	0.0

According to Figure 5.18 that shows preferability of Line 1 for different price levels, when the results are compared with the overall analysis, it is seen that the sensitivity to the price of HRS being more than the price of buses is higher in this project area. If the ticket price of HSR is more than bus ticket prices, 29.8% of the respondents will not prefer HSR as an intercity transportation mode; and 24.6% are not sure, indicating they would be reluctant to use HSRs in this pricing scenario. In other words, less than 50% of the respondents in this region would consider using HSRs if their tickets are more expensive than buses. In the case that HSR ticket price is equal to the bus ticket price, still there are 21% who are not sure about using HSR, but 77% would prefer it over buses. If the price of HSR ticket is less than that of buses, all of the respondents would prefer HSR.

In contrast to the overall analysis, when the price of HSR is more than the bus price, the share of those who do not prefer using the HSR system is much more for this region. For all income levels, more than 20% of the respondents said that they would not prefer HSR in the condition of its price being more than bus price. This rate reaches 38.5% for those with the lowest income, showing that price policies will be important to attract this income group (see Figure 5.19). In the scenario where the price of HSR is equal to bus ticket prices, the results are very similar to the overall analysis. All of the respondents stated that they would prefer HSR as intercity transportation mode when the price of it is less than bus ticket prices regardless of income levels.

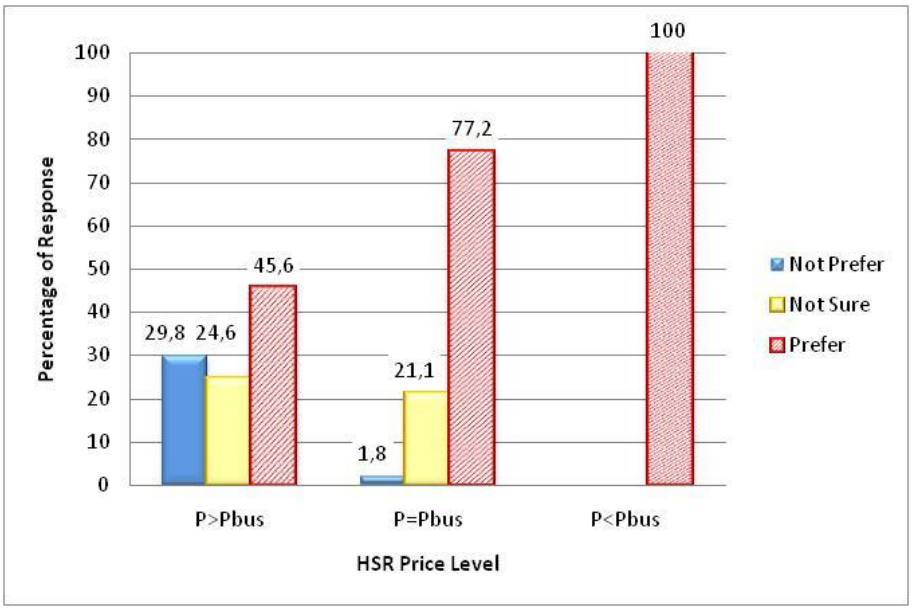
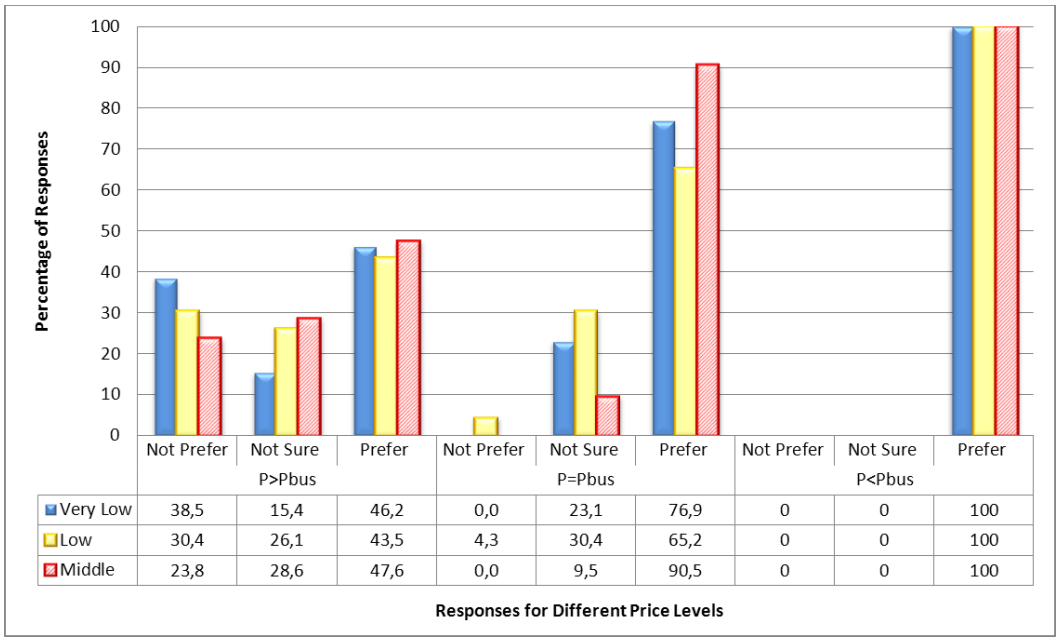


Figure 5.18. Preferability of Line 1 for Different Price Levels (P_{HSR}/P_{Bus})



	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer
	P>Pbus			P=Pbus			P<Pbus		
Very Low	38,5	15,4	46,2	0,0	23,1	76,9	0	0	100
Low	30,4	26,1	43,5	4,3	30,4	65,2	0	0	100
Middle	23,8	28,6	47,6	0,0	9,5	90,5	0	0	100

Figure 5.19. Preferability of Line 1 for Different Income and Price Levels (P_{HSR}/P_{Bus})

It is interesting that people, who have HSR experience before, are not willing to pay more as people who have not experienced HSR before. In the results of overall analysis, there was not much difference in terms of this question between the people who have experienced HSR in the past and those who did not. As

mentioned before, in the region that Line 1 is planned, price sensitivity is higher when compared with the overall sample (see Figure 5.20).

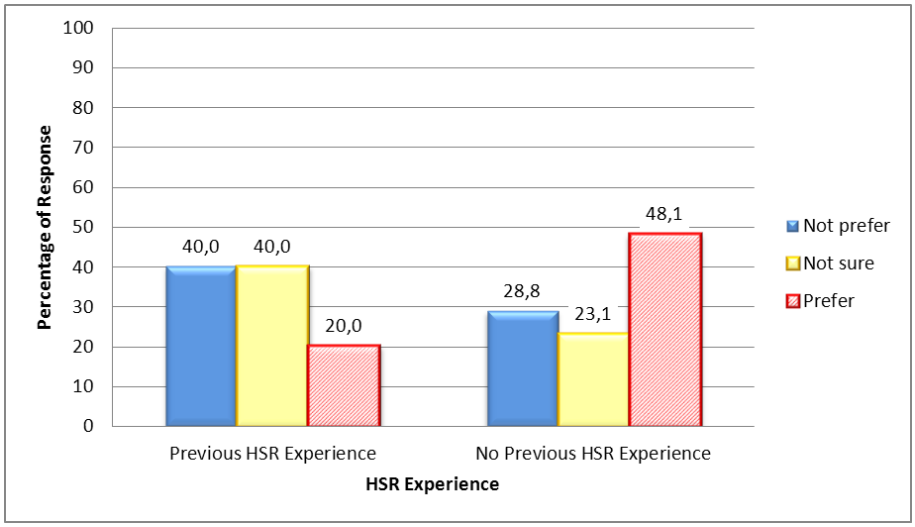


Figure 5.20. Impact of the Previous HSR Experience on Line 1 Usage if $P_{HSR}>P_{Bus}$

In order to assess whether there will be a shift from road to railway, people who prefer private car and bus in their intercity trips are analyzed according to their answer to the question of price levels. It is found that for people who currently use road transportation in their intercity trips pricing policy is important. When it is compared with the overall analysis, the share of people who do not prefer railway in the condition that the price of HSR is more than bus is relatively high.

In addition, it is seen that when HSR ticket price is higher than bus ticket price, 45.8% of private car users would use HSR for work/business trips, but they are less likely to use it for tourism and other trips. Apart from work trips, private car users are not as willing as bus users to choose HRS in the case of its tickets being more expensive than bus tickets. Under the condition of HSR ticket price is equal to bus ticket price, the preference ratios increase to 70% for both private car and bus users (see Table 5.5 and Figure 5.21). In addition, if the ticket price of HSR is determined as less than bus ticket price, all of the road transportation users are willing to use HSR.

