PARKING MANAGEMENT STRATEGIES FOR SUSTAINABLE TRANSPORTATION:
A CASE STUDY FOR ISTANBUL

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ABSTRACT

PARKING MANAGEMENT STRATEGIES FOR SUSTAINABLE TRANSPORTATION: A CASE STUDY FOR ISTANBUL

The rapid growth of the transportation sector during the last decade in Turkey has created many problems particularly in Istanbul such as air pollution, energy consumption, and loss of urban ‘living space’. Different from the traditional approach, where supply is always provided to meet demand, the sustainable transportation is environmentally sensible, society fair, and economically sound. Therefore, the need for a detailed and comprehensive transport policy, to encourage sustainable transport, is essential for Istanbul. One of the most crucial transportation management strategies that can be regarded to achieve more sustainable transportation system is parking management. The objective of this research was to study the nature and level of the parking problem and to recommend some applicable parking management strategies for Istanbul. In order to accomplish this, analysis of “Istanbul Origin-Destination Travel Questionnaire” data and a license plate survey for the selected pilot study area were performed. Next, two parking management strategies, *parking pricing* and *parking duration limitation*, were decided for the pilot study area. The results of the analysis showed that 13% of the on-street parking demand could be decreased due to parking pricing and 15% reduction could be attributed to the parking duration limitation strategy. Beside the ones mentioned above some other recommended parking management strategies for Istanbul metropolitan area were: shared parking, parking regulation, unbundled parking, financial incentives, parking impact fees, increasing the price of parking based on a tax on revenues and/or parking spaces, and combinations of the above strategies.

ÖZET

SÜRDÜREBİLİR ULAŞIMA UYGUN OTOPARK YÖNETİM STRATEJİLERİ: İSTABUL UYGULAMASI

Türkiye'nin ulaşım sektorünün son on yılda hızlı büyümesi özellikle İstanbul'da hava kirliliği, enerji tüketimi, ve 'yaşama alanların' kaybı gibi çok sayıda problemler yaratmıştır. Geleneksel yaklaşımlardan farklı, arz talebi karşılamak için her zaman sağlandığı yerde, sürdürebilir ulaşım çevresel olarak duyarlı, toplumsal olarak hakça, ve ekonomik açıdan tutarlıdır. Bu sebeple, Istanbul'a ayrıntılı ve kapsamlı bir ulaşım politikasına ihtiyacı, sürdürebilir ulaşımı teşvik etmek için, zorunludur. Sürdürebilir ulaşım sistemi sağlamak amacıyla en temel ulaşım yönetim stratejilerinden biri otopark yönetimidir. Bu çalışmanın amacı, otopark sorunun boyutlarını ve çeşitlerini incelenmesi, aynı zamanda Istanbul'da uygulanabilecek çeşitli otopark yönetim politikalarının önerilmesidir. Bunun için, "Çevre Düzeni Planı Hane Halkı Araştırması" anketinin analizleri yapılmış ve seçilen bir pilot bölgede otopark arz ve talep çalışmaları yapılmıştır. Ondan sonra, pilot bölgede iki otopark yönetim stratejisi, *otopark ücretlendirilmesi* ve *otopark süresi sınırlandırılması*, uygunlanmıştır. Çalışmanın sonuçları, yol-üzeri otopark ihtiyacının %13'ü otopark ücretlendirilme stratejisi ve %15'i otopark süresi sınırlandırılma stratejisi ile azaltılabileceğini göstermiştir. İstanbul geneli için: otopark paylaşımı, otopark-daire satışı ayrılması, park düzenlenmesi, mali teşvik uygulaması, otopark kullanım bedeli uygulaması, otopark gelirinin ve/veya otopark alanlarının vergilendirilmesine dayanarak park ücretlerinin arttırılması, ve son olarak yukarıdaki stratejilerin değişik kombinasyonları, gibi stratejiler önerilmiştir.

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LIST OF SYMBOLS / ABBREVIATIONS

D	Average parking duration, h/veh
F	Insufficiency factor to account for turnover - values range from 0.85 to 0.95 and increase as average duration increases
I	Length of the observation interval, h
n	Number of different parking types
N	Number of spaces of a given type and time restriction, stall
N_T	Total number of parked vehicles observed, vehs
N_x	Number of vehicles parked for x intervals, vehs
P	Parking supply, vehs
PH_x	Vehicle parked-hours for the x interval , h
P_S	Total number of legal parking stalls, stall
PV_x	Percentage of parked vehicle for x interval , %
R_d	Estimated demand reduction due to applied strategies, vehs
S_n	Fraction reduction due to the n^{th} strategy (decimal)
T	Time that N spaces of a given type and time restriction are available during the study period, h
TR	Parking turnover rate, veh/stall/h
T_S	Duration of the study period, h
X	Number of intervals parked

1. INTRODUCTION

1.1. Problem Definition

The transportation sector has been rapidly growing during the last decade in Turkey, as a result of a fast economical growth. However, it has created many problems such as traffic congestion particularly for Istanbul. As a result, the quality of the environment and thus the living conditions has started deteriorating considerably.

The significant increase in car ownership and suburban sprawl has overloaded the road network making it insufficient and problematic. As a consequence, Istanbul has not been able to provide to its residents neither an efficient transportation, nor at least a medium-quality environment. The inefficiency of the transportation system is obvious because of the low average traffic speeds and blockages of the traffic flow at many places and many times a day. According to a study for Istanbul (Ergün and Şahin, 2006) the delays were calculated to be 73.9 hrs/person/year. Considering the costs for extra fuel consumption and extra time wastage in traffic, the total cost of congestion were determined to be 3.1$ billion annually.

The main problems, associated with increasing urban traffic and congestion, in some European cities are listed in Table 1.1 (European Commission, 2004). Air pollution, energy consumption, economic efficiency, and loss of urban 'living space' are the most important concerns resulting from the increase of urban traffic and congestion. These concerns result in negative impacts on urban quality of life.

More sustainable transport strategies (EC White Paper, 2001) are needed as a matter of international priority. In Europe a majority of citizens are calling for changes to promote modes of transport which are more respectful of their environment. In 1999, 70 % of Europeans said that they were now more worried about the quality of the air they breathe than they were in 1994. They put air pollution at the top of their list of environmental concerns and quoted car traffic problems as the main reason for their discontent as far as the environment in which they lived was concerned (European Commission Eurobarometer).

Recent surveys have shown that most EU citizens identify as a priority the need to address the issue of too many cars in urban areas, and the pollution, noise and dangers they present. In 2002, more than two-thirds of those surveyed considered environmental factors to be the most important influences on their quality of life and half identified traffic congestion and over reliance on the car as key concerns where they lived (Flash Eurobarometer, 2002). Furthermore, as the Figure 1.1 demonstrates (Eurobarometer, 1999), when people were asked to identify effective solutions to solve environmental problems linked to traffic in towns, priority was given to improving the quality of more sustainable transport modes and greatly reducing the dominance of car traffic.

Table 1.1. The main problems associated with increasing urban traffic and congestion in some European cities (European Commission, 2004)

EQUITY Nearly 30 % of households in Europe have no access to a car — they pay the price of traffic without enjoying mobility benefits offered by car ownership.	**ACCIDENTS** Over 40 000 deaths on Europe's roads/year, of these four times more fatalities occur in urban areas (European Environment Agency, 2000)
ECONOMIC EFFICIENCY Traffic congestion, pollution and accidents result in significant direct and indirect costs. The total bill has been estimated at EUR 502 billion per year across the EU Member States (www.iww.uni-karlsruhe.de, March 2000).	**AIR POLLUTION** Multiple effects including global warming, health problems & building decay. The Department of Health in the United Kingdom estimates the health costs of particulates in urban areas of Britain to be up to GBP 500 million per year (ad-hoc group, 1999)
LOSS OF URBAN 'LIVING SPACE' Motorised transport infrastructure- such as roads and car parking — takes up highly valuable city centre land, and spoils and threatens existing open spaces.	**ENERGY CONSUMPTION** Transport consumes 4 % more energy every year which represents a doubling of energy used every 20 years (Eurostat).
NOISE AND VIBRATION Transport is one of the main sources of urban noise pollution.	**SEVERANCE** Congested urban roads cause severance of communities which can have a social cost.
VISUAL INTRUSION Diminished quality of the urban environment caused by parked cars and other infrastructure.	**COMPETITIVENESS** Traditional centres face competition from less congested out-of-town retail centres.

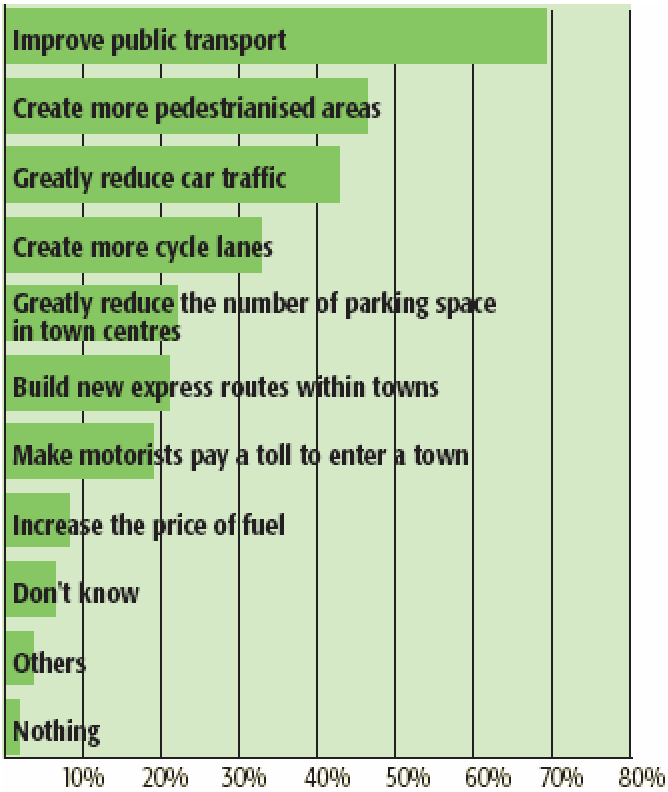


Figure 1.1. Interview results of European respondents identifying effective solutions to solve environmental problems linked to traffic in towns (Eurobarometer, 1999)

1.2. The Traditional (Old) Approach to the Problem

As car ownership and use have increased, in Europe (European Commission, 2004) over the past 30 years and in Turkey (Organization of Turkish Statistics, 2005) in the last 4 years, the reaction to the pressure created by additional traffic demand has often been to increase the level of supply, in other words provide additional road space. This traditional approach of providing supply to meet demand is no longer always appropriate. There is a growing body of evidence indicating that the benefits of creating additional road capacity are not as significant as it was previously believed. As it is indicated in Figure 1.2 (Litman, 2003) the road widening is not a solution for decreasing the congestion level. However, improving public transport and designing High Occupancy Vehicle (HOV) lanes decrease the congestion level.

In extreme cases the provision of new road links may in fact increase congestion problems. This occurs through a process that is known as traffic ‘induction’. In 1994, the

UK Government-commissioned Sactra report (European Federation for Transport and the Environment, 1994) provided evidence on the impact of new road building on traffic levels in the area of the scheme. The report revealed that when new road capacity is provided, overall traffic levels in the vicinity of the scheme may actually increase. The evidence does not offer a reliable means of predicting the extent of this traffic increase but case studies suggest that it is typically around 10 % in the short term, and 20 % in the longer term.

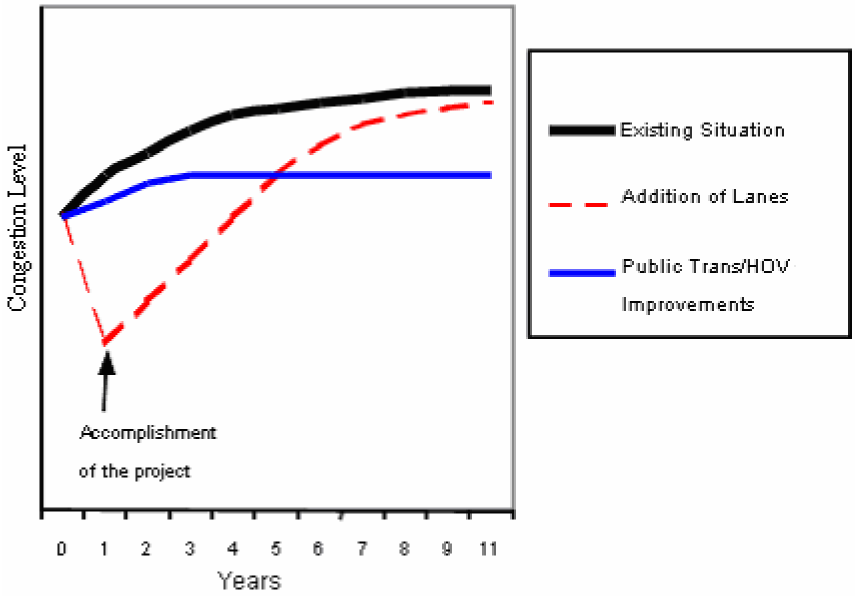


Figure 1.2. Comparison of road widening and public transport/HOV (Litman, 2003)

In Istanbul and many other large cities all around the world there is additional reason as to why the provision of additional road capacity is problematic for city planners. There is a lack of available space in which to expand these capacities. The provision of supplemental road capacity becomes more critical in historic cities like Istanbul, where this provision is very much restricted by historical buildings and ruins.

1.3. A New Approach: Sustainable Transportation

"*Citizens make travel choices based on their individual needs, but a comprehensive plan must be in place to coordinate these individual choices into an efficient transportation system*." (Vuchic, 1999)

Sustainable transport is the transport sector's contribution to sustainability. If sustainable development, as defined by the Brundtland Commission (White Paper, 2001), is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", then sustainable transport should be the use of transport and other factors in helping to meet present needs without jeopardizing future generations.

A sustainable transport system is one that (Center of Sustainable Transport, Government of Western Australia, 2002):

1. "Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and eco-system health, and promotes equity within and between successive generations,
2. Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development,
3. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise".

As it is shown in the Figure 1.3 (Voukas, 2001, Page 4), the three criteria that any element of sustainable transport should satisfy; environmentally sensible, society fair, and economically sound. First of all, the sustainable transportation system has to be environmentally sensible. It has to integrate environmental concerns into transport policy making. Secondly, the sustainable transportation system has to be economically sound. What is good economically is almost always good environmentally, as long as the economic system is working to accurate prices and not subject to distortions from hidden subsidies. And the reverse is true; an economically sound approach to pricing and investment can deliver enormous benefits for the environment. Last but not least, transport can only be sustainable if it is fair on all members of society, in other words, if it provides a minimum level of access to basic services for all people. These three criteria may sound as ambitious as they seem incompatible. But in fact they complement each other.