Table 5.5. Percentage of Road Transport User's Line 1 Preference for Different Price Levels

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$					
Work	Private Car	29.2	25.0	45.8	100.0
	Bus	32.1	25.0	42.9	100.0
Tourism	Private Car	29.2	33.3	37.5	100.0
	Bus	33.3	16.7	50.0	100.0
Other	Private Car	34.8	34.8	30.4	100.0
	Bus	32.0	24.0	44.0	100.0
$P=P_{bus}$					
Work	Private Car	4.2	16.7	79.2	100.0
	Bus	0.0	28.6	71.4	100.0
Tourism	Private Car	4.2	16.7	79.2	100.0
	Bus	0.0	26.7	73.3	100.0
Other	Private Car	4.3	21.7	73.9	100.0
	Bus	0.0	24.0	76.0	100.0
$P<P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0
Tourism	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0

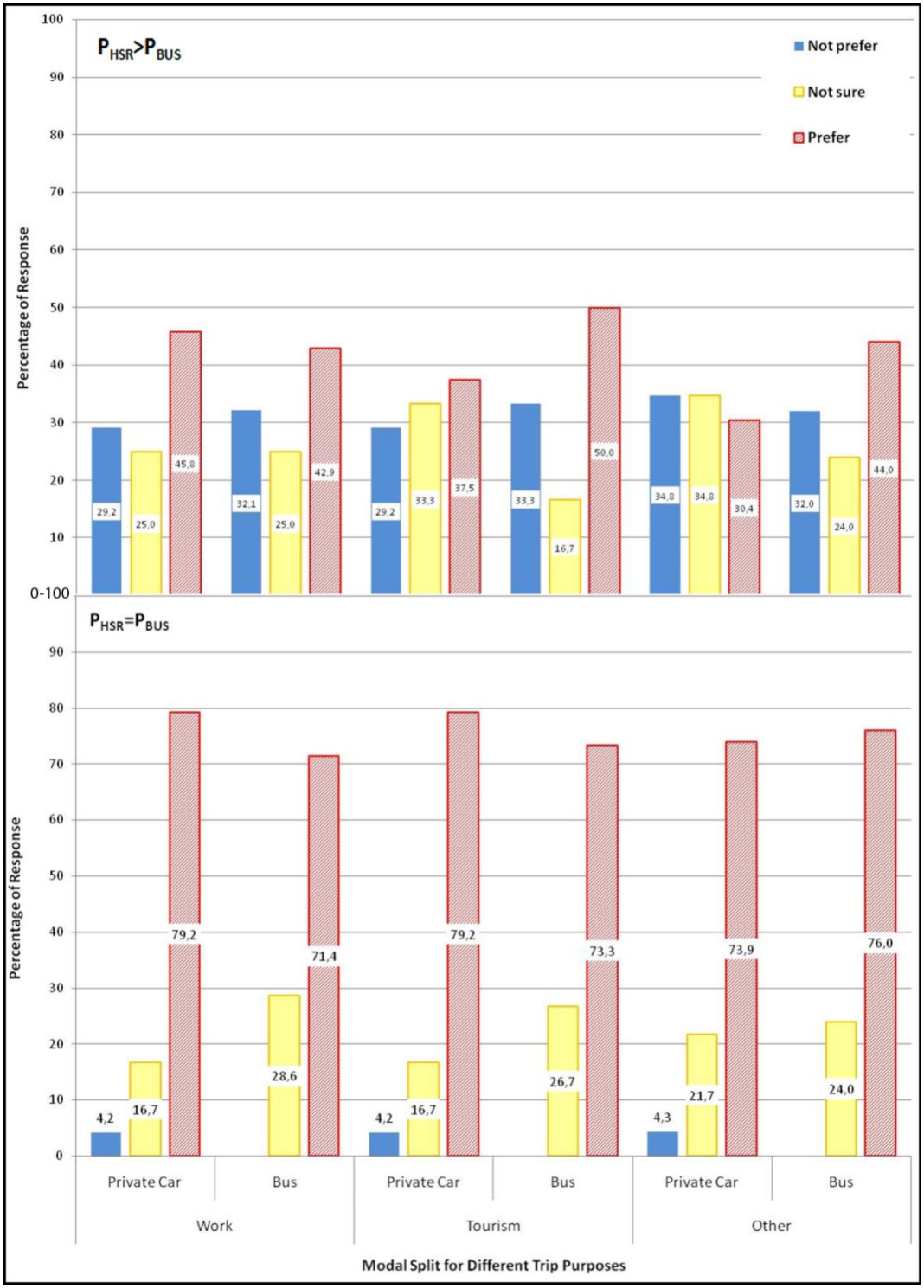


Figure 5.21. Preference Percentage of Road Transport (Bus & Private Car) Users for Different HSR Price Levels

5.3.2. Potential HSR Usage for Line2

Antalya-Konya-Aksaray-Nevşehir-Kayseri Railway Project which is called as Line 2 is planned in the boundaries of five cities, Antalya, Konya, Aksaray, Nevşehir and Kayseri, located in the Mediterranean and Middle Anatolian Regions. In this region, the questionnaire was conducted to 64 people living in these cities.

Unlike Line 1, the share of people who traveled by HSR before is higher when compared with the overall analysis results. It appears that Ankara-Konya HSR which has been operating since August 2011 has an impact on this share (see Table 5.6).

Table 5.6. Percentage of Potential HSR Usage and Previous HSR Experience for Line 2

Total participant	**Number**	**%**				
	64	**100.0**				
Potential HRS Usage						
	Previous Experience (N=36)		**No Previous Experience (N=176)**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Yes	16	25.4	47	74.6	63	100.0
No	1	100	0	0	1	100.0

When the questionnaires conducted in the scope of Line 2 are evaluated within the context of pricing policy, there is not much difference between overall evaluations for all four projects. Approximately similar results are seen in this project: as the ticket price of HSR system decreases in comparison to bus ticket prices, the usage of this system increases (see Figure 5.22 and Figure 5.23).

In contrast to the overall analysis when bus and HSR prices are equal the share of those who stated that they would prefer using HSR is more in this region. Unlike

in previous analysis, the impact of previous HSR experience in travel behavior is more effective in this project area. According to Figure 5.24, 64.7% of people who traveled by HSR before, are willing to pay more than the bus price for HSR.

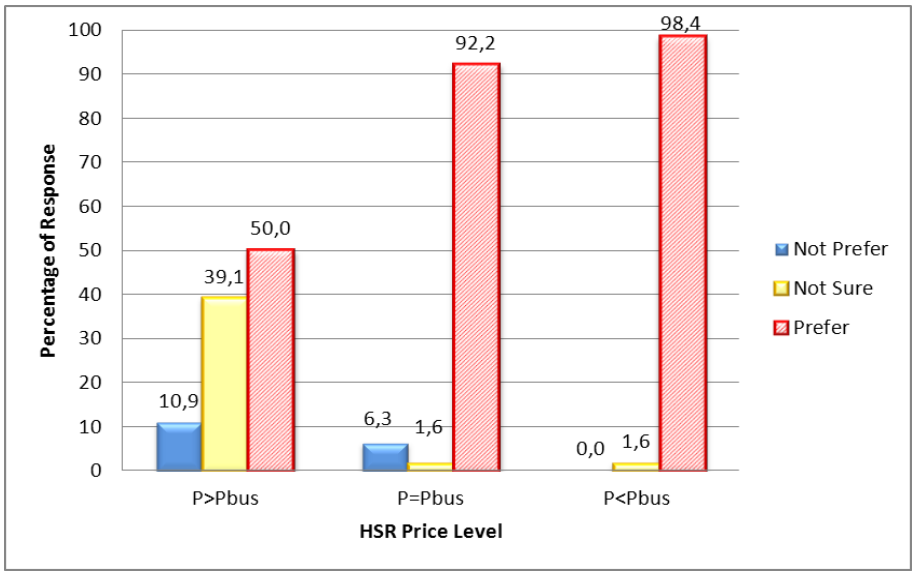
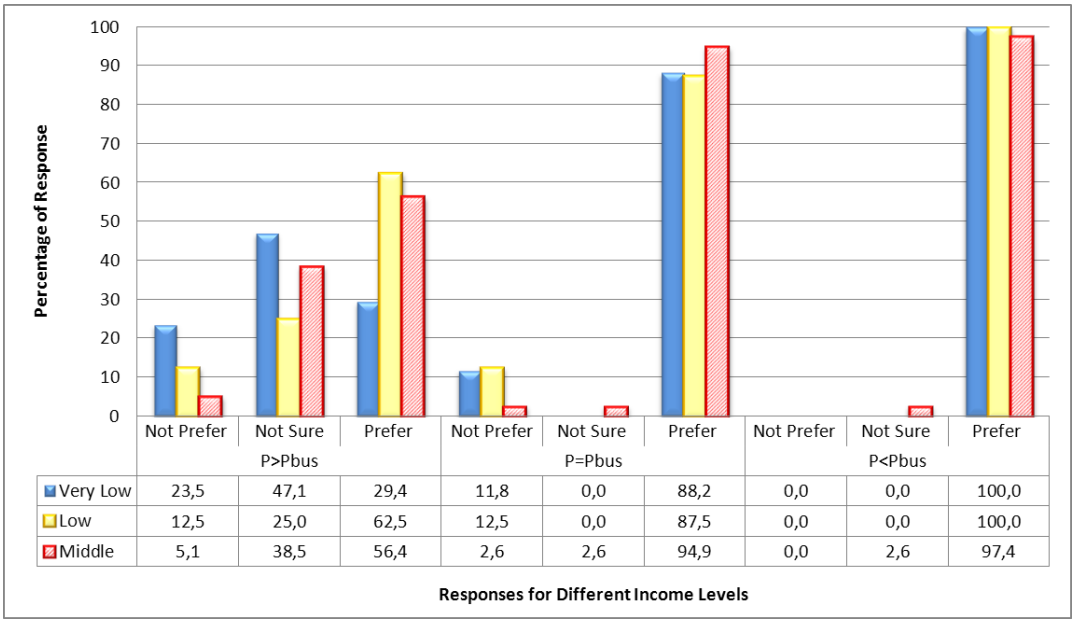


Figure5.22. Preferabilityof Line 2 for Different Price Levels (P_{HSR}>P_{Bus})



	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer
	P>Pbus			P=Pbus			P<Pbus		
Very Low	23,5	47,1	29,4	11,8	0,0	88,2	0,0	0,0	100,0
Low	12,5	25,0	62,5	12,5	0,0	87,5	0,0	0,0	100,0
Middle	5,1	38,5	56,4	2,6	2,6	94,9	0,0	2,6	97,4

Figure 5.23. Preferability of Line 2 for Different Income and Price Levels (P_{HSR}>P_{Bus})

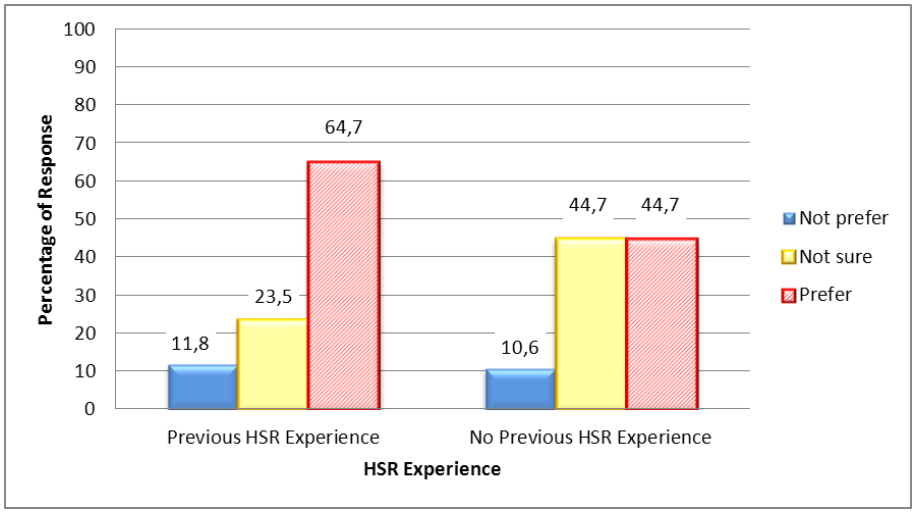


Figure 5.24. Impact of the Previous HSR Experience on Line 2 Usage if $P_{HSR}>P_{Bus}$

Table 5.7, which shows the responses of road transport users to the question about ticket price levels, reveals similar results with the overall analysis. For Line 2, different from the overall analysis, the share of those who stated that they would "not prefer" using HSR if its price is more expensive than bus ticket prices is higher. In the overall analysis there was only a small portion of people (1% - 5%) who said they would "not prefer". Under the condition that HSR price is equal to bus ticket price, more than 90% of the respondents claimed that they will prefer HSR**.** The result for the case of HSR price being less than the bus price is similar to the overall evaluation (see Table 5.7 and Figure 5.25).

Table 5.7. Percentage of Road Transport User's Line 2Preference for Different Price Levels

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$					
Work	Private Car	5.6	38.9	55.6	100.0
	Bus	16.1	32.3	51.6	100.0
Tourism	Private Car	10.0	53.3	36.7	100.0
	Bus	18.2	27.3	54.5	100.0
Other	Private Car	9.1	45.5	45.5	100.0
	Bus	11.1	40.7	48.1	100.0
$P=P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	9.7	0.0	90.3	100.0
Tourism	Private Car	6.7	3.3	90.0	100.0
	Bus	9.1	0.0	90.9	100.0
Other	Private Car	4.5	0.0	95.5	100.0
	Bus	3.7	3.7	92.6	100.0
$P<P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0
Tourism	Private Car	0.0	3.0	96.7	100.0
	Bus	0.0	0.0	100.0	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	3.7	96.3	100.0

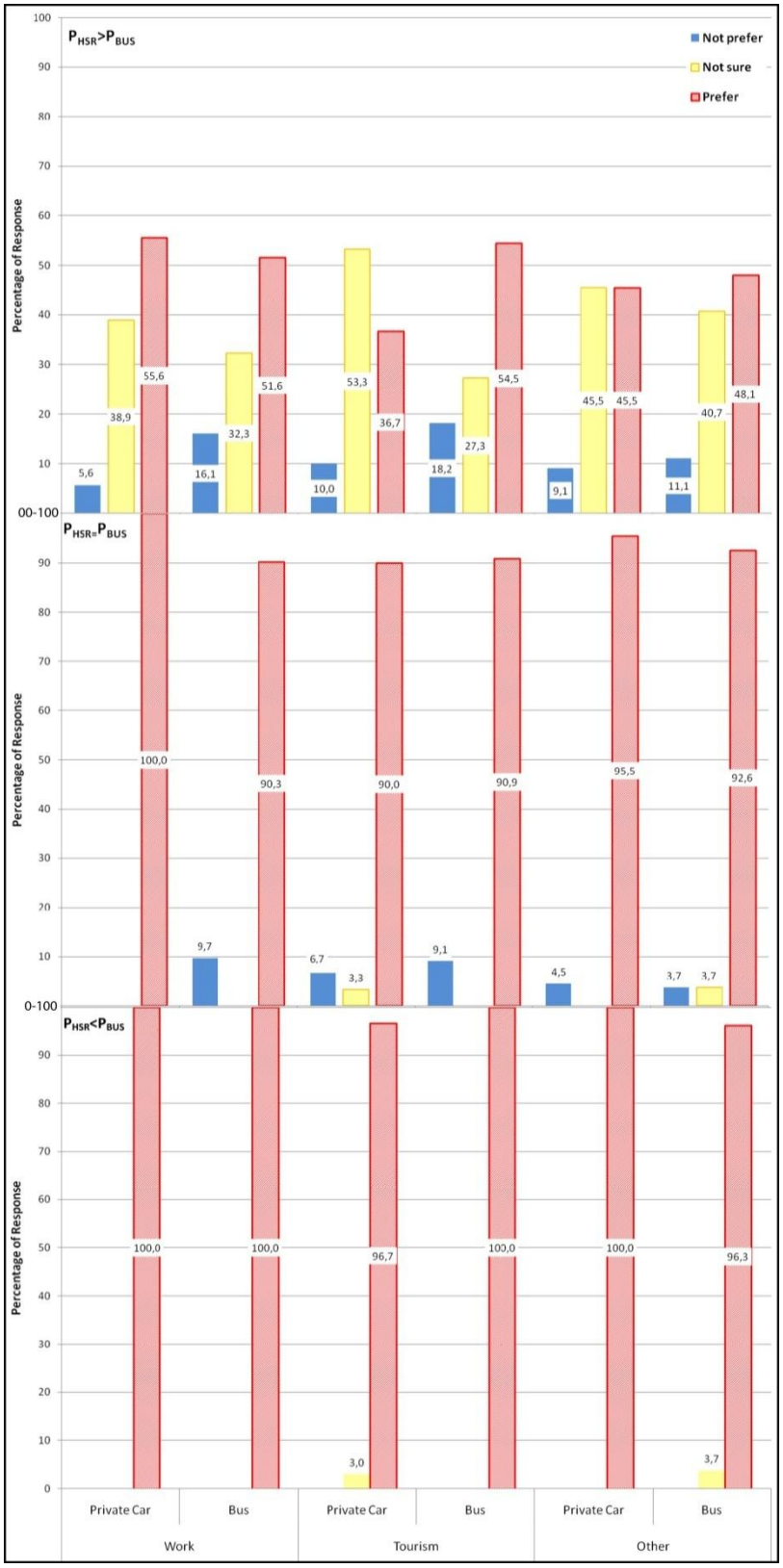


Figure 5.25. Preference Percentage of Road Transport (Bus & Private Car) Users for Different HSR Price Levels