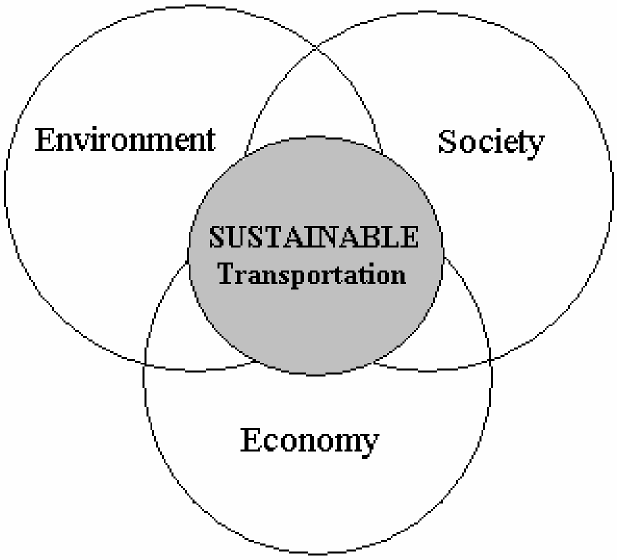


Figure 1.3. The criteria of Sustainable Transportation (Voukas, 2001, Page 4)

The concerns that arise from the increased demand for transportation, made transport a crucial issue in many European metropolitan cities (EC White Paper, 2001) and therefore for Istanbul too (Ergün and Shahin, 2006). The actual transportation system in Istanbul does not take into account the fundamentals of the sustainability. Therefore, the need for a detailed and comprehensive transport policy, to encourage sustainable transport and sustainable mobility, is essential and crucial.

The principal challenge for most European cities and also for Istanbul is to find ways of using the existing road capacity more efficiently (European Commission, 2004). While it is obvious that provision for car-based mobility will continue to be an essential part of traffic management planning, searching and finding ways to encourage more use of alternative modes of transport (public transport, cycling and walking) is the goal of any sustainable urban policy. Where road space is restricted, providing adequate space for these alternative modes may require a reallocation of highway capacity. When the roads under consideration are already highly congested, it is typically assumed that reducing the capacity available for cars will result in increased traffic congestion in the surrounding streets. However, as the evidence in the previous applications this is not necessarily the case. Some pioneering cities, for example Copenhagen in Denmark, have adopted such a policy for many years with great success (Gehl and Gemzøe, 1996).

The greatest challenge is presented in cities or areas of cities where road conditions are already congested, in particular during peak times. In these cases the only way to provide more space for more sustainable modes of transport is to take road space from private cars, either on a permanent 24-hour or on a temporary 'shift' basis. Taking capacity away from the dominant road user (i.e. the private car) is a brave decision for an authority to take. Logic suggests that if a network is already congested, the removal of capacity can only exacerbate the situation. However like Copenhagen in Denmark some other cities such as Kajaani in Finland (1996), Wolverhampton in England (1986), Vauxhall Cross - London in England (2001), Nuremberg in Germany (1994), Strasbourg in France (1992), Ghent in Belgium (1997), Cambridge (1997), and Oxford (1999) in England are living proofs for the benefits of sustainable transport approach (European Commission, 2004). Many of these cities continued with road space rearrangement schemes despite the traffic chaos that would result. However, the initial problems of traffic congestion had short life and after an adaptation period a portion of the traffic was reduced.

There is a growing body of evidence that where well-planned measures to reduce road space for private cars are implemented in congested areas and where no alternative network capacity is available, over the long term the predicted traffic chaos does not occur. The experience in a number of European cities is that (Cairns *at al.*, 1998):

- Traffic problems following the implementation of a scheme are usually far less serious than predicted,
- After an initial period of adjustment, some of the traffic that was previously found in the vicinity of the scheme 'disappears' or 'evaporates', due to drivers changing their travel behavior,
- As a result the urban environment becomes more livable in many respects.

In addition, there are many innovations and transport management strategies and initiatives that can be regarded to achieve more sustainable transportation system. Some of these could be listed as below (Litman, 2006):

- Parking management strategies,
- Public transport initiatives,
- Walking and bicycling initiatives,
- Smart growth strategies and initiatives.

Parking is an essential component of the transportation system. Vehicles must park at every destination. A typical automobile is parked 23 hours each day, and uses several parking spaces each week (Litman, 2006).

Parking facilities are a major cost to society, and parking conflicts are among the most common problems facing designers, operators, planners and other officials. Such problems can be often defined either in terms of supply (too few spaces are available, somebody must build more) or in terms of management (available facilities are used inefficiently and should be better managed). Management solutions tend to be better than expanding supply because they support more sustainable transportation (Litman, 2006).

Vehicle parking is particularly appropriate for reform (Shoup, 1999). Current parking planning practices tend to favor generous parking supply and minimal parking prices, which have unintended and undesirable consequences: they increase development costs, reduce housing affordability, cause dispersed land use patterns (commonly called *sprawl*), and increase automobile travel which exacerbates various problems including traffic congestion, roadway costs, crashes and pollution emissions. As a result, many professional organizations and planners recommend parking planning and management reforms (Litman, 2006).

Parking management refers to policies and programs that result in more efficient use of parking resources. When appropriately applied parking management can significantly reduce the number of parking spaces required in a particular situation, providing a variety of economic, social and environmental benefits. When all impacts are considered, improved management is often the best solution to parking problems.

Some of the potential parking strategies are listed below. They are explained in more detail in the literature review part with their impacts.

- Shared Parking,
- Parking Pricing,
- Unbundled Parking,
- Financial Incentives (Cashing-Out Employer-Provided Parking),
- Parking Regulation,
- More Flexible Standards,
- Increasing the Price of Parking, Based on a Tax on Revenues,
- Increasing the Price of Parking, Based on a Tax on Parking Spaces,
- Parking Impact Fees,
- Restrict Parking Supply by Changing Zoning Ordinances,
- Combinations of the Above Strategies

These strategies are technically feasible, cost effective, and can provide many benefits to users and communities. Although all of these strategies have been implemented successfully, in some situations they are not being implemented as much as economically justified, due to various institutional barriers. Parking management implementation requires changing the way we think about parking problems and expanding the range of options and impacts considered during planning.

Most parking management strategies have modest individual impacts, typically reducing parking requirements by 5-15%, but their impacts are cumulative and synergistic. A comprehensive parking management program that includes an appropriate combination of cost-effective strategies can usually reduce the amount of parking required at a destination by 20-40%, while providing additional social and economic benefits (Litman, 2006).

1.4. Scope, Objectives and Goals

The major goal of this research is to understand the nature and the level of the existing parking problem in Istanbul and to suggest some possible strategies that could be used generally and/or in particular parts of Istanbul. To reach this goal this research focused on the objectives listed below:

- To search the literature about the old and new concepts in parking management strategies,
- To study the nature and level of the parking problem in Istanbul through the existing data sources and new parking studies,
- To recommend parking strategies for Istanbul in general and the pilot study area in particular.

2. LITERATURE REVIEW OF THE PARKING MANAGEMENT PRINCIPLES AND STRATEGIES

Transport is a key factor in modern economies. However, there is a permanent contradiction between society, which demands ever more mobility, and public opinion, which is becoming increasingly intolerant of chronic delays and the poor quality of some transport services. As demand for transport keeps increasing, the Community's answer cannot be just to build new infrastructure and open up markets. The transport system needs to be optimized to meet the demands of enlargement and sustainable development, as set out in the conclusions of the Gothenburg European Council (White Paper, 2001). A modern transport system must be sustainable from an economic and social as well as an environmental viewpoint.

A sustainable transportation system operates fairly and efficiently. It also supports a competitive economy by offering a choice of transport mode. Furthermore, a sustainable transportation system allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and eco-system health, and promotes equity within and between successive generations. Not least but certainly last, a sustainable transportation system limits emissions and waste within the planet's ability to absorb them by the use of renewable and environmental-friendly resources (Center of Sustainable Transport, Government of Western Australia, 2002).

Parking management strategies are important transport management strategies that can be reconsidered to achieve more sustainable transportation system. These strategies are concerned in more detail in the following paragraphs.

2.1. Existing Situation in Istanbul

2.1.1. Geography and Population

Being one of the biggest cities in the world, Istanbul is the largest city in Turkey with an area of more than 5750 km^2 and a population of around 12 million (Organization of

Turkish Statistics, 2005). It is spread into the Asian and European side by Bosporus Strait (connects the Black Sea to the Sea of Marmara and the Mediterranean Sea). A hilly terrain is a distinguishing feature of Istanbul. Referring to the data of Organization of Turkish Statistics in 2003, around 65% of the population was living on the European side of the city which is generally an industrial-commercial area.

As with many other metropolises, Istanbul has also been encountering problems of sustainability due to a severe increase in population, urban sprawl and highway dependency. The city is highly urbanized with its average population density of 89 persons/ha (Alpkokin *et al.*, 2005), and still keeps on growing with an annual rate of 4.3%. As it is shown in the Figure 2.1 the Organization of Turkish Statistics (2004) estimates that the population will increase to 13 million by 2010.

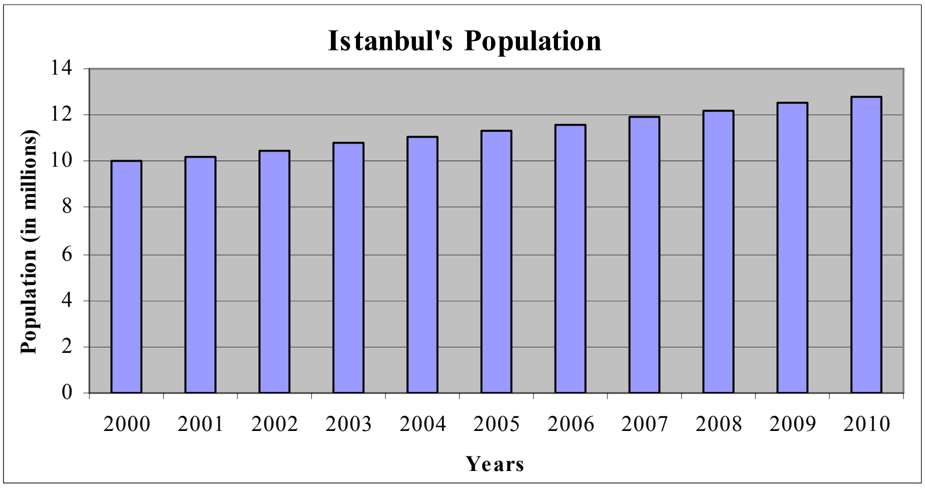


Figure 2.1. Expected Population of Istanbul (Organization of Turkish Statistics, www.tuik.gov.tr, 2005)

Residential, industrial, recreational, agricultural and forest areas, commercial, institutional and military sites all make up the land use mosaic of Istanbul. The distribution of residential, commercial, and institutional uses occupies a small area compared to spaces dedicated to forests and water resources.

2.1.2. The Mode and Network Features

The road infrastructure of the city consists of about 6000 km road network (Istanbul Municipality, 2006) and about two thirds (4000 km) of it serves for the Istanbul's traffic. The rest of streets serve transport within residential areas and special usage areas.

Table 2.1 summarizes the public transportation infrastructure of Istanbul. With route length of 448.000 km, 7.889 stations, 4.437 units, 468 lines, and about 1.2 million daily passengers, bus is the most used public transportation mode in Istanbul. Note that, the rail system in Istanbul, which adds up to a total of 130 km comprising Light rail, Metro, Tram, Regional Rail, and Funicular, is very short for such a large and densely populated city.

Table 2.1. A summary of transportation infrastructure in Istanbul, (Public Transport Organization of Istanbul, 2006), (Wikipedia, 2006)

	Light Metro	Metro	Tram	Regional Rail	Funicular	Bus	Sea	TOT
Route Length (km)	19,3	8,5	23	77	1,2	448.000	-	448129
No. of Stations	18	6	44	56	4	7.889	33	8017
No of units	37	8	55	-	3	4.437	41	4540
Lines	1	1	3	2	2	468	33	477
Passenger-trip per day	200.000	130.000	157.000	468.000	30.000	1.191.780	167.123	2176780

As can be seen in Figure 2.2, about half of all travelers in Istanbul who use public transport use buses for their travel. The regional rail consists of only 20% of all public transport users. Sea travel (7%) is very low for a city like Istanbul that has a suitable geographical condition for sea transportation.

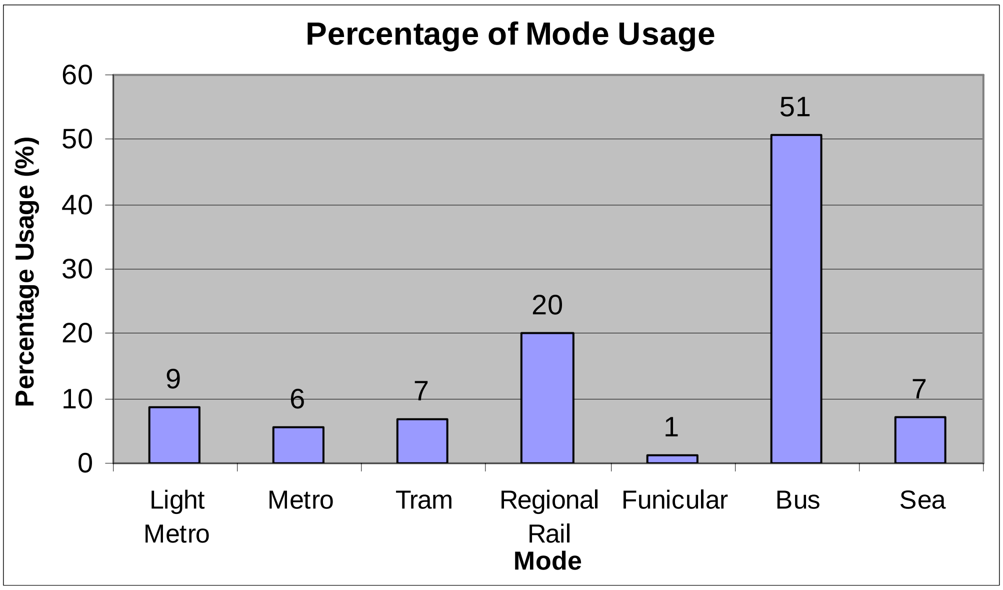


Figure 2.2. Percentage of public transportation mode usage in Istanbul (The State Institute of Statistics, www.tuik.gov.tr, 2005)

2.1.3. Private Car Trends and Vehicle Ownership

Istanbul's motorization trends faced a significant increase during the last two years, mainly because of the economic growth of the country (Figure 2.3). Due to better economic conditions and higher incomes, car ownership has become much more affordable than before. It is obvious from the graph that the number of cars in Istanbul raised slightly from 1995 to 2000. This was followed by a mild decrease resulting by the 2000 economic crisis in Turkey. Between 2003 and 2005 the number of private automobiles increased significantly from 900,000 to 1.6 million units.

It is calculated that 500-600 cars enter to the heavy traffic of Istanbul every day (Organization of Turkish Statistics, 2005). The number of vehicles in Istanbul is measured to be about 2.5 million and about one million of them are continuously in motion during a working day (ISPARK, 2006).