5.3.3. Potential HSR Usage for Line3

In the scope of this railway project, the questionnaire was conducted to 26 people in 4 cities: Kırşehir, Aksaray, Konya and Niğde. When the past HSR experiences of the respondents are analyzed, it is seen that the share is less than the overall evaluation because in this region, there are no HSR lines in close proximity. Therefore, according to Table 5.8,it is seen that only 2 of the 26 people had a trip by HSR before.

Table 5.8. Percentage of Potential HSR Usage and Previous HSR Experience for Line 3

Total participant	**Number**	**%**				
	26	**100.0**				
Potential HRS Usage						
	Previous Experience (N=36)		**No Previous Experience (N=176)**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Yes	2	7.7	24	92.3	26	100.0
No	0	0	0	0	0	0

In terms of the preference of HSR when its price is more than bus ticket price, the share of those who “prefer” using HSR is more than 50% for all levels of income. Nevertheless, for lower income groups 37.5% of the respondents stated that they would not use the system under this pricing condition. It shows similar result with the overall evaluation (see Figure 5.26). Particular to Line 3, all of the people who have very low income are willing to use HSR when its price is equal to bus ticket price. However, when the other income groups are analyzed, it is seen that there are people who are not sure about their HSR usage in that pricing scenario.

Furthermore, in the case that the price of HSR ticket is less than the bus ticket price, 7.1% of the people in middle income group stated that they would not prefer HSR. It is interesting that people who have middle income are not willing

to pay for HSR as the lower level income groups. This question was about the comparison of the two modes, bus and HSR; however, this result indicates that 7.1% of the higher income group would not use HSR in any pricing scenario, possibly because they would always prefer using their private cars or air transport (see Figure 5.27).

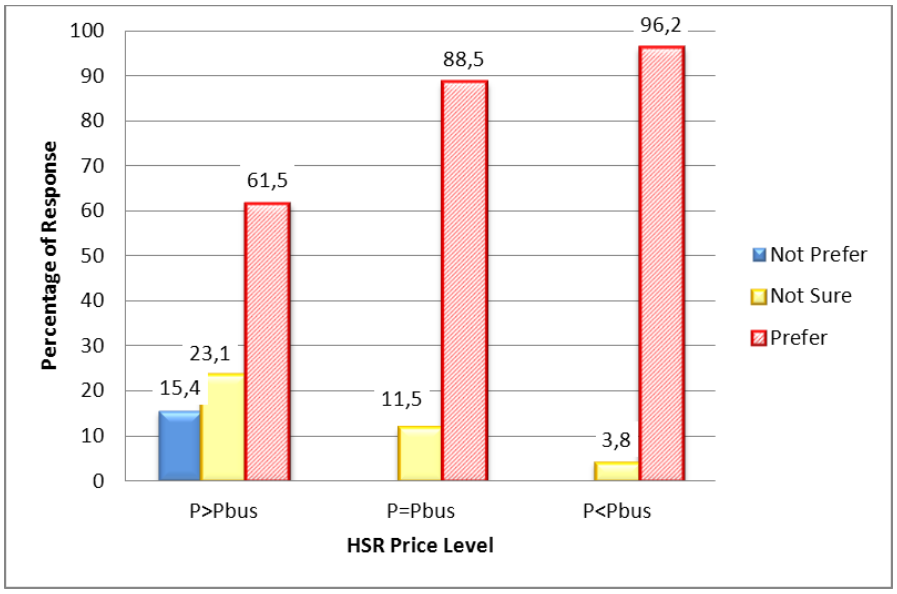


Figure 5.26. Preferabilityof Line 3 for Different Price Levels (P_{HSR}/P_{Bus})

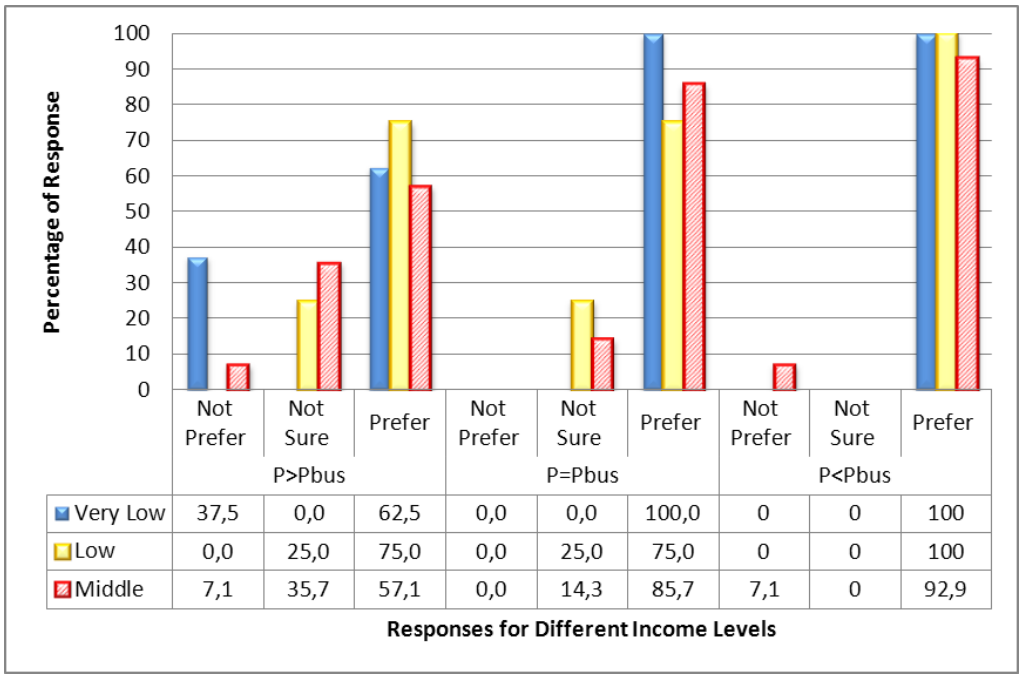


Figure5.27. Preferability of Line 2 for Different Income and Price Levels ($P_{HSR}>P_{Bus}$)

When the past HSR experience and willingness to pay for HSR is evaluated; the result is similar to the overall evaluation. 64.7% of the respondents who traveled by HSR in the past stated that they would prefer HSR even if its price is more than bus ticket price. Also 44.7%of the respondents who have not experienced HSR before stated that they would prefer HSR in the same pricing scenario (Figure 5.28).

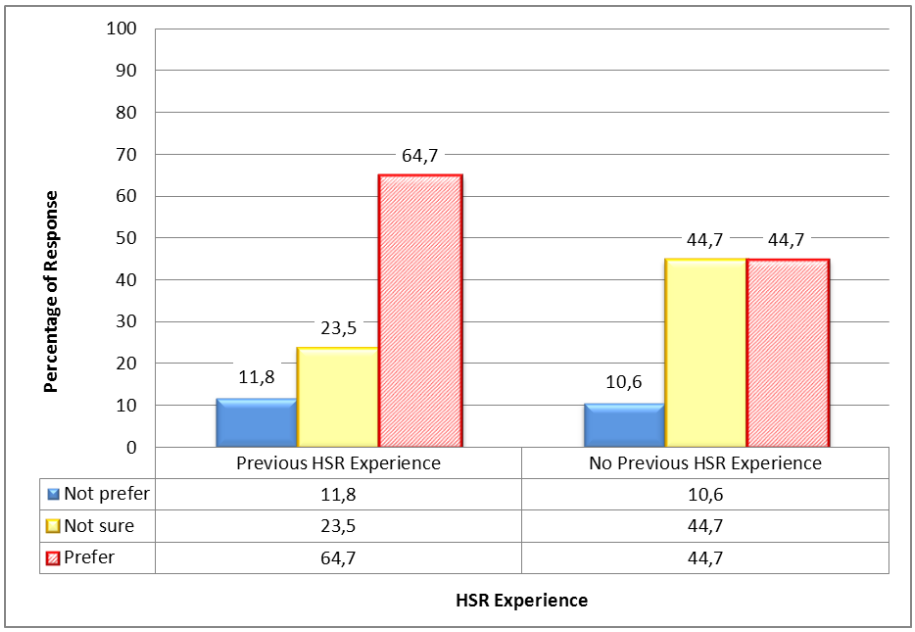


Figure 5.28. Impact of the Previous HSR Experience on Line 3 Usage if $P_{HSR}>P_{Bus}$

As seen in Figure 5.29, willingness to pay more for HSR for middle income class is less than other income groups. One of the reasons for this situation could be private car ownership. When the possible shift from road to rail is evaluated, it is seen that at least 40% of private car users are not willing to pay for HSR if its price is more than bus ticket price. Although it was mentioned before that this may also be because this income group would not consider using this mode at all, preferring their private cars instead at all pricing conditions, this does not seem to be the case as seen in the other figures below. Price of HSR would have a significant impact on modal shift because if the price of HSR is equal to bus ticket price, all of the people who use private cars in tourism and other trips are willing

to use HSR. Only for work trips, 11.1% of car users are not sure whether they would prefer HSR. It is interesting that when the price of HSR is less than bus price, although every private car users claimed that they would prefer HSR, a small portion of bus users said they are not sure about whether they would switch to railways (see Table 5.9 and Figure 5.29).

Table 5.9. Percentage of Road Transport User's Line 3 Preference for Different Price Levels

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$					
Work	Private Car	33.3	22.2	44.4	100.0
	Bus	11.1	22.2	66.7	100.0
Tourism	Private Car	22.2	11.1	66.7	100.0
	Bus	16.7	33.3	50.0	100.0
Other	Private Car	22.2	11.1	66.7	100.0
	Bus	15.4	30.8	53.8	100.0
$P=P_{bus}$					
Work	Private Car	0.0	11.1	88.9	100.0
	Bus	0.0	11.1	88.9	100.0
Tourism	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	16.7	83.3	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	15.4	84.6	100.0
$P<P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	11.1	88.9	100.0
Tourism	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	8.3	91.7	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	0,0	7.7	92.3	100.0

Figure 5.29. Preference Percentage of Road Transport (Bus & Private Car) Users for Different HSR Price Levels

5.3.4. Potential HSR Usage for Line4

Erzincan-Diyarbakır-Mardin Railway Project which is called as Line 4 passes through the boundaries of five cities: Erzincan, Tunceli, Elazığ, Diyarbakır and Mardin. These cities are located in the East Anatolian Region and South East Anatolian Region. In the scope of this project, the questionnaire was conducted to 65 people living in close proximity to the area that the railway investment is planned.

The share of people who traveled by HSR previously is close to the share in overall evaluation, however it is interesting that it is relatively high when it is considered that there are not any HSR lines currently operating in this region. According to the results of the questionnaire, as in the previous analysis the share of those willing to use HSR under the condition that it goes to desired destinations is very high: 98.5% (see Table 5.10).

Table 5.10. Percentage of Potential HSR Usage and Previous HSR Experience for Line 4

Total participant	**Number**	**%**
	65	**100.0**

Potential HRS Usage

	Previous Experience (N=36)		**No Previous Experience (N=176)**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Yes	12	18.8	52	81.2	64	100.0
No	0	0	1	100.0	1	100.0

When the share of preferences according to different pricing levels is analyzed, it is seen that the share of those who would "prefer" using HSR is higher than those in the overall analysis (see Figure 5.30). In contrast to the overall analysis, the shares of the respondents who are in very low income level are willing to use HSR even if the price is more than bus ticket prices. In contrast to the evaluation

above, the share of those who would prefer using HSR in the case that HSR ticket price is equal to bus ticket prices is 93.5% for those having middle income. The share of those who would "prefer" using HSR in this pricing scenario is 78.6% for those with a very low monthly income. According to the analysis, if the price of HSR is less than bus ticket price, all of the respondents claimed that they will use HSR (see Figure 5.31).

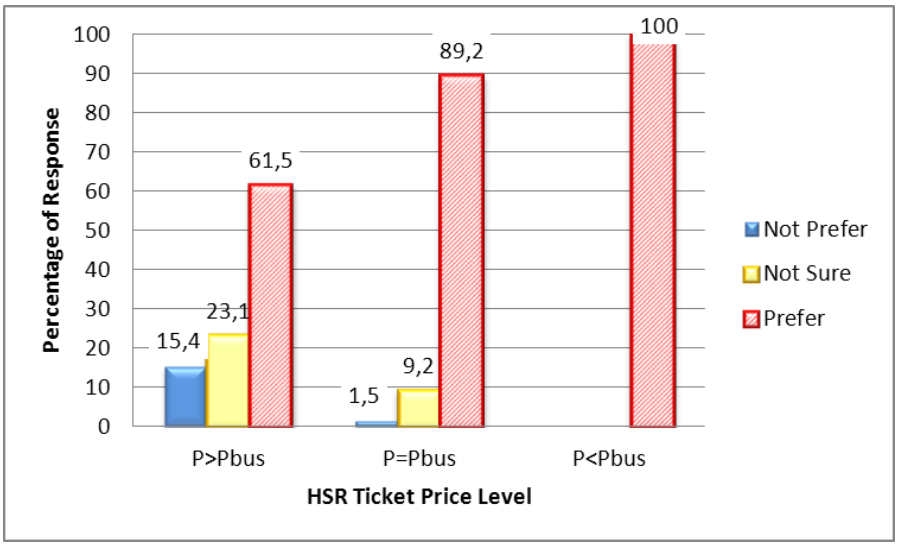
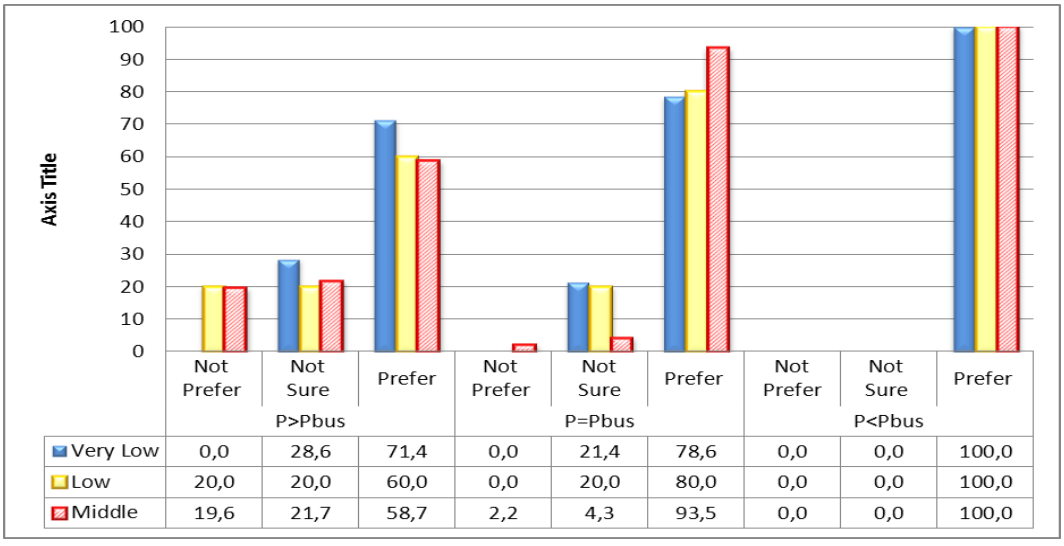


Figure 5.30. Preferability of Line 4 for Different Price Levels (P_{HSR}/P_{Bus})



	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer	Not Prefer	Not Sure	Prefer
	P>Pbus			P=Pbus			P<Pbus		
Very Low	0,0	28,6	71,4	0,0	21,4	78,6	0,0	0,0	100,0
Low	20,0	20,0	60,0	0,0	20,0	80,0	0,0	0,0	100,0
Middle	19,6	21,7	58,7	2,2	4,3	93,5	0,0	0,0	100,0

Figure 5.31. Preferability of Line 4 for Different Income and Price Levels ($P_{HSR}>P_{Bus}$)

One of the interesting points in this project area is that the share of people who said they would "prefer" HSR if the HSR price is more than bus ticket price is higher for the respondents who have not experienced HSR before. Generally it is expected that if the characteristics of the transportation mode, such as cost, travel time, and comfort are considered convenient based on a past travel experience, then the past experience could be effective for willingness to pay for it. For such a region where air transport has an important share despite its higher price compared to bus, the share of those who would "prefer" HSR after a past HSR travel experience would be expected to be higher than others (see Figure 5.32).