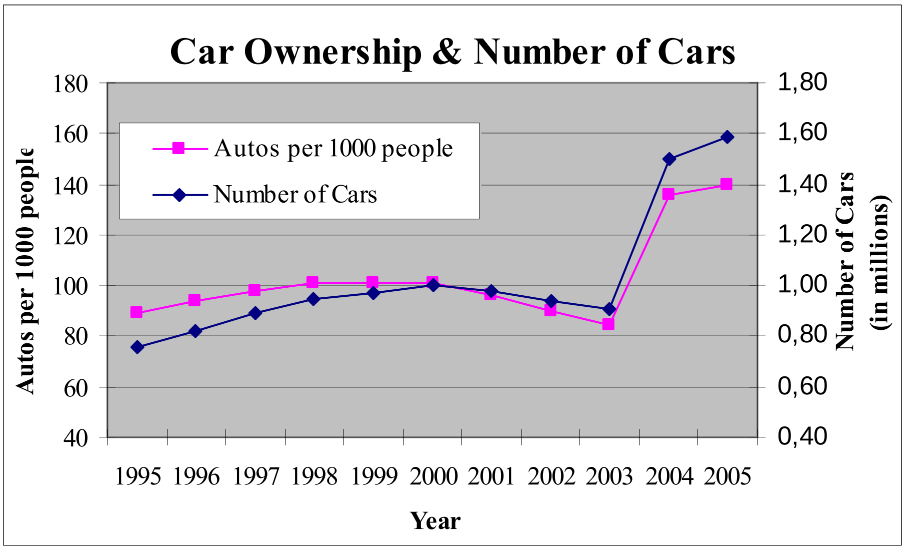


Figure 2.3. Fluctuation of car ownership and number of cars in Istanbul from 1995 to 2005 (Organization of Turkish Statistics, 2005)

As it is shown in Figure 2.4 private car (71%) is the most dominant vehicle type in Istanbul. According to a study made in Istanbul (Ergün and Şahin, 2006) trips made by private car mode (31%) are still the leader among all modes in Istanbul. These results show that Istanbul transportation is significantly based on private automobiles. Furthermore, Figure 2.4 depicts the relatively significant percentages of small Lorries (16%) and Trucks (5%) which are an indication of commercial and light industry land use type.

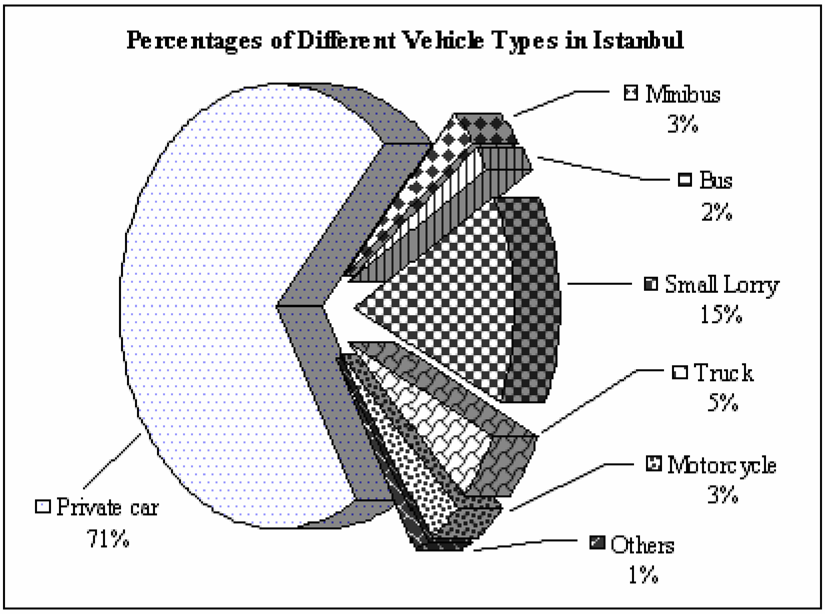


Figure 2.4. The percentage of different vehicle types in Istanbul (www.tuik.gov.tr, 2005)

2.1.4. Parking

Parking problem comprises a very important problem in Istanbul's transportation. As indicated in a study conducted by Istanbul Municipality (http://www.ibb.gov.tr, 2003), parking planning should be to decrease the influence of parked vehicles to the traffic to minimum, to shift the commuters to public transport, and to prevent traffic congestion. This study was the first study in Istanbul regarding the parking inventory. The study indicated that, there were 1630 parking facilities with a total parking space capacity about 228.110 spaces. However, the required parking space number in Istanbul was calculated as 800.000 spaces. Faced with this shortage, the authorities planned 268 parking facilities; 139 underground garages, 118 parking lots, and 11 surface garages, with a total capacity of 214.000 more parking spaces in 26 districts.

As stated in the report (www.ibb.gov.tr, 2003) the main goal of Istanbul Municipality is to centralize and control the management of parking facilities. Parking facilities in Istanbul are operated mostly by vendors. Some unauthorized individuals collect parking charges from on-street parkers, even though the spaces are part of the roads which are under the control of the Municipality. Istanbul Municipality decided to centralize the whole parking system to cope with all these problems. ISPARK, the parking Management Organization, has been operating under Istanbul Municipality for 6 month.

According to the data of ISPARK (Istanbul's Parking Management Organization) (www.ispark.com.tr, 2006), 90% of parking in Istanbul is surface parking. By December 2006, ISPARK controls parking in 159 locations (off-street and on-street) consisting of 8.903 parking spaces in European side. In the Asian side it operates in 68 locations with a capacity of 7.256 parking spaces. These figures add up to 227 locations with 16159 parking spaces. It should be noted that, this number is continuously increasing day by day as their influence in the area increases.

2.2. Proximity: Walking Distances From Parking to Destination

The longest walking distances that drivers will tolerate vary with trip purpose and urban area size. Generally these tolerable walking distances are longer for work trips than for any other type of trip, perhaps because of long duration involved. Longer walking distances are tolerated for off-street parking spaces as opposed to on-street (curb) parking spaces. As the urban area increases, longer walking distances are experienced.

The willingness of drivers to walk certain distances to (or from) their destination to their car must be well understood, as it will have significant influence over where parking capacity must be provided. Under any conditions, drivers tend to seek parking spaces as close as possible to their destination.

Table 2.2 shows the distribution of walking distances between parking places and final destinations in urban areas. The distribution is based on studies in five different cities (Atlanta, Pittsburg, Dallas, Denver, and Seattle), as reported in 1990 (Weant, R. and Levinson, H.). As indicated in this table, parkers like to be close to their destination. One-half of the drivers park within 500 ft (155m) of their destination.

Table 2.2. CBD walking distances to parking spaces (Weant, R. and Levinson, H. 1990)

Distance	% Walking This Distance or Further	
Feet	Mean	Range
0	100	
250	70	60 - 80
500	50	40 - 60
750	35	25 - 45
1000	27	17 - 37
1500	16	8 - 24
2000	10	15 - 15
3000	4	0 - 8
4000	3	0 - 6
5000+	1	0 - 2

Figure 2.5 shows average walking distances to and from parking spaces vs. the total urban area population. Again, this data emphasizes the need to place parking capacity in close proximity to the destination(s) served. In an urban region of 12.000.000 population like Istanbul, the average walking distance to parking place is approximately 950f ft (300m).

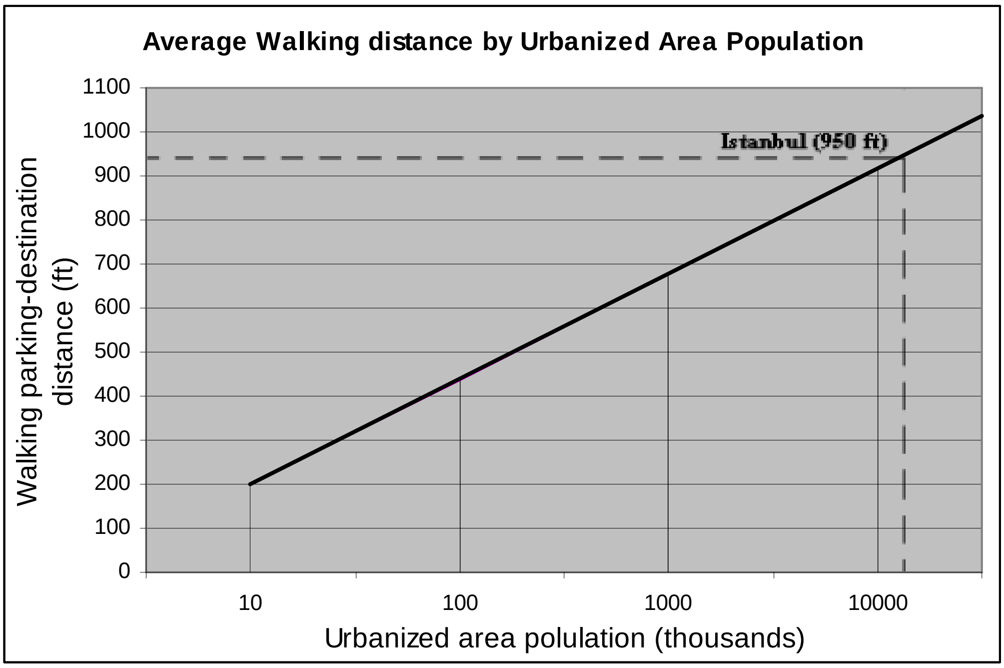


Figure 2.5. Average walking distance by urbanized area population (Weant, R. and Levinson, H. 1990)

2.3. Transportation Demand Management Principles

The biggest struggle is made toward the Transportation Demand Management (TDM) principles. TDM consists of management strategies that result in more efficient use of existing transportation resources. This is very beneficial when all effects are taken into consideration. The fundamentals of this model are (Litman, 2005):

- To improve basic mobility services (i.e. walking, public transit services, road system management) and,
- To encourage efficiency of these services, instead of constructing more roads or parking spaces.

TDM, named also Mobility Management (MM), takes into account the value and costs of each trip when prioritizing trips. It gives higher value trips and lower cost modes priority over lower value, higher cost travel, so that it increases overall system efficiency. It gives priority to ridesharing, public transport and non-motorized travel especially for congested areas like Istanbul by basing the emphasis on people and goods movement rather than on vehicles.

The new paradigm that TDM considers for parking facilities is the efficient usage of parking spaces by improving the travelers' information system. Furthermore, shared parking is another strategy that improves the efficiency of parking lots and garages. In addition, parking pricing is a very useful method by discouraging vehicle usage and directly charging the user and not charging the non-user, fulfilling the equity principle. Some other strategies could be included as; parking management, commute trip reduction, smart growth, and commuter financial incentives.

The most effective TDM strategies are those that include financial incentives (Litman, 2006). These applications tend to have a stronger impact on travel behavior. Furthermore, the impact of a TDM program will depend on the travel alternatives available. A program will have more impact if the site is served by frequent transit, for instance.

2.4. Parking Management

Parking facilities are an essential component of the transport system, because every vehicle requires a space for parking at its destination. As a result parking is one of the first things that people think of when traveling. Parking supply is a crucial part of the transport system and should be handled properly in order not to create other concerns like spillover parking problems. An adequate, comfortable, easy to find, free, near to the destination, and cheap parking has been the most fundamental requirements of drivers for years.

Nevertheless, providing a space for every vehicle in any time, especially in Istanbul with a high number of vehicles, not only burdens a financial cost on governments but also imposes an environmental problem on the whole population (European Commission, 2004). The number of walkable and livable communities are becoming less and less. This have made the researchers search for better planning models that will be beneficial directly as well as indirectly for the community.

Parking Management includes a variety of strategies that encourage more efficient use of existing parking facilities, improve the quality of service provided to parking facility users and improve parking facility design (Litman, 2006). On the other hand, Parking Management can help address a wide range of transportation problems and help achieve a variety of transportation, land use development, economic, and environmental objectives.

Current parking requirements are often inflexible and generous, applied with little consideration to specific geographic and demographic factors that affect parking demand at a particular location (Shoup, 1999; CTR, 1999; Litman, 1999; Millard-Ball, 2002). Parking requirements are based on parking generation studies made in suburban cities leading to standards that tend to be excessive in urban areas (Shoup, 2002).

More accurate and flexible parking requirements mean that parking standards reflect the parking demand and costs at a particular location, taking into account geographic, demographic, economic, and management factors. This allows parking requirements to be reduced in exchange for implementation of specific parking and mobility management strategies, such as: shared parking, parking cash out, transit and ride share, and priced parking.

The biggest concern about parking is the high fluctuation of parking usage between peak and off-peak parking periods (Figure 2.6).

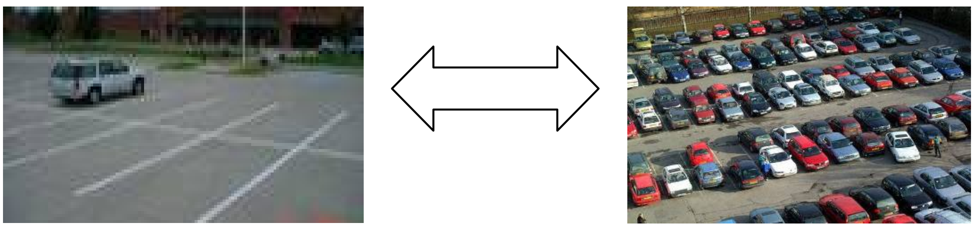


Figure 2.6. Fluctuation of parked vehicles

Litman (2006) considered parking management as a better solution than supply expansion. He put strong emphasize on parking management because it supports more strategic planning targets by:

- Stimulating use of other modes and reducing vehicle usage,

- Reducing development cost and increasing affordability,
- Creating more compact multi-modal community planning (smart growth),
- Avoiding environmental concerns and improving aesthetics.

As it is shown in Figure 2.7 the parking generation supply is a crucial component of the automobile dependency cycle. The need for parking supply is increased by automobile oriented land use planning. As a result of this parking supply generation, formation of dispersed development patterns is inevitable. The loop in Figure 2.7 encourages vehicle usage, decreases alternative modes and creates urban sprawl. One of the most efficient elements that could help to break this cycle is parking management.