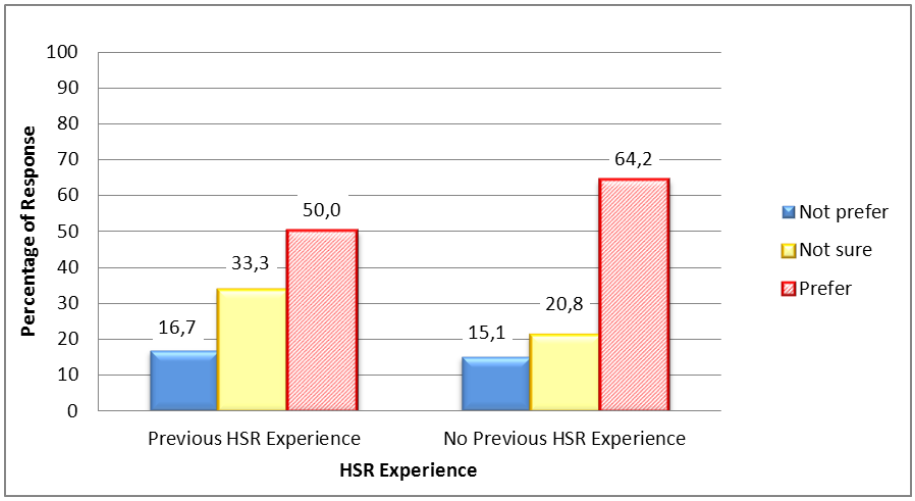


Figure 5.32. Impact of the Previous HSR Experience on Line 4 Usage if $P_{HSR}>P_{Bus}$

When the responses of road transportation users are analyzed, the share of those road users who would prefer HSR for their work/business trips even if the HSR is more expensive than bus tickets are considerably similar to the overall analysis; however, this rate is much higher for tourism and other trips. As for the pricing scenario, in which the price of HSR tickets are equal to bus ticket prices, the share of those who would prefer HSR is slightly higher in this region when compared to the overall analysis. This is the case for all trip purposes, and this may be due to the remote location of this region in comparison to other project areas that are more centrally located in the country.According to the findings of the study, if the

price of HSR is determined as less than bus ticket price, all of the respondents are willing to use HSR regardless of trip purpose (see Table 5.11 and Figure 5.33).

Table 5.111. Percentage of Road Transport User's Line 4Preferencefor Different Price Levels

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$					
Work	Private Car	20.0	30.0	50.0	100.0
	Bus	15.0	30.0	55.0	100.0
Tourism	Private Car	21.1	21.1	57.9	100.0
	Bus	11.1	27.8	61.1	100.0
Other	Private Car	0.0	9.1	90.9	100.0
	Bus	4.8	4.8	90.5	100.0
$P=P_{bus}$					
Work	Private Car	0.0	10.0	90.0	100.0
	Bus	0.0	10.0	90.0	100.0
Tourism	Private Car	5.3	5.3	89.5	100.0
	Bus	0.0	5.6	94.4	100.0
Other	Private Car	0.0	9.1	90.9	100.0
	Bus	4.8	4.8	90.5	100.0
$P<P_{bus}$					
Work	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0
Tourism	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0
Other	Private Car	0.0	0.0	100.0	100.0
	Bus	0.0	0.0	100.0	100.0

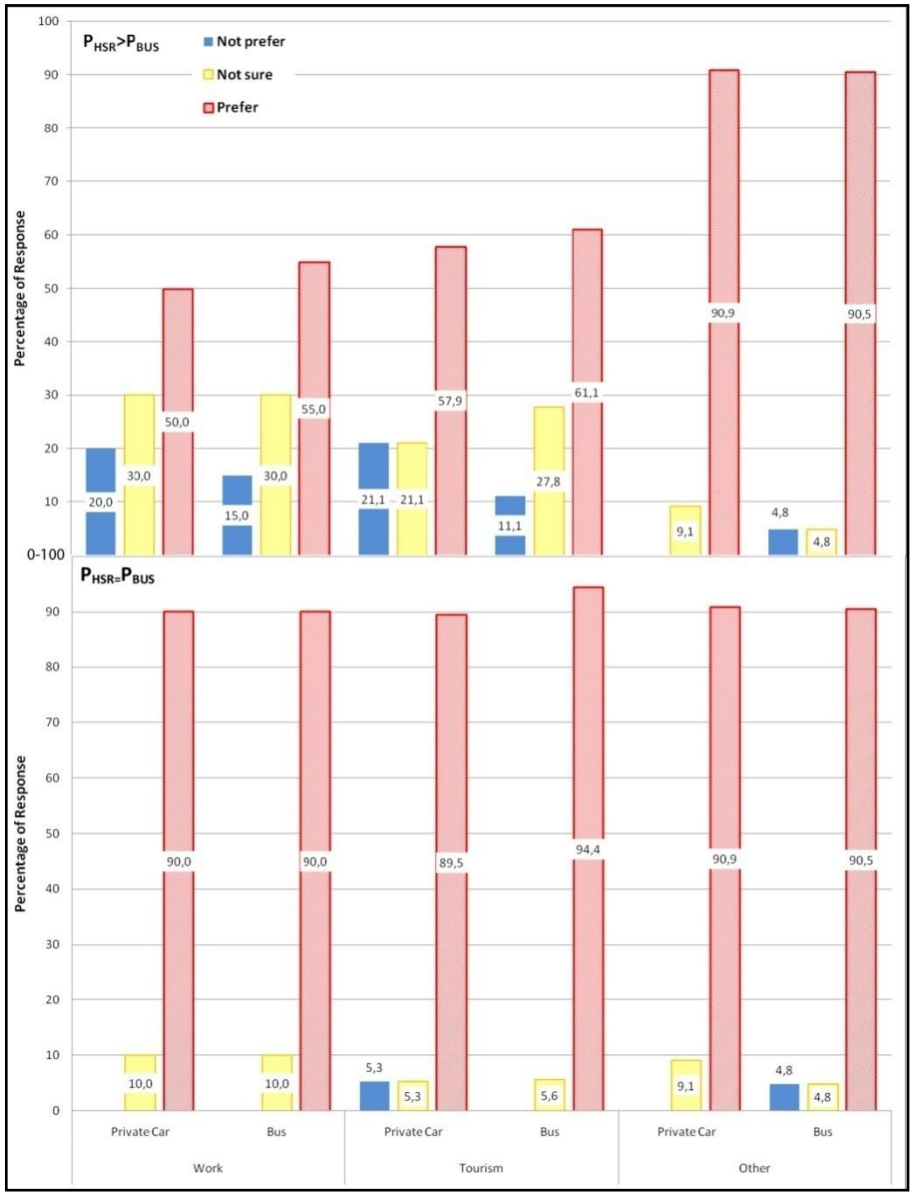


Figure 5.33.Preference Percentage of Road Transport (Bus & Private Car) Users for Different HSR Price Levels

5.4.Findings & Discussion

This chapter focused on the results of the questionnaire conducted with people living in close proximity to planned HSR investments. In this chapter, the following research questions that were stated in the previous chapters were expected to be answered.

1. What are the perceptions of potential users for high speed rail; in other words are these rail systems likely to be used by the inhabitants that currently use road transportation?
2. Under what conditions (price, time and other) are the users likely to prefer railway systems?
3. Is a passenger shift from road to railways likely to happen as a result of these HSR investments? In other words, considering the dominance of road transport, and particularly bus transport in inter-city travel in Turkey, would pricing levels in relation to bus ticket prices have an impact on the decision of whether or not to use the high speed rail system?
4. In the light of answers to the above questions, are HSR investments in Turkey likely to change passenger transportation patterns and mode choices and hence help mitigate climate change?

According to the questionnaire results, for the majority of people safety of the transportation mode is a major concern, followed by travel time. Although cost seems to be less important than other parameters according to the 1st question, in the further questions about relative levels of ticket prices of HSR and buses, it is seen that cost is likely to affect travel behavior, particularly for lower income levels.

Respondents generally use road transportation for their intercity trips, which is expected considering the country statistics. However, in the cities that are in close proximity to an existing conventional railway network, railway usage share is

relatively higher. Especially in the evaluation of the Erzincan-Diyarbakır-Mardin Railway Project area (Line 4),it is seen that railway usage share is higher than the overall evaluation. Furthermore, it is found that airway is also a strong alternative for some regions.

The share of people who had travelled by HSR before is low in the 16 cities that the questionnaire was conducted. Only 17% of the respondents had an HSR experience by the currently operating lines. However, the perception of HSR is quite positive as 99.1% are willing to use this system when the current projects are completed and start operating in their cities.

In the introduction of a new transportation mode, pricing is a significant issue. Questionnaire results support this situation; however, it is hard to remark that the level of income has a substantial impact on the willingness to pay for HSR. When the shares of "not prefer" and "not sure" responses to the question of preference of HSR under the condition that its price is higher than bus ticket price are analyzed, it is seen that ratios are close to each other for each income levels in overall analysis. The analysis shows in general that about half of the respondents would use the HSR even if it is more expensive than making a bus journey. However, this also indicates that the remaining half would be reluctant to use the system under this pricing condition.

When the price of HSR decreases in comparison to bus ticket prices, the share of those who "prefer" using HSR increases for all income groups. Thus it can be stated that in order to encourage people to use HSRs, the price of HSR tickets should not be higher than bus ticket prices. When ticket prices on HSR are lower or at least comparable, i.e. equal, to bus ticket prices, users are more likely to choose this alternative. However, the sensitivity of different income groups for different HSR ticket price levels varies. Furthermore, preferences may vary according to the location of the lines. In some regions that the questionnaire was

conducted, for example in Line 4, none of the "very low" income respondents stated that they would not prefer HSR if its price was more than bus ticket prices.

In the overall analysis, it is seen that the past HSR experiences of people does not have a substantial impact on their mode choice decision. Both those with a prior experience and those with no past experience of using a HSR system have similar levels of willingness to use HSR if their city is connected with such a system. On the other hand, project based analysis shows some differences. For example, for Line 1, which is Sincan-Çayırhan-İstanbul Railway Project covering respondents from Ankara, Bolu, Sakarya, Kocaeli and İstanbul, only 48% of the respondents who had previous HSR experience stated that they would prefer HSR if its ticket price was more than bus ticket prices. In Line 2, the Antalya-Konya-Aksaray-Nevşehir-Kayseri Railway Project, 64.7% of people who traveled by HSR before, are willing to pay more than the bus price for HSR. In Line 4, which covers the South-East cities in Turkey this ratio is 62%, which is also quite high. This difference may be due to the location of the lines. Line 1 and the cities there are in close proximity to the Ankara-Istanbul motorway and therefore may be considering bus transportation service quality quite high due to relatively higher speeds. In contrast road connections in Line 2, although not in poor standards, are not as direct and high-speed as the motorway in Line 1. Similarly, cities in Line 4 experience very long distances to get connected to Central and Western Anatolia that their willingness to pay more for a high-speed journey is probably quite high.

In order to understand the potential usage of planned HSR investments by inhabitants that currently use road transport, different pricing conditions were introduced to them to assess under which conditions they were more willing to use HSR. It was seen that bus users are more willing than private car users to use HSR even when its price is more than bus ticket prices. This may be due to travel conditions on the bus: as stated before safety and travel time are considered by the respondents as the most important aspects for transport modes. Therefore, a significant percentage of bus users would prefer HSR over buses even if the

former has more expensive tickets. However, overall, for both private car users and bus users, it is clear that when the price of HSR decreases, they are more likely to prefer HSR over inter-city buses.

In order to compare each HSR projects with each other, a summary table is built up. In Table 5.12, only the project specific results are shown as a summary to understand the differences of HSR projects evaluations in different regions.

Table 5.12. Comparison of the HSR Projects with Respect to Questionnaire Results

% of respondents who	**Line 1**	**Line 2**	**Line 3**	**Line 4**
stated Environmental Sensitivity is **"very important"**	66.7	53.1	50.0	73.8
Prefer**bus** for work/business trips	49.1	48.4	34.6	30.8
prefer **private car** for work/business trips	42.1	28.1	34.6	15.4
prefer **airway** for work/business trips	3.5	14.1	23.1	41.5
prefer **bus** for tourism trips	52.6	34.4	46.2	27.7
prefer **private car** for tourism trips	42.1	46.9	34.6	29.2
prefer **airway** for tourism trips	3.5	12.5	0.0	16.9
prefer **railway** for tourism trips	1.8	6.3	19.2	16.9
have previous HSR experience	8.8	26.6	7.7	18.5
-have "**very low"**income -do not prefer HSR if **P>P_{bus}**	38.5	23.5	37.5	0.0
-have **"low"** income -do not prefer HSR if **P>P_{bus}**	30.4	12.5	0.0	20.0
-have **"middle"** income -do not prefer HSR if **P>P_{bus}**	23.8	5.1	7.1	19.6
-have previous HSR experience -do not prefer HSR if **P>P_{bus}**	40.0	11.8	11.8	16.7
-have noprevious HSR experience -do not prefer HSR if **P>P_{bus}**	28.8	10.6	10.6	15.1

The comparisons once again highlight the start difference in geography for Line 4, where intercity travel distances tend to be high and therefore responses with regards to the willingness to use HSR differ from the other lines. Line 4

inhabitants are more willing to use HSR, and they also use conventional railway systems more when compared to other projects' respondents. They also use air transport more in their work and business trips, possibly due to the remote location again. This stark difference shows that for connections in that region, inhabitants may be more willing to use HSR systems when they are built. On the other hand, in the corridors where other transport options are available and convenient, such as the existence of a motorway for Line 1, price of HSR may have a stronger impact on whether the inhabitants use this system or not.

CHAPTER 6

CONCLUSION

6.1.Summary of the research

In the world, sustainable transport systems have become an increasingly important policy area because of the rising environmental problems such as climate change. Therefore, there is a tendency to invest more in sustainable modes of transport all over the world. In general, railways are seen as a more sustainable alternative to road and air transportation for passenger and freight movement due to relatively low environmental impacts. Furthermore, HSRs are seen as effective alternatives that can attract both road users and airway passengers due to the fast service they offer and time-savings they provide. Therefore, HSR investments are in the policy agenda of many countries in the recent years. In Turkey too, they have received an increasing emphasis and many HSR projects are being planned or constructed.

HSR investments are made with various expectations, such as a shift from road and air transport to railways, and reductions in greenhouse gas emissions and energy consumption in the transport sector. However, for these expectations to be attained, it is crucial that the systems carry reasonably high numbers of passengers. Unless ridership expectations are attained and a shift from road and air transport is realized there will not be a any significant improvements in energy efficiency and greenhouse gas reductions. As mentioned in the previous chapters, railways are considered as more environmentally friendly systems in terms of energy consumption and emitted greenhouse gas emissions; however, this is only possible if the systems attract substantial numbers of passengers. Therefore, if the shift from road and air transport to railways does not materialize, total energy

consumption and greenhouse gas emissions will not decrease. On the contrary, the investment will result in loss of money, land and environmental damage while not providing any benefit to the current transportation system.

This study had two main research questions, as listed below together with sub-questions:

1. What are the perceptions of potential users with regards to HSR?
    1. Are the high speed rail systems that are being planned in Turkey likely to be used by inhabitants that currently use road transport?
    2. Under what conditions (price, time and other) are the users likely to prefer railway systems?
    3. Is a passenger shift from road to railways likely to happen as a result of these HSR investments?
2. Are HSR investments in Turkey likely to change passenger transportation patterns and mode choices and hence help mitigation of climate change?

In order to answer these research questions, the following four planned HSR projects were chosen as case studies and a questionnaire was conducted to people living in the cities that the planned HSR lines connect:

- **Line 1:**Sincan-Çayırhan-İstanbul HSR Line Ankara-Kocaeli Section
- **Line 2:** Antalya-Konya-Aksaray-Nevşehir-Kayseri HSR Line
- **Line 3**: Kırşehir-Aksaray-UlukışlaHSR Line
- **Line 4:** Erzincan-Diyarbakır-MardinHSR Line

The findings, regarding both the above questions and the differences between the four projects are described in the section below.