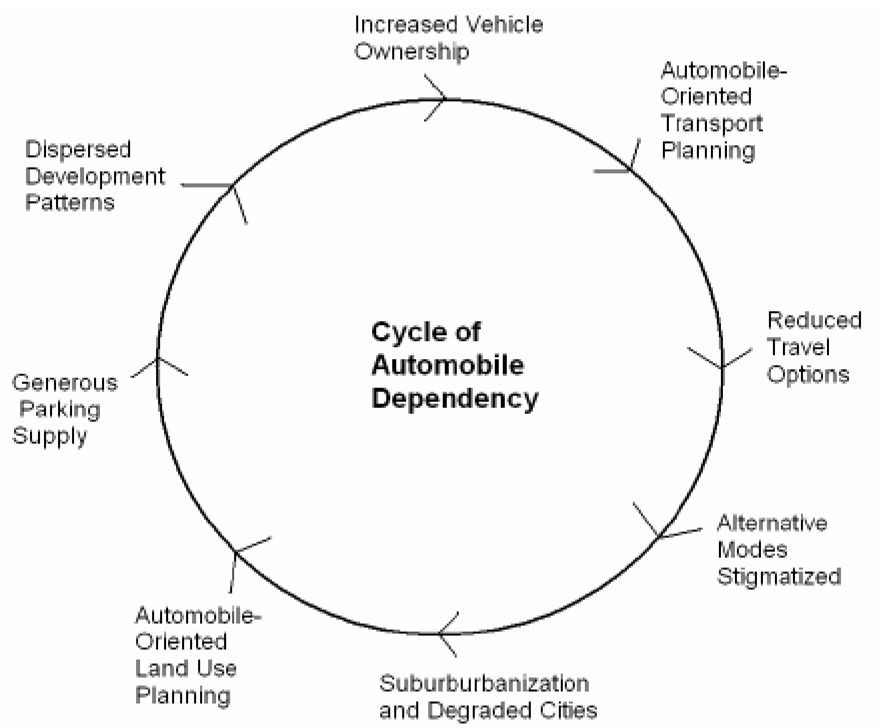


Figure 2.7. Vicious cycle of automobile dependency (Litman, 2006)

Reducing reliance on private automobile, shifting travelers' and goods' movement to other modes and increasing transit ridership has appeared as the major objective of planners and policymakers at all levels. They have formulated some strategies some of which have been tested and have indicated good results and some others have not been applied yet due to lack of political and institutional reforms but are expected to show beneficial outcomes. The most important strategies would be:

- Shared Parking,
- Parking Pricing,
- Unbundled Parking,
- Financial Incentives (Cashing-Out Employer-Provided Parking),
- Parking Regulation,
- More Flexible Standards,
- Increasing the Price of Parking, Based on a Tax on Revenues,
- Increasing the Price of Parking, Based on a Tax on Parking Spaces,
- Parking Impact Fees,
- Restrict Parking Supply by Changing Zoning Ordinances,
- Combinations of the Above Strategies

2.4.1. Parking Pricing

Most vehicle parking is provided free or significantly subsidized. Many people who commute by their vehicles are not charged for their usage of the parking facilities. About 90 percent of all customer and employee parking in the U.S. is free (Bianco *at al.*, 1999). However, the planning, the construction, and the maintenance costs of these facilities are paid by the whole community in the form of higher taxes, retail prices, and reduced profits. This situation in essence violates the principle of the equity by not differentiating users from non-users. As a result, parking users pay only an undervalued (low) amount of these costs which in turn encourages them to use their automobiles.

Parking pricing is a direct charge for usage of parking facilities. Parking pricing has an essential effect on a wide spectrum. To begin with, by paying directly for parking facility usage drivers attempt to reduce their driving frequencies and choose other cheaper travel modes like walking, transit, carpooling, and ridesharing. As a result, vehicle traffic is reduced in these areas and other modes improve due to their share increase. Furthermore, parking pricing plays an important role as revenue generation for other purposes. For instance, instead of incorporating parking facility costs into building rents and mortgages, charging commuters directly for using parking may increase property revenues or reduce building rental fees. These generations can also be used for downtown and CBD areas' improvements and/or local transportation programs. Hence, parking pricing can be used as a very efficient parking management strategy. By undertaking some management regulations it can reduce parking concerns in a specific location. Last but not least, the combination of all these objectives will have a very beneficial effect.

There are some key factors to be considered when deciding about parking prices. These can be listed as follows:

- Apply marketing principles,
- On-street parking prices should be higher than of-street ones,
- Price for short time intervals like 30-min, hourly, or daily intervals instead of leasing by the month,
- Put higher prices for peak hours parking,
- Price the most convenient parking spaces for customers and clients, with minute or hourly rates,
- Use a progressive price structure in more convenient spaces to favor short-term users,
- Charge for parking to equal or exceed transit fares,
- Provide free or discounted parking to rideshare vehicles,
- Limit use of on-street parking to area residents,
- Price on-street parking in residential neighborhoods.

In general, the on-street spaces in commercial areas are often filled, while other less convenient spaces like parking lots behind buildings are often unoccupied. Shoup (2005) indicated that 8-74% of urban traffic congestion is caused by vehicles cruising for on-street parking, and motorists spend an average of 3.5 to 13.9 minutes finding a curb parking space, both indications of inefficiency due to underpricing.

2.4.2. Shared Parking

One of the most effective applications of reducing parking spaces is shared parking. The City of Portland's zoning regulations (Bianco *at al.*, 1999) define shared parking as the "joint use of required parking spaces . . . where two or more uses on the same or separate sites are able to share the same parking spaces because their demands occur at different times". Table 2.2 shows typical peak parking periods for various land uses. Combining parking for different land uses which have different peak parking periods decreases significantly the number of parking spaces required. For example, parking facilities of offices and other employment centers (weekday) can be used by restaurants (evening), banks and public services (weekday) can be used by theatres (evening), and parking spaces of schools (weekday) can be used during football games (weekend).

Table 2.3. Typical peak parking periods for various land uses (Litman, 2006)

Weekday	**Evening**	**Weekend**
Banks and public services Offices and other employment centers Park & Ride facilities Schools, daycare centers and colleges Factories and distribution centers Medical clinics Professional services	Auditoriums Bars and dance halls Meeting halls Restaurants Theaters Hotels	Religious institutions Parks Shops and malls Football matches

Sharing parking spaces typically account for 10–30% more users than if each motorist is assigned a space (Litman, 2006). This result is more successful if destinations have different peak periods or if they share patrons, thus motorists are able to park at one facility and walk to multiple destinations.

Furthermore, sharing can involve mixing land uses on single site, such as a mall or campus, or by creating a sharing arrangement between sites located suitably close together. Although, shared parking would have no direct impact on transit ridership, it may indirectly encourage transit usage because the strategy would promote more compact and denser developments, as establishments "cluster" around their shared parking facilities.

Finally, developers and firms can benefit from shared parking because they save on monetary outlays in providing exclusive parking spaces. However, special attention should be drawn to spillover parking onto unmetered on-street spaces may also follow, if shared parking results in inadequate parking of off-street supply.

2.4.3. Unbundled Parking

Unpriced parking is often "bundled" with building costs, which means that a certain number of spaces are automatically included with building purchases or leases. Unbundling Parking means that parking is sold or rented separately. For example, rather than renting an apartment for 1200YTL per month with a parking space at no extra cost, each apartment can be rented for 1000YTL per month, plus 200YTL per month for each parking space. Occupants only pay for the parking spaces they actually need. This is more efficient and fair, since occupants save money when they reduce parking demand. They are not forced to pay for parking they do not need, and can adjust their parking supply as their needs change.

For this to function efficiently, building owners must be able to lease or sell excess parking spaces, and local officials should regulate nearby on-street parking to avoid spillover problems that could result if residents use on-street parking to avoid paying rents for parking spaces.

2.4.4. Financial Incentives (Cashing-Out Employer-Provided Parking)

In order to encourage the alternative mode usage and reduce use of parking especially during peak periods, commuters are offered financial incentives. These incentives tend to reduce automobile commuting by 15-25%, and are fairer, since they give non-drivers benefits comparable to those offered motorists (Litman, 2006).

Cashing-out employer-provided parking is a strategy whereby employees get the cash equivalent of any parking benefit provided, so they could then either spend that cash toward paying for the parking (rather than continuing to receive it free) or spend it toward any other modes, including transit. These benefits express the cost saving that result from reduced parking demand. Thus, the commuters consider these options because they provide positive rewards for those who reduce vehicle trips leading to a decrease in parking demand. This financial incentive stimulates businesses to implement commute trip reduction programs for their employees indicating satisfactory effects about 20% reduction of automobile commuting (Litman, 2006).

However, there are some limitations considering employees who cannot benefit from this strategy. The cash-out amount is limited only to those employees to whom employers presently offer subsidized parking. Furthermore, employers who lease parking are forbidden from cashing-out. This is due to the reason that, it is easer to impute a cash value to that parking than to parking that the employer own.

Those who would benefit from strategy are employees to whom employers offer this option that they did not have before. The more commuters use this option, the higher the transit share will be. The higher the transit share is, the better the transit service will be. Thus, this increase stimulates centralization over the long run making CBD retails better off. Although some spillover parking may result, cashing-out is a revenue neutral strategy that is designed to produce few negative effects.

2.4.5. Parking Regulations

In order to prioritize parking facility use, some parking regulations are applied. Parking regulations control who, when, and how long vehicles can use the parking facility.

First of all, parking regulations control the type of vehicles that could use the parking facility. Different spaces dedicated to loading, service, taxis, customers, rideshare vehicles, disabled users, buses and trucks. Employer restrictions encourage employees to use less convenient parking spaces. Whereas residential permits give area residents priority uses of parking near their homes. Large vehicle restrictions are also applied because they limit on-street parking of large vehicles, such as freight trucks and trailers.

Secondly, the parking regulations control the time of parking. Time period restrictions, for instance, are used to prohibit occupancy at certain times, such as before 10 AM, to discourage employee use, or between 10 PM and 5 AM to discourage resident use. On the other hand, overnight parking restrictions discourage use by residents and campers.

Finally, how long vehicles can use the parking facility can be controlled by parking regulations. Limit parking duration such as 5-minute loading zones, 30-minutes adjacent to shop entrances, 1- or 2-hour limits, are generally used for different trip purposes.

2.4.6. More Flexible Standards

Standards have to be adjusted to the conditions and features of each area in particular. Factors shown in Table 2.3 are considered to adjust the standards to different regions.

Table 2.4. Parking requirement adjustment factors (Litman, 2006)

Factor	Description
Geographic Location	Vehicle ownership and use rates in an area.
Residential Density	Number of residents or housing units per acre/hectare.
Employment Density	Number of employees per acre.
Land Use Mix	Range of land uses located within convenient walking distance.
Transit Accessibility	Nearby transit service frequency and quality.
Carsharing	Whether a carsharing service is located nearby.
Walkability	Walking environment quality.
Demographics	Age and physical ability of residents or commuters.
Income	Average income of residents or commuters.
HousingTenure	Whether housing are owned or rented.
Pricing	Parking that is priced, unbundled or cashed out.
Unbundling Parking	Parking sold or rented separately from building space.
Parking &Mobility Management	Parking and mobility management programs are implemented at a site.
Design Hour	Number of allowable annual hours a parking facility may fill.
Contingency- Based Planning	Use lower-bound requirements, and implement additional strategies if needed.

2.4.7. Increasing the Price of Parking, Based on a Tax on Revenues

One efficient way to encourage park pricing is to tax the revenues that parking providers get. In addition to the private cost, imposing on motorists the social cost of driving is the most outstanding economic cause for applying this tax. The targets of this strategy are central business districts (CBD) and highly populated areas, those which actually generates these revenues.

Past researches indicate that a 20 % tax on revenues is estimated to result in 7% increase in transit share for home-based work trips region-wide (Bianco *at al*, 1999). However, the transit level plays a very important role in claiming this increase. This strategy will be beneficial if the application is executed in an area with high level transit service, and may even worsen the existing conditions if it is applied in a region with low level of transit service. Furthermore, the size of the tax is also a very crucial indicator of the effectiveness of this strategy.

In general, this increase in transit share result in a decrease of travel and parking congestion which in essence makes traveler better off. On the other hand, motorist who cannot afford this price are badly affected by this strategy. However, policy makers can use these revenues to reimburse those who are worse off. Moreover, special attention should be kept when deciding the percentage of the tax. If the tax is low, the modal shift is very slight. On the other side, if the tax is high, it may decrease the vehicle usage but stimulate decentralization in long run. The tax on parking revenues appears to be primarily for revenue generation and is largely unrelated to transportation policy in general.

2.4.8. Increasing the Price of Parking, Based on a Tax on Parking Spaces

Instead of taxing revenues, as described above, taxing actual parking spaces is another way of encouraging parking pricing. The best advantage of this strategy is that it affects all parking independent of their location and density, whether CBD area or suburb. However, parking should be presently priced in order to apply this approach.

The crucial point of this model is that parking suppliers are likely to pass all or a high percentage of this tax on to automobile users, charging them directly by a higher fee. As a consequence, this situation will stimulate them to shift to other modes like walking, transit, carpooling, and ridesharing. A $1 tax per space is estimated to result in a 22% increase in transit share for the home-based work-trip region-wide (City of Portland, 1975). A higher percentage of tax is passed on drivers in CBD area than in suburb because there are fewer opportunities for spill over in CBD areas.

On the other side, this approach, like the tax on parking revenues, may encourage decentralization over the long run. Thus, this may result in a shift of firms from CBD area to suburb. Furthermore, spillover parking onto unmetered on-street spaces is another disadvantage of this approach.

Like the tax on parking revenues, this strategy may stimulate decentralization over the long term, as CBD employees and firms might find suburban locations more attractive, though this effect may be offset if firms have to absorb a larger proportion of the tax in such areas.

2.4.9. Parking Impact Fees

Increasing the number of parking spaces by constructing new parking facilities not only creates a construction cost, but also generates a cost to the whole transportation system. Government and/or local authorities would impose a one-time fee on developers to cover this cost. The developers are charged for the number of spaces that they provide. The more spaces provided, the higher the fee will be. As a result parking impact fees encourage developers to supply only the amount of parking actually needed.

“Making development pay its own way” (City of Portland, 1995) is currently a popular notion among planners and policy-makers. Although parking impact fees affect regions of new development only, they have a considerable influence in long run. People living in and users of already developed areas benefit most from this strategy. However, developers and users of newly developed areas would be worse of because they will compensate this cost in the form of higher prices.

Because the developers would not provide extensive parking spaces due to parking impact fees, this situation will encourage more compact development in newly grown regions. This outcome is appreciated by many policy-makers and environmentalists because it stimulates slow growth. However, parking impact fees may lead to an increase in traffic of those areas. Furthermore, this strategy may bring about spillover parking concerns if the fees result in insufficient parking supply. As a consequence, as long as parking supply standards are high; this strategy will encourage a more efficient parking supply.

2.4.10. Restrict Parking Supply by Changing Zoning Ordinances

Many planners have based their assumptions on the minimum parking requirements for many years. Zoning ordinances often contain minimum parking requirements to ensure adequate parking supply and to discourage spillover parking during peak periods. The most essential factor in applying minimum parking requirements is considering the peak (maximum) use of the parking demand and then deciding about the number of the spaces according to this number. However, this old paradigm often results in excess supply during the off-peak periods (Shaw, J, 1997)

According to a study in City of Portland, (1995) the emphasizes are put on three main zoning ordinances as follows; imposing maximum parking requirements, decreasing minimum parking requirements, and issuing conditional-use permits. To start with, a new approach is to impose parking maximums. Parking Maximums means that an upper limit is placed on parking supply, rather than a minimum, either at individual sites or in an area. They often apply to specific types of parking, like surface, long-term, free, or singe-use parking. Furthermore, another way to regulate zoning ordinances is to diminish the minimum parking requirements. This is done in order to decrease the difference between peak and off-peak parking demands, thus bringing them closer. Finally, sometimes local municipalities may accept conditional-use for some developers that supply a lower amount of spaces than minimum required or even no spaces. In general, in such conditions cities invokes suppliers to pay money into in-lieu found or other transport modes in exchange of providing parking spaces within the building. Cities also encourage developers to unbundle parking from the buildings by applying in-lieu fund approach.