6.2.Research findings

Based on the questionnaire conducted in this study, it is possible to answer the research questions as follows:

1. In general potential users of HSR have a positive perception for this system as almost all of the respondents (99,1%) are willing to use HSRs if an investment is made to connect their city to the HSR network

    a. Road users are likely to use HSR systems, hence a shift to railways may be possible, since all of the respondents stated a willingness to use these systems as mentioned above.

    b. However, under certain pricing conditions they are less likely to use HSR systems. If the HSR tickets are more expensive than intercity bus tickets, then about 18% of the respondents would definitely not use the system while 28% are not sure whether or not they would use it. Under this condition, about 21% of the *road users* would not use HSRs, and about 30% are not sure. This indicates that *more than half* of the road users may be reluctant to use HSR systems if travelling with them is more expensive than intercity bus journeys. Notwithstanding this finding, it should be noted that in south-east Turkey, where connections to central and western parts of the country require longer journeys, more people (68%9 are willing to pay higher fares to travel with HSR.

    c. These findings show that a passenger shift is possible from road to railways as a result of these HSR investments particularly when connections are made to remote parts of the country, such as south-eastern Turkey where intercity travels are often long-distance. In addition, pricing is effective: a passenger shift can be attained if travelling on HSR is not more expensive than travelling with intercity buses.

2. As a result, HSR investments in Turkey may change passenger transportation patterns and mode choices, and hence help mitigation of climate change; however, pricing conditions will have a major effect.

In addition to pricing conditions, other parameters, such as safety, may also be important and hence safe and secure operation should be ensured. Further findings regarding this issue and other wider issues are summarized below:

1. Questionnaire results showed that safety is major concern for users, as they rank it more important than travel time, comfort, cost, etc.
2. However, as described above cost is an important parameter. Although responses to the importance of transport parameters revealed cost as a less important aspect among other characteristics like safety, travel time, comfort, etc. mode choice behavior of people is directly impacted according to the cost of mode in relation to other modes (high speed rail cost in relation to intercity bus ticket cost in this case).
3. Road oriented transport patterns are clearly demonstrated in the questionnaire results. Road transport is the dominant mode in many cities. If travel distance increase, airway usage also increases directly related with cost and travel time relationship. People living in the five cities that the Erzincan-Diyarbakır-Mardin Railway Project is planned use air transportation more than others. According to the existence of conventional or high speed lines, railway is also a considerable alternative for people.
4. The share of people who had travelled by HSR before is low in the 16 cities that the questionnaire was conducted. Only 17 % of the people had an HSR experience by the currently operating HSR lines. However, 99.1 % of people are willing to use HSRs in the case that projects are completed and begin to operate in their cities.
5. To attract passengers to HSRs, pricing is a significant issue as discussed above. However, it is hard to claim that the level of income has a

substantial impact on people's willingness to pay for HSR, because in overall evaluation of questionnaires, the shares of those who would "not prefer" to use HSRs are similar to each other for each level of income for the case that HSR price is more than bus ticket price. When the price of HSR decreases in comparison to bus ticket prices, the shares of those who "prefer" using HSR increases for each level of income. Thus it can be inferred that in order to change travel behavior of people, price of the new alternative mode is quite important.

6. The overall analysis shows that the past HSR experiences of people do not have a substantial impact on mode choice. For example it is not an effective factor that may increase people's willingness to pay more if the price of HSR is more than bus ticket prices. On the other hand, project based analysis shows some differences. When there are high standards of road and motorway connections, respondents (with or without previous HSR experience) are relatively less willing to pay more for HSR. In corridors where road connections require long and lower standard journeys (in comparison to motorway speeds for example) higher numbers of the respondents are willing to pay more for HSR, and the share of those willing to pay more increases for those with a past HSR experience.

7. Another finding is related with differences between car users and bus users. In road transport, private car has unique characteristics, such as comfort, convenience and providing door to door transportation. Also, its costs may be reduced when the number of passengers in the car increases. In the analysis that considers road transportation users shifting their travels to HSR, bus users are more willing to change their travel behavior even if the price of HSR is more than bus ticket prices. Car users are less willing to pay higher prices for HSR. This may be due to other mode characteristics: bus users may perceive buses as slower, less comfortable and perhaps less reliable; and therefore, they are more willing to pay more.

6.3. Policy recommendations

It is clear that there is a lack of inter-city transportation alternative in Turkey. Road transportation has a high share among other alternatives whereas airway has been increasing its share with newly built airports in the cities. As mentioned in Chapter 3, railway network had developed until the 1950s, and then there has been a period of stagnation until today. In the 2000s, conventional railways continued to receive almost no investment; however, new HSR investments came into the policy agenda and received an increasing emphasis.

HSR investments are being planned and constructed in many corridors in Turkey. However Turkey does not have a recently developed National Transport Plan and there is no certain data about how the investments were decided to be planned in appropriate corridors. It is not clear what travel demand is in certain corridors ad whether the systems are going to be used, resulting in a shift from roads to railways.

This study showed that pricing will have a significant impact on the usage of these HSR systems that are being planned and constructed. The price of high speed rail tickets should be comparable to intercity bus tickets in the corridors that service is going to be offered.

For regions that have long surface transport connections to central and western Turkey, high speed service appears to be quite important and inhabitants in such regions, such as South-eastern Anatolia, are more willing to use HSR systems when they are built. On the other hand, in the corridors where other transport options, are available and convenient, such as the presence of a motorway, price of HSR in relation to bus ticket prices may have a stronger impact on whether the inhabitants use HSRs or not.

Majority of passengers consider safety as one of the most important transport mode characteristics. Therefore, safe and secure operation should be ensured on

HSRs as the system's image with regards to safety may have an impact on mode choice too.

As discussed above, the recent decades witnessed investment in railways in Turkey; however, almost all of this investment is for high-speed railways while the conventional rail lines have not been extended. It was described in Chapter 2, when the high speed rail technology was presented, that these rail lines cannot have too frequent stations so as not to compromise high-speed service. In addition, as they are quite expensive systems to construct and operate, they cannot be built on every corridor. Therefore, it is important that there are services that provide access to the high-speed rail stations in order to increase the service area of these systems. Some intercity bus companies already started to provide this service for the Ankara-Eskişehir high speed rail system as they now operate in a way that feeds into the high speed rail line, bringing passengers from nearby cities to the HSR and delivering the rail passengers back to these cities. Similar services appeared in railways too in areas where there are conventional rail connections. This experience shows that in order to strengthen the role of railways in passenger transport, investment on conventional railways is also necessary, both to extend the network and to improve service quality on existing lines, so that more rail services can be provided in a way to feed into the HSRs. This can also help increase the ridership of high-speed railways.

6.4.Future Research

As stated before, there is a limited data for the HSR projects demand analysis. This study could be developed with additional questionnaire studies in order to obtain further results regarding mode choice. For example, this study focused on pricing conditions, but the findings showed that an analysis on safety as well as the pricing of the mode could also reveal important conclusions with regards to mode choice.

In terms of the impact of pricing conditions on mode choice, this study had originally aimed at including questions that compared the HSR price with air transport ticket prices too. The questionnaire was initially prepared to include this comparison; however, this had to be changed later. The implementation of the questionnaire was made during public participation meetings organized by the environmental impact assessment company, which kindly accepted to conduct this questionnaire. However, they required it to be shortened and asked to omit air transport related questions. Since no funds were available to carry out the longer version of the questionnaire under different circumstances, the shorter version had to be implemented for practical reasons. As a result, future research can include comparisons with air transport ticket prices.

In addition, if the questionnaire is conducted in other cities that HSR is being planned, user's perspective for the other projects can be observed as well. Data collection and receiving public opinion by questionnaires opens the way to analyze the impact of newly introduced transport alternative. A further study can include other planned HSR projects and an overall analysis that covers all HSR projects that are planned in Turkey.

Another research recommendation is to analyze the social impacts of HSR. In Chapter 2, transport systems and social challenges are analyzed in terms of equity of accessibility. HSR's impact on the settlements that are close to the rail line could be analyzed from the perspective of accessibility to the stations and benefit from the HSR. Furthermore impact of HSR investment on regional economic disparities is an area of research that requires analysis.

Finally, the impact of newly planned and built HSR lines on the climate change can be analyzed in terms of the reduction of the consumed petroleum product in a region or emitted greenhouse gas emission. Such an analysis is possible only with scientific data collection with the help of state institutions.

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