It is expected that these models has a great effect on other modes especially in transit share depending on the region conditions. These changes are applied in areas of new growth and would impact a small percentage of drivers. Those who benefit from these strategies are developers that will reduce building costs as a result of reducing number of parking spaces. They may encourage a more compact development. Special attention should be drawn to spillover problems when either minimums or maximums lead to insufficient supply.

2.4.11. Combinations of the Above Strategies

Although some strategies may be very beneficial in some aspect on the other hand they might be ineffective or harmful in some other ones. Thus, instead of applying only one strategy at a particular area, using a combination of two or three of them might show very good effects. For example, pricing parking and shared parking strategies can be applied together. Thus, they can reduce parking spaces, generate revenues, reduce traffic, and create a compact area. When deciding about these combinations the following factors have to be kept in mind:

- Other modes’ improvements like transit, walking, ridesharing, and carpooling have to be a crucial component of these packages. This will attractive alternative for motorists who shift to this modes,
- These combinations has to address spillover parking problems, strong decentralizing trends or other negative effects from individual strategies,
- By considering these packages, at least one revenue-producing strategy has to be included to support financial requirements for implementation or compensation,
- Each combination should be applicable only in a specific geographic areas and specific parking problems, not the same package everywhere,
- Packages have to be region-wide and appropriate for the current situation.

3. METHODOLOGY

The establishment of the methodology for Parking Management in Istanbul based on sustainable transportation concepts is one of the objectives of this study.

Comprehending the real parking situation in Istanbul is a necessary step prior to drawing conclusions. Deciding on different parking strategies without knowing very well the actual picture may result not only in unsolved problems, but even in deterioration of the situation. Furthermore, not only qualitative measures but also quantitative ones are very essential in policy-making decisions. This is because the quantitative results are compared very easily with each other and/or with appropriative standards.

As a consequence, this research comprises some detailed inventories and results which can help in better indicating the parking problems of Istanbul, analyzing it, and then deciding some sound and possible strategies.

3.1. Stages in Parking Management

The proposed methodology for the thesis research is basically summarized in the Figure 3.1. The flow chart shown in Figure 3.1 indicates the steps that have to be followed in the parking management methodology.

To begin with, searching the literature for parking management and parking strategies (A) was the first stage of the methodology. First, parking search on the internet and libraries about parking management is conducted. Then, a more comprehensive and detailed review of the collected information was carried on. Both, old and new concepts were reviewed to understand the advantages and disadvantages of different approaches. Beneficial information was also gathered from the cities that applied different parking management strategies. A special attention is drawn to the experienced difficulties and problems as well as to the benefits that these strategies showed in different cities. Finally, the most successful parking management strategies are summarized.

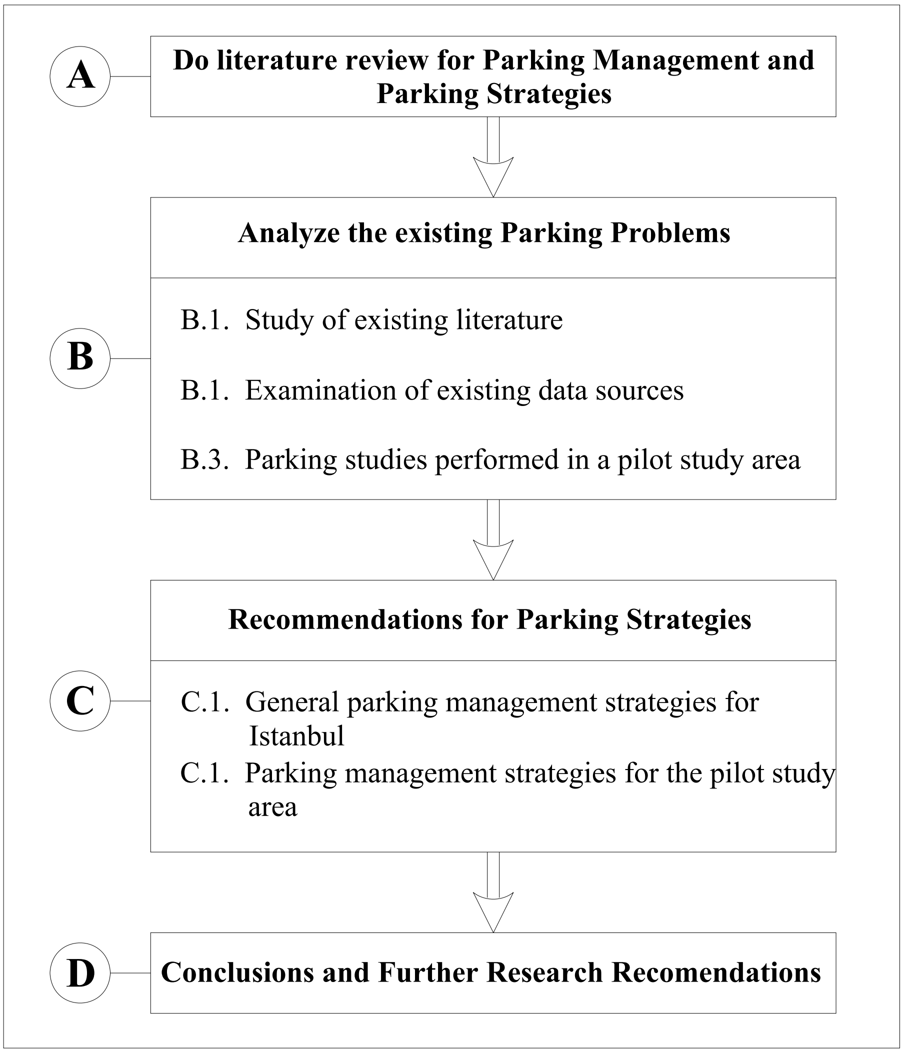


Figure 3.1. Flow chart for parking management

Analyzing the existing parking problems was the next step shown in the flow chart (Figure 3.1). This stage consisted of three sub-stages such as: study of the existing literature (B.1), examination of data sources (B.2), and parking studies performed in pilot study area (B.3). Existing literature regarding the parking situation in Istanbul was studied first. The problems that existing research point out about parking management in Istanbul and the solutions suggested by them, were analyzed in detail. Then, the existing data sources that were related to parking management in Istanbul were examined. Results from pilot study areas were very important. Questionnaires about parking were also considered because they indicated public attitudes about parking. Finally, region-wide pilot parking studies were conducted to understand the existing parking situation. Different inventories were conducted to collect the required information about some parameters that were used in the analysis stage.

The third step (C) considers the recommendations for parking management strategies. Parking management strategies both for Istanbul and for the pilot study area were recommended. The proposed strategies were assessed though effectiveness, economic efficiency, and ease of implementation and administration dimensions.

The final step (D) consists of the conclusions and further research recommendations. Lessons learned from this research and other recommended researches about parking management in Istanbul were discussed.

3.2. Applied Methodology in Fulya Pilot Study Area

The applied methodology in Fulya pilot study area was composed of the stages summarized in the scheme shown in the Figure 3.2. The first stage of the flow diagram was the selection and codification of the study area. This region had to consist of different land-uses in order to be a representative of Istanbul. Blocks and streets were codified to simplify the data collection process. Inventories for parking facilities were conducted in the second phase. On-street and off-street parking inventories were made in order to gather information about the type, condition, number of spaces, and location of the facilities. Furthermore, other information about parking rates, time restrictions, and physical layout were collected. The third stage was a license plate survey which was for the calculation of parameters, such as parking duration, accumulation, demand etc. After the license plate survey was conducted, all data sheets were coded to computer format so that we could be able to compute accumulation, fluctuation, turnover, and demand for each street, block, and the whole region (4^{th} step).

The violations of the rules and/or illegally parked vehicles were detected by field observations in the pilot study area (5^{th} step). Some of these problems were also explored during the conduction of license plate survey. Apart from the above mentioned problems, difficulty in finding an empty space and/or slowing down of the traffic which some times may create spillover problems were also indicated.

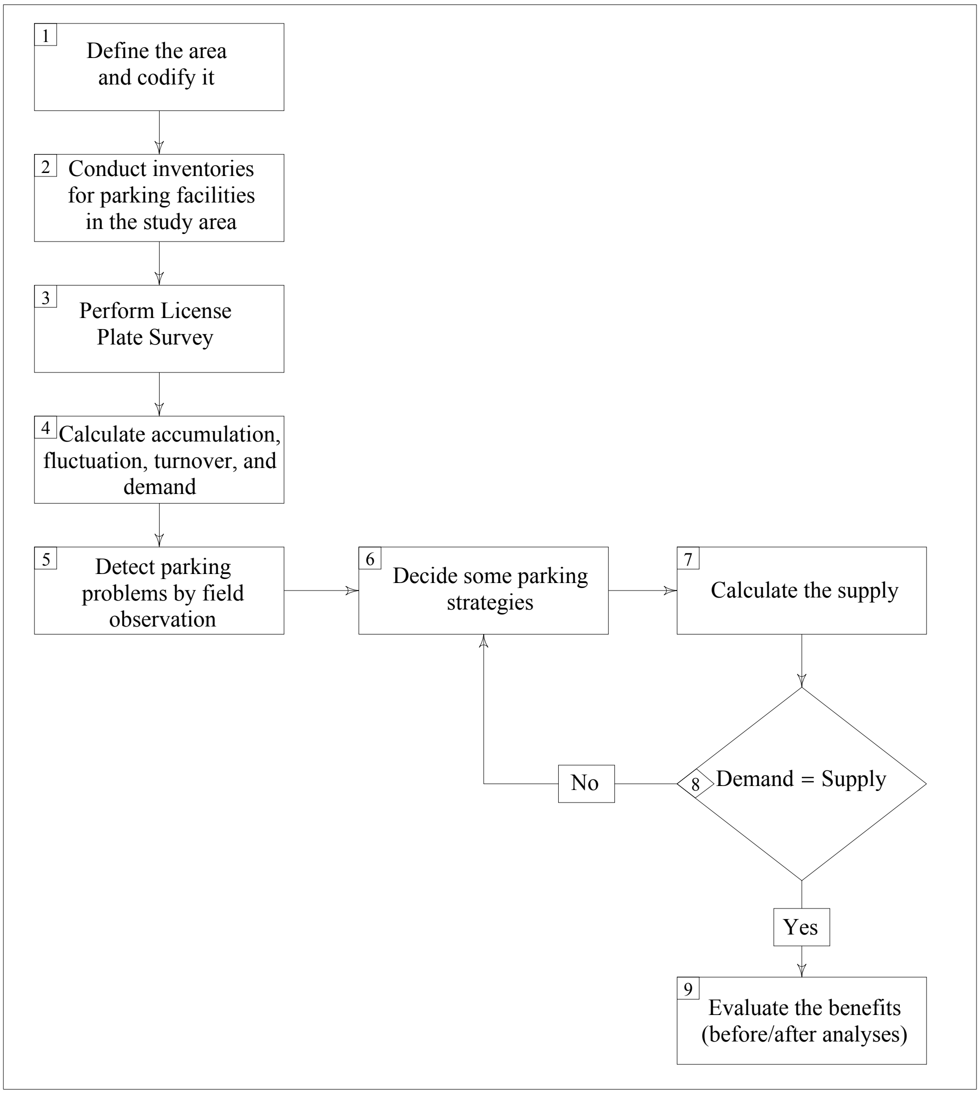


Figure 3.2. Flow diagram followed in Fulya pilot study area

The sixth stage was based on the experience and knowledge of the planning engineer. He/she has to have good abilities in realizing and finding the most effective and logical strategies that can solve the parking concerns of the region. His/her ability to select the right strategy plays a very important role in determining the calculation time of the process.

In the seventh phase we computed the supply according to the strategies we decided to use. Some parking physical layout standards were also considered in this stage.

Then, the demand and supply results were calculated and compared with each other (8^{th} step). If the demand is higher than the supply, spillover problems can be observed, meaning that the system is not able to handle the demand. Hence, we have to go back to the strategy decision step making some changes, calculating the supply, and comparing the supply with the demand. This has to continue until the equilibrium is reached. The same steps were applied in the situation where the supply was greater than the demand.

When the equilibrium between the demand and supply is reached, some evaluations of the benefits should be conducted. A before/after comparison analysis can be performed to quantify the benefits. This constituted the last step of flow diagram followed in Fulya pilot study area.

4. DATA COLLECTION

4.1. Origin-Destination Study

Traffic is one of the most crucial concerns of Istanbul and has affected the environment, the society, and the economy of this historical metropolitan city in a bad way. The slow movement of people and goods, the deterioration of the environment due to high amounts of hazardous gases released in the combustion process of cars, and the increasing number of stressed people are only some of the concerns that unfortunately Istanbul has to cope with.

It is clear that these problems cannot be handled within a short period of time. One of the most challenging issues of Istanbul’s traffic is the drawing of a clear vision of the whole infrastructure. In other words, comprehensive and detailed scientific, economical, and environmental analyses should be performed for future infrastructural planning.

In the light of this, Planning Center of Istanbul Metropolitan Municipality (PCIMM) conducted the “Istanbul Origin-Destination Travel Questionnaire” to be used in transportation planning process. The project was carried out in all districts (33 districts including Gebze) of Istanbul. About 40.000 face-to-face interviews were applied to people more than 6 years old in the selected households.

The goals of this questionnaire were to obtain:

- 24 hour weekday travel behavior of people living inside the boundaries of Istanbul (from where to where, the reasons of travel, the travel time, etc),
- The demographic features like age, education, occupation, and income of the respondents,
- Vehicle ownership, car-usage behavior, and the relation of them,
- Travel habits of Istanbul citizens.

Among the five survey types conducted in the selected pilot area, face-to-face interview was decided to be the most appropriate one. Furthermore, it was concluded that making appointments during daytime and interviews during evening gives the highest efficiency. The mean time for conducting the questionnaire was calculated to be 20.3 minutes, with a minimum and maximum of 3 and 79 minutes respectively (BİMTAŞ, 2006). Moreover, a team of two interviewers was able to interview approximately 2 families out of 7 appointments made.

4.1.1. Questionnaire Form

The questionnaire form, given in Appendix A, includes the six sections given below:

A. Address information and questionnaire check details,
B. Demographic information,
C. 24 hour trip information,
D. Private automobile behavior information,
E. Ownership and income information,
F. Transportation concerns and suggestions.

4.1.2. Travel Modes and Grouping

There were 20 types of travel modes considered in the questionnaire sheet listed as below:

1. Walking
2. Private Automobile
3. Shared Private Automobile
4. Taxi
5. Service Houses
6. Dolmuş
7. Minibus
8. IETT (Municipality)Bus
9. Private Bus
10. Motorcycle
11. Bicycle
12. Metro (Taksim-4.Levent)
13. Light Metro (Aksaray-Airport)
14. Tramway
15. Funicular
16. Boat

17. Sea Bus
18. Sea Motor
19. Suburban Train
20. Others

Considering some common features, these modes were categorized in 8 groups. Walking, Taxi, and Service House modes were not joined with the other modes since their functionalities were different. Private Automobile was joined with Shared Private Automobile and named Private Car. Road Public Transport is the category formed by Dolmuş, Minibus, IETT (Municipality) Bus, and Private Bus because they operate on roads and carry more than 7 passengers. Whereas the group based on rail transport, consisting of Metro (Taksim-4.Levent), Light Metro (Aksaray-Airport), Tramway, Funicular, and Suburban Train, was named Rail Public Transport. Furthermore, Marine Public Transport was the class where sea travel by Boat, Sea Bus, and Sea Motor was considered. Finally, Motorcycle and Bicycle were considered in the group named Others, due to the low (negligible) usage of these modes. The new mode groups are given below:

Apart from the above modes, the questionnaire collected information about trips made by more than one mode. Multi-Modal was the category where all trips consisting of more than one mode was grouped.

1. Walking
2. Private Car
3. Taxi
4. Service Houses
5. Road Public Transport
6. Rail Public Transport
7. Marine Public Transport
8. Others
9. Multi-Modal

4.1.3. Trip Segmentation Methodology

The Figure 4.1 explains the concept of trip segmentation used in gathering the information about trips. The trip is divided into four main sectors as listed below:

- Walking to station time – the time spend walking from the starting point of the trip to the station (or private car),
- Waiting time – the time spend waiting for the vehicle to arrive at the station,
- In-vehicle time – the time spend traveling inside the vehicle,
- Walking to destination time – the time spend walking from the station to the destination.

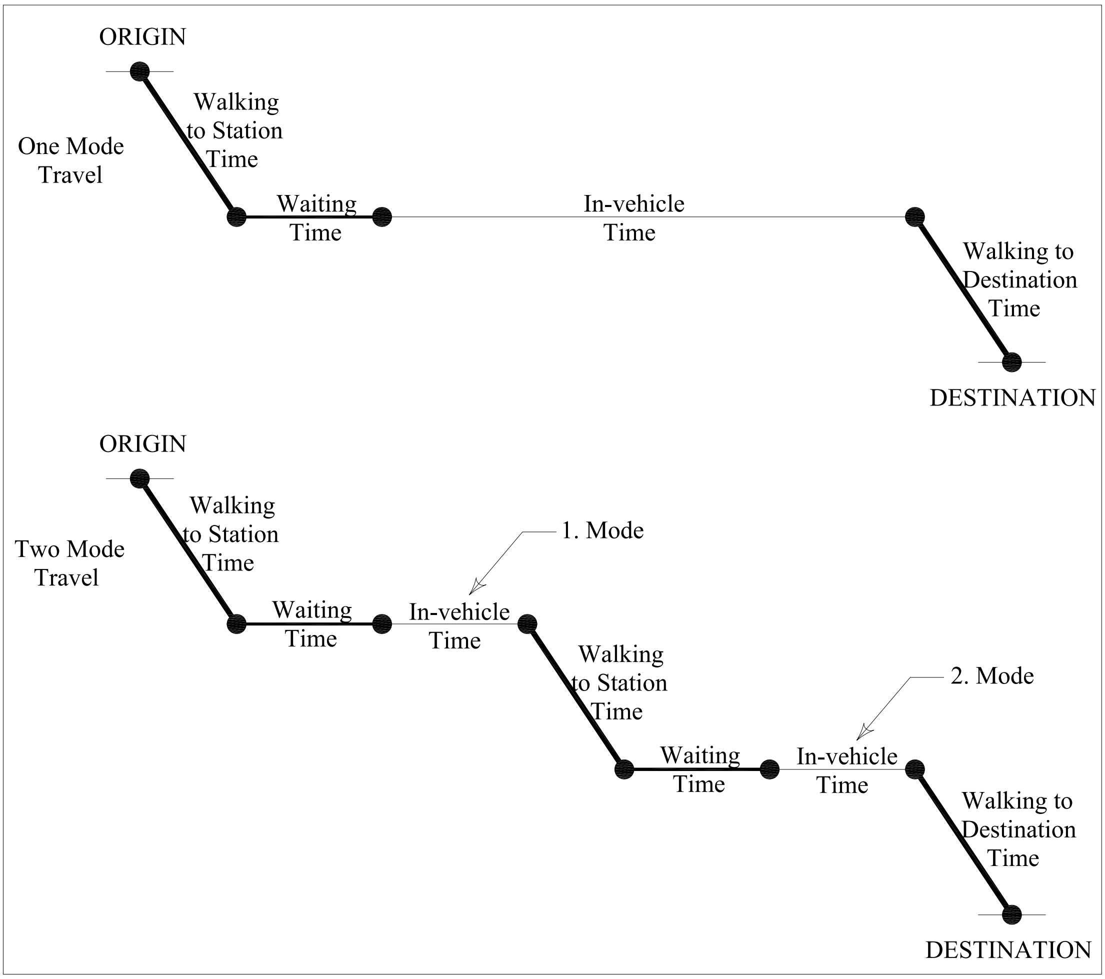


Figure 4.1. Travel segmentation

Thus, the total trip duration is the sum of the above sectors. Consider the one-mode trip in the Figure 4.1. A person walks from his/her starting point, say home, to the station which can be the bus station. Then he/she waits for the vehicle (bus in our assumption) to arrive to the station and get in. After the vehicle departs, the traveler spends some time in the vehicle until he/she arrives at the desired station. The last sector of this passenger is the time that he/she spends walking to the destination, suppose office. As a result all these segments make up the total travel duration required from the starting point to the final destination.

The questionnaire also gathered information about trips with more than one mode. It considered trips consisting of up to 5 different modes. Let's explain with a simple example the trips with two modes. Suppose a person will travel from Kadıköy, where he lives, to Mecidiyeköy, where he works. He gets out from his home at 7:20 AM and then walks for 10 minutes to boat wharf and waits 8 minutes for the boat to come and depart. Then the boat travels to Beşiktaş for 32 minutes. After he drops off the boat he walks to the bus station for 5 minutes. He waits for the bus to come and depart for 10 minutes. He spends 30 minutes in the bus on the way to Mecidiyeköy. Then he walks to his office for 5 minutes, being at his office at 9:00 AM.

As a result, the person walked a total time of 15 (10 + 5) minutes to the stations, 18 (8 + 10) minutes waiting for the bus and boat to arrive and depart, 62 (32 + 30) minutes traveling by boat and bus, and then walked to his destination for 5 minutes. His total trip lasted 100 minutes. For simplifying the calculations the segments of one mode are combined with the segments of other modes in the trips that consist of more than one mode. For instance, in two mode trips (bus and metro), we combine walking times, waiting times, and in-vehicle times of the bus with metro.

4.1.4. Grouping of Trips

Istanbul is a city spread into two continents (Europe and Asia). Each side of Istanbul consists of counties, and each county consists of neighborhoods. There are 11 counties consisting of 384 neighborhoods in the Asian side. On the other hand, there are 21 counties consisting of 596 neighborhoods in European side.

Thus, the data were grouped in six categories such as Intra-Neighborhood, Inter-Neighborhood, Intra-County, Inter-County, Intra-Continental, Inter-Continental. Continental based travel is a special feature only for Istanbul because it is spread into two continents. Intra-continental based analyses considered the trips made at either part of

Istanbul, European side or Asian side; whereas the Inter-Continental based analyses consider the trips that start at one side of Istanbul and end at the other. Another classification of the analyses was the county based one. An Intra-County trip starts and ends at the same county. On the other hand, Inter-County ones start at one county and finish at another county which may be also Inter-continental. The same concept was also regarded for the neighborhood based analyses.

4.2. Pilot Parking Study

4.2.1. Defining Study Area

The study should be defined before parking studies are initiated. As it is shown in Figure 4.2, a cordon line is drawn to delineate the study area. It should consist of traffic generators and a periphery, including all points within an appropriate walking distance. The survey area should also include any area that might be impacted by the parking modifications. The boundary should be drawn to facilitate cordon counts by minimizing the number of entrance and exit points.

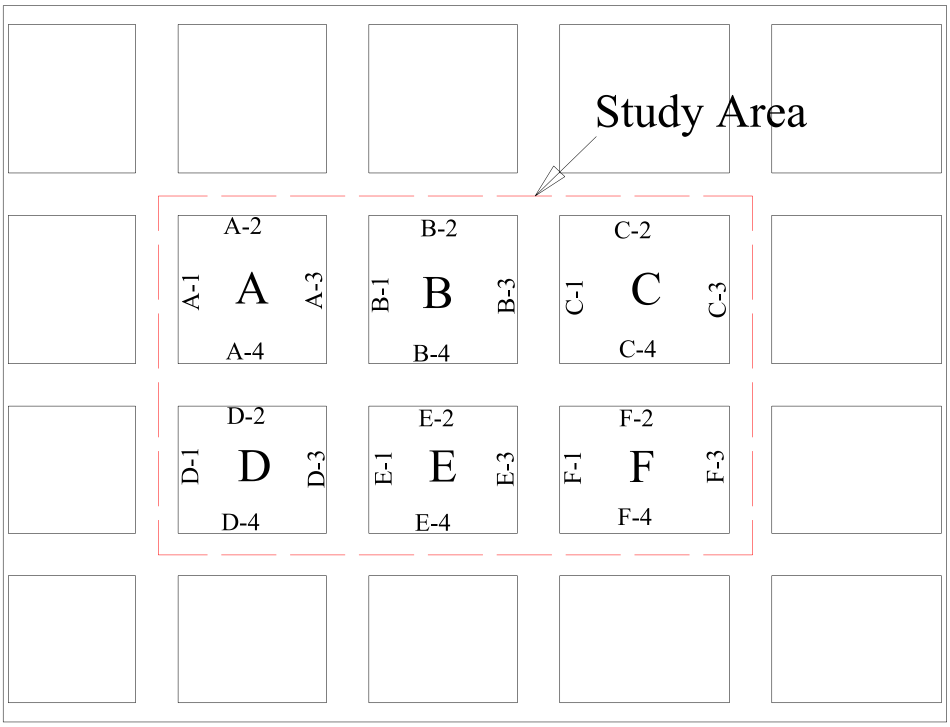


Figure 4.2. Defining and codifying the study area

Furthermore, the survey area has to be chosen so that it represents the characteristics of the whole city. Areas with different land-uses are more representative and realistic, giving more accurate results than one land-use areas such as residential or industrial alone.

To facilitate the recording of parking locations, the study area is usually mapped and coded in a systematic fashion. Figure 4.2 illustrates a simple coding system for block and block faces. Each block is represented by a letter. The side of the block is coded in letter-number (i.e. A-3) manner, letter showing the block and number showing the side of the block.

4.2.2. Parking Inventories

Once the study area has been defined, several different types of parking studies are conducted. These study types which are discussed in detail in the remaining paragraphs, are listed as the following:

- Inventory of Parking Facilities,
- Accumulation Counts,
- Duration and Turnover Surveys,
- User Information Surveys,
- Land Use Method of Determining Demand

Most parking inventory data is collected manually, with observers investigating an area on foot. This makes the collection of the information difficult and expensive. Use of intelligent transportation system technologies will begin to enhance the quality and quantity of information available and the ease of accessing it. Electronic tags and smart parking meters can provide parking durations and accumulations on a real-time basis.

4.2.3. Inventory of Parking Facilities

The first and the easiest study in the selected area is the collection of information from the current condition of parking facilities which include the followings:

- The location, condition, type, and number of parking spaces,
- Parking rates if appropriate. (These are often related to trip generation or other land use considerations),
- Time limits, hours of availability and any other restrictions,
- Layout of spaces: geometry and other features such as crosswalks and city services,
- Ownership of the off-street facilities.

4.2.4. Accumulation Counts

These counts are performed in order to obtain data on the number of vehicles parked in a study area during a specific period of time. First, the number of vehicles already found in that area are counted or estimated. Then, the number of vehicles entering and exiting during that specified period are noted, and added or subtracted from the accumulated number of vehicles.

Accumulation data are normally summarized by time period for the entire study area. The occupancy can be calculated by taking accumulation/total spaces. Peaking characteristics can be determined by graphing the accumulation data by the time of the day. The accumulation graph usually includes cumulative arrival and cumulative departure graphs as well.

4.2.5. Duration and Turnover Surveys

The accumulation study does not provide information on parking duration, turnover or parking violations. This information requires a *license plate survey,* which is often expensive but the most widely used. At regular intervals of 10, 30, and 60 minutes, an observer walks a particular route (up one block face and down the opposite block face, or around a block), and records the license plate numbers of vehicles occupying each parking space. A typical form for the license plate survey is given in the Figure 4.3.

LICENSE PLATE CHECK FIELD DATA SHEET

City:__________ Date:___/___/____ Recorded by:______________Side of Street:___

Street:__________________between_________________and________________

Space and Regulation	Time Circuit Begins											
	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30
A-1	102	√	√	√	√	246	25	–	713	√	√	√
	M223	√	57	963	442	614	38	–	025	√	823	169
	–	840	√	√	√	√	√	–	–	77	√	√
	–	–	333	895	–	–	14	T14	√	√	√	√
	–	M079	T994	√	√	√	√	√	√	√	√	√
	496	M96	569	467	637	√	√	028	184	√	√	√
	–	061	346	–	590	–	166	T703	641	425	633	T945
	–	–	945	–	77	048	√	√	√	√	√	√
	–	–	–	–	–	–	–	–	–	–	264	–
	–	–	–	–	–	–	–	–	–	–	61	√

Figure 4.3. License plate check field data sheet

Each defined parking space is listed on the field sheet prepared for the specific study, along with any time restrictions associated with it. A variety of special notations can be used to indicate a variety of circumstances, such as “T” for truck, “TK” for illegal parked and ticketed vehicle, B for bus parking, M for minibus, H for handicapped, and so on. In planning a *license plate survey*, assume that each patrolling observer can check about four spaces per minute. Therefore, study areas must be carefully mapped to allow planning of routes compute data coverage.

Analysis of the data involves several summaries and calculations that can be made using the field sheet information:

4.2.5.1. Accumulation Totals. Each column of each field sheet is summed to provide the total accumulation of parked vehicles within each time period on each observer’s route.

4.2.5.2. Vehicle-Parked Hours. Vehicle parked-hours is calculated by multiplying the duration of the parked vehicles’ interval with the number of cars parked only during that duration.

$$PH_x = I * N_x \qquad (4.1)$$

Where:

PH_x: Vehicle parked-hours for the x interval, h

N_x: Number of vehicles parked for x intervals, vehs

I: Length of the observation interval, h

4.2.5.3. Percentage of Parked Vehicles. Percentage of parked vehicles is the fraction of parked vehicles during a particular interval to the whole number of parked vehicles during the survey duration.

$$PV_x = \frac{N_x}{N_T} * 100 \tag{4.2}$$

Where:

PV_x: % of parked vehicle for the x interval , %

N_x: Number of vehicles parked for x intervals, vehs

N_T: Number of total vehicles parked during the survey period, vehs

4.2.5.4. Duration Distribution. By observing the license plate records of each space, vehicles can be classified as having been parked for one interval, two intervals, three intervals, etc. By examining each line of each field sheet, a duration distribution is created.

4.2.5.5. Average Parking Duration.

$$D = \frac{\sum_x (N_x * X * I)}{N_T} \tag{4.3}$$

Where:

D: Average parking duration, h/veh

N_x: Number of vehicles parked for x intervals, vehs

X: Number of intervals parked

I: Length of the observation interval, h

N_T: Total number of parked vehicles observed, vehs

4.2.5.6. Parking Turnover Rate. Another useful statistic is the parking turnover rate, TR. Parking turnover is the rate of use of a facility. It is determined by dividing the number of available parking spaces into the number of vehicles parked in those spaces in a stated time period. It is computed as:

$$TR = \frac{N_T}{P_S * T_S} \quad (4.4)$$

Where:

TR: Parking turnover rate, veh/stall/h

N_T: Total number of parked vehicles observed, vehs

P_S: Total number of legal parking stalls, stall

T_S: Duration of the study period, h

4.2.5.7. Parking Supply. The calculation of the total parking supply can be measured in terms of how many vehicles can be parked during the period of interest within the study area:

$$P = \frac{\sum_{n} (NT)}{D} * F \quad (4.5)$$

Where:

P: Parking supply, vehs

N: Number of spaces of a given type and time restriction, stall

T: Time that N spaces of a given type and time restriction are available during the study period, hrs

n: Number of different parking types

D: Average parking duration during the study period, hrs/veh

F: Insufficiency factor to account for turnover - values range from 0.85 to 0.95

4.2.5.8. Estimated Demand Reduction Due to Applied Strategies. The following formula is used to estimate the demand reduction due to strategies decided:

$$R_d = N_T * (1 - S_1) * (1 - S_2) * . . . (1 - S_n) \quad (4.6)$$

Where:

R_d: Estimated demand reduction due to applied strategies, vehs

N_T: Total number of parked vehicles observed, vehs

S_1: Fraction reduction due to the first strategy (decimal)

S_n: Fraction reduction due to the n^{th} strategy (decimal)

The *average duration* and *turnover rate* may be computed for each field sheet, for sectors of the study area, and/or for the study area as a whole.

Note that the survey includes only the study period. Thus, vehicles parked before the study period will be considered as parked at the beginning of counting period. The same situation exists for the parking beyond the survey duration. Although vehicles may remain parked for an additional time period outside the study limits, parking time finishes at the end of the study period. For convenience, only the last three digits of the license plates are recorded. For instance, 34 FB 6582 license plate was recorded simply as 582.

For off-street facilities, the study procedure is somewhat different, with counts of the number of entering and departing vehicles recorded by 15, 30, and 60 minute intervals. Accumulation estimates are based on starting count of occupancy in the facility and the difference between entering and departing vehicles. A duration distribution for off-street facilities can also be obtained if the license plate numbers of entering and departing vehicles are also recorded.

4.2.6. User Information Survey

Individual users can provide valuable information that is not attainable with license plate surveys. The two major methods for collecting these data are parking interviews and postcard studies. For the parking interviews, drivers are interviewed right in the parking lot. The interviews can gather information about origin and destination, trip purpose, and trip frequency. The postage paid postcard surveys request the same information as in the parking interview. The bias can take two forms. Drivers will sometimes overestimate their parking needs in order to encourage the surveyors to recommend additional parking. Or, they may file false reports that they feel are more socially acceptable.

4.2.7. Land Use Method of Determining Demand

The Land Use Method of Determining Demand has been extensively discussed by scientists and policy-makers. The theory behind this demand determination method is based on minimum parking requirements. However, these standards are often excessive, and can usually be justified significantly downward (Litman 2006). Applying these standards results in far more parking supply than is usually needed at most destinations, particularly where land use is mixed, where there are good travel options, and where parking is priced. Therefore, maximum parking standards are used instead of minimum ones. Maximum parking standards means that an upper limit is placed on parking supply, either at individual sites or in an area (Litman 2006). The procedure used to estimate the demand for parking is

- Tabulate the type and intensity of land uses throughout the study area,
- Based on reported parking generation rates, estimate the number of parking spaces needed for each unit of land use,
- Determine the demand for parking from questionnaires. A rule of thumb is to overestimate the demand for parking by about 10 %. If the analysis suggests that the parking demand for a particular facility will be 500 spaces, then the design should be for 550 spaces.

4.2.8. Indication of Parking Problems

Understanding and identifying the parking problems is the first step in parking strategy decision making. The following indicators can be used to determine if parking problems exist at a particular location that may require mitigation.

- More than 90% of short-term parking (2 hour or parking duration) is occupied during peak periods (Shoup, 2002),
- Vehicles often cruise streets while searching for parking,
- Drivers often have difficulty finding a suitable parking space,
- All spaces within view of a destination are frequently occupied,
- Vehicles frequently park illegally, like parking in no-parking areas, or double parking to load and load,
- Motorists are frequently cited for parking violations.

4.2.9. Parking Time Required for Different Purposes

One of the most common ways to manage parking is to limit parking durations. Shorter time periods increase turnover but constrain the activities that can be performed. Thus, time restrictions have to be handled very carefully in order not to create spillover problems. Parking restrictions should be flexible and adjusted as needed to reflect changing conditions. It is very crucial that time restrictions are clearly indicated to users. A very useful way to do this is by using different curb colors indicating different parking limits or purposes. Furthermore, user information on parking restrictions should generally include information on where parking is available. Some guidelines for the parking restriction limits are mentioned below.

- *Very short time periods* (3 to 10 minutes) accommodate passenger drop-offs and deliveries. This is appropriate in busy loading areas, like in front of transportation terminals, schools, theaters, hotels, and hospitals.
- *Short time periods* (15 to 30 minutes) accommodate quick errands. This is appropriate for the most convenient parking spaces at post offices, stationer's shops, and other similar destinations.
- *Medium time periods* (30 minutes to 4 hours) accommodate long errands and activities, shopping and dining. Costumers often find that one hour is inadequate for

a shopping trip, meal, or errand, so 90 minutes or two-hour limits are common. Three or four hour limits are generally applied to prevent commuters for using parking spaces in business districts and nearby residential streets, although some commuters will simply move their vehicles once or twice each day.

- *Long time periods* (more than 8 hours) accommodate commute trips and residential parking.
- *Special time restrictions* can be used to discouraging certain uses, such as parking prohibited before 10 Am (to discourage use by employees) or between 10 Pm and 5 Am (to discourage use by residents and campers).

4.2.10. Geometric Design of Parking Spaces

The geometric design of parking spaces is based on Turkish Standards (TS 10551). A copy of the design sheet is given in the Appendix B. The two basic types of parking terminals are the on-street (curb) space and the off-street parking facilities.

On-street Parking

The geometry of on-street parking illustrated in the standards shows that, the number of spaces that can be accommodated per linear meter of curb increases as the angle of parking increases. Angle parking, however, interferes more severely with moving traffic than parallel parking, and accident rates are higher for angle parking than for parallel parking. Angle parking is therefore recommended for local streets which are wide, have good sight distance, and carry low traffic volumes. The required layout for buses, trucks, and taxi stands should be determined on the basis of vehicle dimensions and operational characteristics of the vehicles.

Off-street surface parking and garages

Parking lots must be designed to achieve the following objectives:

- Provide maximum number of spaces,

- Minimize travel discomfort while parking, unparking, and driving within the lot,
- Minimize interference of entrance and exit lanes with pedestrian and vehicle movement external to the lot.

Several parking stall layouts are available for use in a parking lot. Selection of the best parking angle, however, depends primarily on the size and shape of the parking lot. More than one parking layout may be used in a parking lot to maximize space utilization.

90-degree parking layout uses the space most efficiently. Cars can use aisle in either direction, so that the travel distance is reduced. It permits use of dead-end aisles, thereby minimizing wasted space. If the parking angle is less than 90 degrees, the travel aisles must be made one-way. One way circulation is desirable (but not essential) for a busy lot, since the 30-degree and 45-degree angles are more easily accessible by self-parkers. These layouts are generally used for customer parking and where space is available.

Regardless of the parking angle used, however, the traffic engineer should insure that the circulating system of the lot should permit easy and efficient movement of both the car and the pedestrian. Entrances and exits should be placed with the objective of minimizing potential conflicts within the parking lot, and between lot traffic and access street traffic. Entrances and exits of parking lots should be located at mid-block to provide the least interference with street intersection areas where pedestrians and vehicles are in greatest competition for street space.

Parking areas should be located, preferably, on the local street subsystem, and should be avoided along major arterial street subsystem, whose primarily function is to move traffic and not to give land use service.

5. ANALYSIS OF ORIGIN-DESTINATION INTERVIEWS

Planning Center of Istanbul Metropolitan Municipality (PCIMM) conducted about 45,000 household questionnaires giving information about 170,000 trips all around Istanbul. A sample size of 8% of all the information, consisting of 13,368 trips, was decided to be sufficient and selected for the analyses of this research. The 8% sample size was selected systematically from the questionnaire data.

It has to be emphasized that the data taken from the PCIMM in the SPSS (statistical program) file had some wrong, unneeded and misleading information. Thus, it was decided to go through an investigation and correction process of the data. During this examination process all cases were checked, some of them were corrected whereas some other ones were excluded.

In the end of the correction process the final number of cases was reduced to 12,033, meaning that 1.335 cases were excluded. In other words, about 10% of the total cases included incorrect and misleading information. This value seems to be slightly high, however, about 900 of them were trips made by walking mode which showed zero minute trip durations. Some other cases excluded did not give information about starting and ending points of the trips. Some other ones showed unreliable information like using rail or walking modes crossing the two sides of Istanbul, which is not possible in present time. Furthermore, some cases extracted from the analyses demonstrated that very long distances were made in very short travel times, which were very unrealistic.

Figure 5.1 shows the distribution of the age of the respondents varying from 6 to 93 years. The average age of the respondents was calculated to be 29.47 years with a standard deviation of 16 years. Moreover, as it was shown in the Figure 5.2, about one third of the trips were made by females.

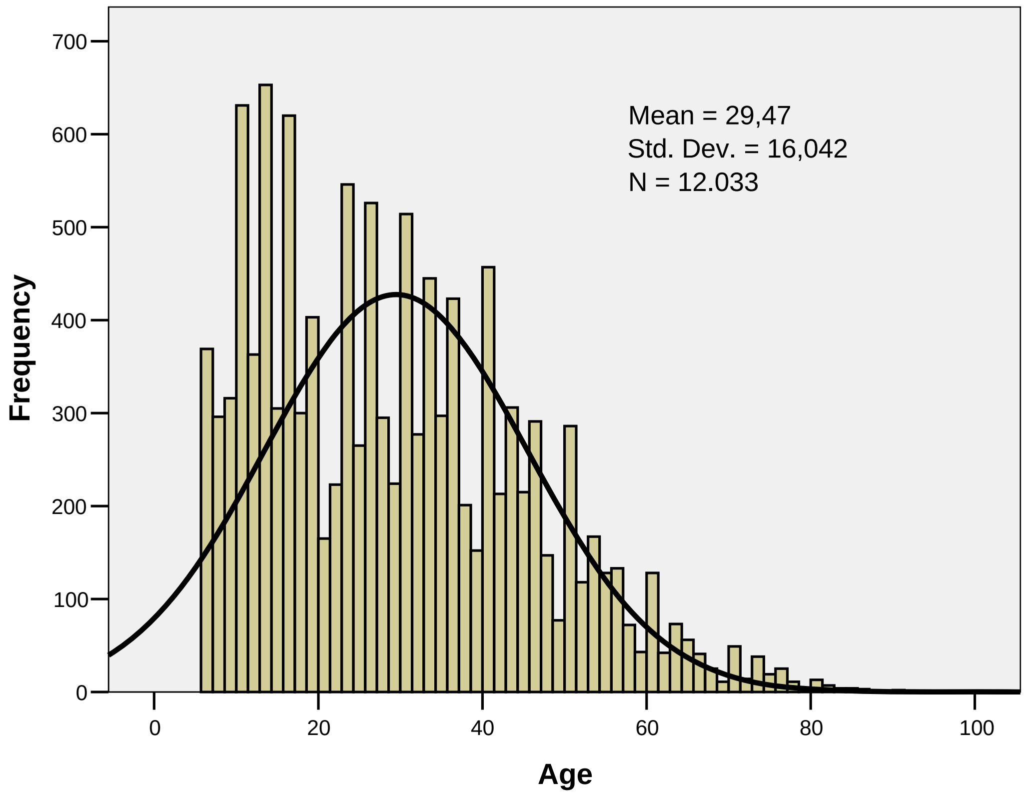


Figure 5.1. Age distribution of respondents

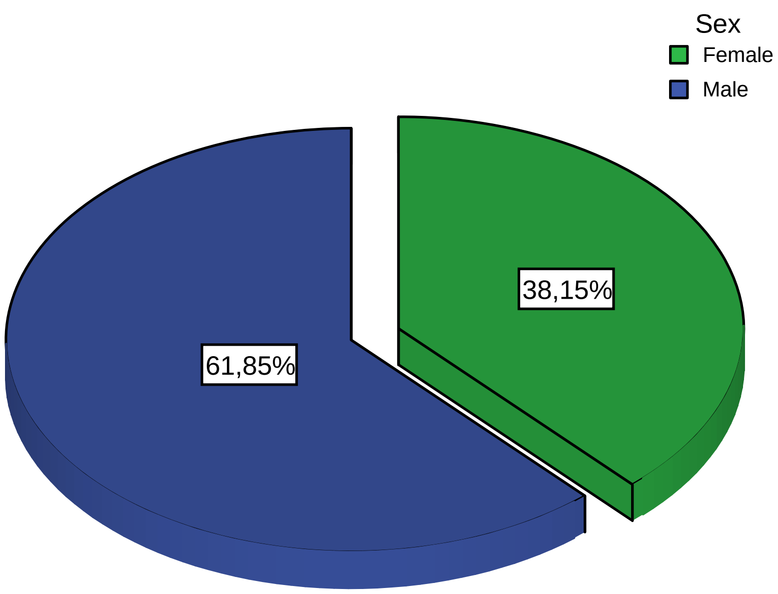


Figure 5.2. Percentages of male and female respondents

5.1. General Origin-Destination Analysis for the Total Metropolitan Area

5.1.1. Frequencies of Trips

As it can be seen in Table 5.1 walking was the dominant mode in Intra-Neighborhood trips, accounting for 90% of all trips. Private car mode, composed of 4%, was the second most commonly used mode inside the neighborhoods. Service House and Road Public Transport modes make up 3.2% and 2% of this type of trips, respectively. Intra-Neighborhood trips made by other modes like Taxi, Rail Public Transport, and Marine Public Transport were zero. It should be noted that Intra-Neighborhood trips are the shortest trips and are generally made by Walking mode.

We observed a decrease in the percentage of trips made by Walking mode while traveling from one neighborhood to another inside the county. These trips made up for 45% of all Inter-Neighborhood trips. Road Public Transport was the second widely used mode making up 22.3%. Service House and Private Car modes increased slightly up to 15.2% and 14.3%, respectively. Taxi, Rail and Marine Public Transport modes were still negligible.

The situation changed for the trips starting from one county and ending to another one. Road Public Transport was the prevalent mode accounting for 37.3%. On the other hand, walking trips were reduced significantly when Inter-County trips were considered. The other modes like Private Car, Service House, and Rail Public Transport were increased moderately, reaching percentages of 22.9%, 18.8%, and 3.3%, respectively.

The number of Inter-Continental trips (564) was the lowest among all trip types. Notice that Walking and Rail Public Transport modes are not possible for this trip type in Istanbul in present time. Private Car mode (27.5%) was the most dominant mode in Inter-Continental trips. About one fourth of all Inter-Continental trips were made by more than one mode. Furthermore, Service House (19.3%) and Road Public Transport (19.7%) modes were also high when traveling from one side of Istanbul to the other one.

The last column in the Table 5.1 displays the total trips made by each travel mode. About half of the total respondents (46.9%) used Walking mode. This high percentage was because of the high number of Intra-Neighborhood trips made by Walking mode. Road Public Transport mode (19.8%) was calculated to be the second most dominant mode in Istanbul. This result indicates that the trips made in Istanbul are generally based on Road Public Transport. The next two most widely used modes in Istanbul were Private Car (14.0%) and Service House (12.3%). Notice that the mode shares of Rail (1.2%) and Marine (0.3%) Public Transport modes were very low for this highly populated city.

Table 5.1. The frequencies of each mode in continental, county, and neighborhood base

	Intra-Continental						Inter-Continental		Total Trips	
	Intra-County				Inter-County		Inter-County			
	Intra-Neighborhood		Inter-Neighborhood		Inter-Neighborhood		Inter-Neighborhood			
	Count	%	Count	%	Count	%	Count	%	Count	%
Walking	3.814	89,7	1.498	45,0	326	8,4			5.638	46,9
Private Car	170	4,0	475	14,3	889	22,9	155	27,5	1.689	14,0
Taxi	10	0,2	47	1,4	78	2,0	4	0,7	139	1,2
Service House	137	3,2	506	15,2	730	18,8	109	19,3	1.482	12,3
Road Public Transport	85	2,0	742	22,3	1.449	37,3	111	19,7	2.387	19,8
Rail Public Transport	2	0,0	10	0,3	128	3,3	0	0,0	140	1,2
Marine Public Transport	0	0,0	0	0,0	1	0,0	32	5,7	33	0,3
Others	32	0,8	30	0,9	44	1,1	14	2,5	120	1,0
Multi-Modal	2	0,0	20	0,6	243	6,3	138	24,5	403	3,3
Total Modes	4.252		3.328		3.888		564		12033	
% of Total Modes	35		28		32		5			
Motorized Modes	438		1830		3562		563		6394	
% of Motorized Modes	6,9		28,6		55,7		8,8			

It has to be emphasized that Road Public Transport mode was the most widely used mode in medium-length and long-length travel distances. On the contrary, walking trips decreased with the increase of distance. Another very important result was concluded about Private Car mode which was more useful for long trips.

Figure 5.3 shows modal splits in Istanbul for 2005 provided from The State Institute of Statistics (www.tuik.gov.tr) and for 2006 obtained from Origin-Destination Interview (BİMTAŞ). The modes considered in Figure 5.3 were Bus, Metro, Light Rail, Tram, Funicular, Sea Travel, and Regional Rail. Note that 2005 data may be incorrect because it may be impossible to have such significant changes. The modal share of Bus mode was increased significantly from 2005 (51%) to 2006 (82%). On the other hand, shares of all other modes decreased in 2006. This means that Istanbul municipality encouraged Bus mode more than the other ones. This may be explained by 500 new buses added to the Bus fleet in 2006 (www.ibb.gov.tr). Region Rail mode showed the most significantly modal share decrease from 21% (2005) to 2% (2006).

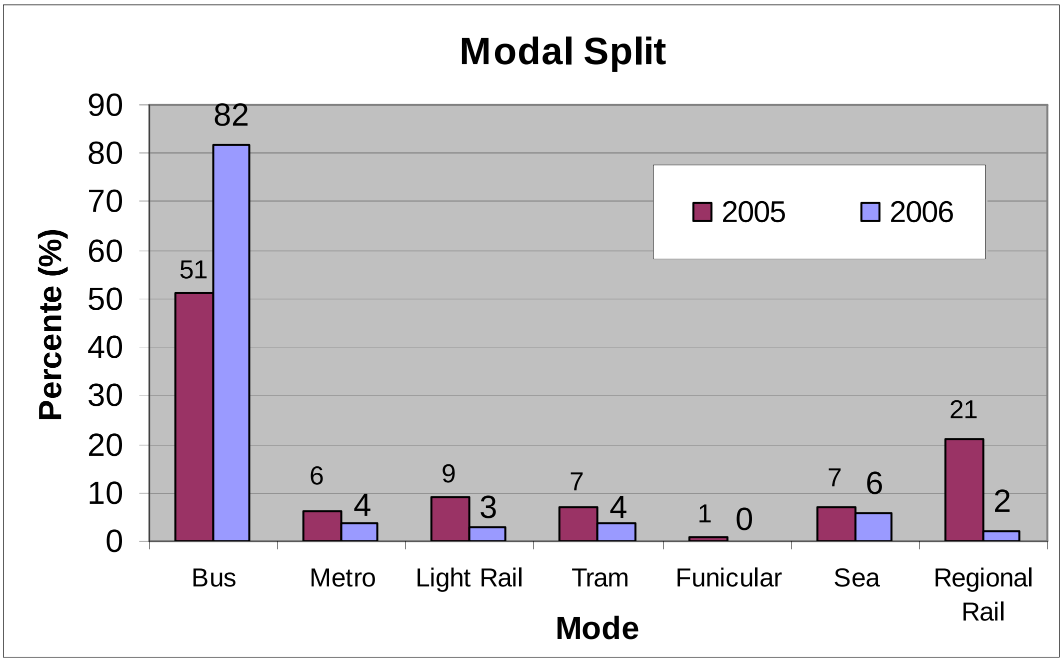


Figure 5.3. Modal split (2005 data taken from The State Institute of Statistics, www.tuik.gov.tr, 2005) (2006 data from Origin-Destination Interview, BİMTAŞ)

5.1.2. Mean Travel Times

Travel time is a very important component in trip analyses. Travel durations of the main modes are extensively used by planners in planning analyses. Different model types based on mean travel time values have shown pretty good results in many planning analyses.

Table 5.2 presents the mean travel times and their standard deviations of each mode in continental, county, and neighborhood base. According to the first column of the Table 5.2 the Walking mode (12 minutes) had the shortest mean travel time of trips starting and ending inside the same neighborhood. On the other hand, as expected, Road Public Transport mode showed the highest mean, consisting of 35 minutes. The other In-quarter trips made by Private Car, Taxi, and Service House modes exhibited average travel times of 13 minutes, 16 minutes, and 24 minutes, respectively.

Still the minimum and maximum mean travel times in Inter-Neighborhood base were made by Walking (19 minutes) and Road Public Transport (39 minutes) modes, respectively. Notice that, we observed some Inter-Neighborhood trips made by Rail Public Transport consisting of 28 minute mean travel time. On the other hand, yet no Marine Public Transport mode based trips were made from one neighborhood to another within the same county.

All modes were used while traveling from one county to another. Multi-Modal (83 minutes) trips had the highest mean travel time. Furthermore, Marine Public Transport mode had the second highest mean travel time of 65 minutes. This is thought to be due to the low speed and frequency of these modes, which increase the waiting times and thus the mean travel times. The average trip duration of Road Public Transport increased significantly from Intra-County to Inter-County ones reaching a value of 59 minutes. Service House (48 minutes) and Rail Public Transport (48 minutes) modes had lower values than the above mentioned modes. The shortest travel time trips were still made by Walking mode which reached a value of 25 minutes. Private Car and Taxi modes showed average travel durations of 37 and 32 minutes, respectively. The mean travel time for all modes was calculated to be 50 minutes.

Moreover, we observed no trips made by Walking and Rail Public Transport modes traveling from one side of Istanbul to the other one, because their usage is impossible in Istanbul in the present time. Multi-Modal trips had the highest mean travel time of about 98 minutes. The second longest travel time trips were made by Road Public Transport which reached a value of 85 minutes. It should be noted that Road Public Transport mode was the most extensively used one in Inter-Continental trips. The mean travel time for Service House mode also showed a significant increase of 30 minutes (from 48 to 78). Private Car and Marine Public Transport modes displayed mean travel times of 68 and 48 minutes, respectively. Note that the shortest travel times were made by Taxi mode, averaged to 35 minutes.

Table 5.2. The mean travel times of each mode in continental, county, and neighborhood base

	Intra-Continental						Inter-Continental		Total Trips	
	Intra-County				Inter-County		Inter-County			
	Intra-Neighborhood		Inter-Neighborhood		Inter-Neighborhood		Inter-Neighborhood			
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Walking	0:12	0:09	0:19	0:12	0:25	0:15			0:15	0:11
Private Car	0:13	0:09	0:22	0:13	0:37	0:22	1:08	0:34	0:33	0:25
Taxi	0:16	0:06	0:20	0:10	0:32	0:20	0:35	0:18	0:27	0:18
Service House	0:24	0:14	0:32	0:16	0:48	0:22	1:18	0:28	0:43	0:24
Road Public Transport	0:35	0:21	0:39	0:18	0:59	0:26	1:25	0:35	0:53	0:27
Rail Public Transport	0:12	0:02	0:28	0:09	0:48	0:20			0:46	0:20
Marine Public Transport					1:05	.	0:48	0:20	0:49	0:20
Others	0:19	0:21	0:23	0:13	0:47	0:27	0:57	0:30	0:35	0:27
Multi-Modal	1:06	0:09	1:05	0:19	1:23	0:29	1:38	0:35	1:27	0:32
Total	0:13	0:10	0:26	0:17	0:50	0:28	1:19	0:35	0:32	0:27

The longest trips in Istanbul were the trips made by more than one mode accounting for 87 minutes. Furthermore, Marine Public Transport averaged to 49 minutes. Road Public Transport which was the most dominant mode in Istanbul had a mean travel time of 53 minutes. In other words, 19.8% of trips in Istanbul (see Table 5.1) were made for a average duration of 53 minutes. The mean travel time for Rail Public Transport mode was also high (46 minutes). Average speed of this mode was high, however, this result may be attributed to long walking distances to the rail stations. Another mode that had high mean travel time was Service House (43 minutes). On the contrary, mean travel times for Private Car (33 minutes) and Taxi (27 minutes) modes were lower. These results may be because of that high priority modes such as Service House and Public Transport are discouraged and lower priority modes like Private Cars and Taxi are encouraged.

As it is shown in Table 5.3 travel times were grouped in four cumulative categories like: Intra-Neighborhood, Intra-County, Intra-Continental, and Inter-Continental. Intra-Neighborhood, Inter-Continental and total trips' travel times are the same as indicated in Table 5.2. Intra-County category includes all Intra-Neighborhood and Inter-Neighborhood trips. Multi-Modal (65 minutes) trips were the highest among all Intra-County trips. Road Public Transport mode had the second highest mean travel time (38 minutes). The average travel time of all modes in Intra-district category was calculated to be 19 minutes. This value seemed to be slightly low; however, this may be due to high number of trips made by Walking mode, which had a low mean travel time (see Table 5.1).

Travel times of Intra-continental trips were averaged to 29 minutes (Table 5.3). The longest mean trip durations in Intra-continental trips were still made by more than one mode (82 minutes). Marine Public Transport mode (65 minutes) was the second one. Those who used Road Public Transport mode spent an average of 52 minutes in Intra-continental trips. In contrast to other high priority modes like Rail Public Transport (46 minutes) and Service House (40 minutes), low priority modes such as Private Car (30 minutes) and Taxi (26 minutes) had low mean travel times.

Table 5.3. The cumulative travel times of each mode in Continental, District, and Quarter base (hours)

	Intra-Neighborhood		Intra-County		Intra-Continental		Inter-Continental		Total Trips	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Walking	0:12	0:09	0:14	0:10	0:15	0:11	0:10	.	0:15	0:11
Private Car	0:13	0:09	0:19	0:13	0:30	0:21	1:08	0:34	0:33	0:25
Taxi	0:16	0:06	0:19	0:10	0:26	0:18	0:35	0:18	0:27	0:18
Service House	0:24	0:14	0:30	0:16	0:40	0:22	1:18	0:28	0:43	0:24
Road Public Transport	0:35	0:21	0:38	0:19	0:52	0:26	1:25	0:35	0:53	0:27
Rail Public Transport	0:12	0:02	0:25	0:10	0:46	0:20			0:46	0:20
Marine Public Transport					1:05	.	0:48	0:20	0:49	0:20
Others	0:19	0:21	0:21	0:18	0:32	0:25	0:57	0:30	0:35	0:27
Multi-Modal	1:06	0:09	1:05	0:18	1:22	0:29	1:38	0:35	1:27	0:32
Total	0:13	0:10	0:19	0:15	0:29	0:25	1:19	0:35	0:32	0:27

5.1.3. Travel Time for Each Segment of the Trip

Table 5.4 depicts the averages of different trip sections such as walking to destination time, waiting time, in-vehicle time, and walking to destination time, for different mode types. Notice that walking mode was excluded from the computation in this table because it consisted of only one sector, walking; however, it was expressed in the Table 5.2 and Table 5.3 in a more detailed form.

The mean walking-to-station time for Rail Public Transport stations (10 minutes) was the highest one among all modes. Next high travel time for this segment was observed for Marine Public Transport mode users, consisting of 9.6 minutes. Long station-to-station distances can be one of the reasons of these high walking-to-station durations. Furthermore, these high values could also be attributed to the limited networks of these modes. On the other hand, Road Public Transport mode, which has a wide network, indicated a mean walking-to-station time of 6.3 minutes. Taxi (1.2) and Service House (2.2) modes showed low walking times. However, walking durations to Private cars (30 seconds) both at origin and destination were the lowest ones. These low walking durations indicates that private car users park their cars very near to their origin and destination. The total mean of walking times was computed to be 3.7 minutes.

Table 5.4. Average segment times for different modes

Mode	Walking to Station Time (minutes)	Waiting Time (minutes)	In-Vehicle Time (minutes)	Walking to Destination Time (minutes)	Total Access-Egress Time (minutes)	Total Travel Time (minutes)
Private Car	0,5	0,1	32,6	0,5	1,1	33,7
Taxi	1,2	0,7	24,1	1,1	3	27,1
Service House	2,2	2,1	36,9	1,9	6,2	43,1
Road Public Transport	6,3	7,5	33,9	6,1	19,9	53,8
Rail Public Transport	10	5,9	22	8,8	24,7	46,7
Marine Public Transport	9,6	2,8	28,5	9,1	21,5	50
Others	1,2	1,5	32,5	1,3	4	36,5
Multi-Modal	6,8	14,6	57,1	10,1	31,5	88,6
Total	3,7	4,4	35,2	3,8	11,9	47,1

As it can be seen from Table 5.4, waiting time in the stations for the vehicle to come and depart showed different results from the previous segment, walking-to-station time. In this category the highest waiting time was spent by those who used more than one mode accounting for about 15 minutes. This may be an indication of an uncoordinated public transport system. The second one was Road Public Transport (7.5) mode only half of the Multi-Modal. This result denotes that, although Road Public Transport network is wide with a large number of lines and high frequencies it may be attributed to the unreliable of travel times. Thus, Road Public Transport mode users end up spending more time waiting relative to other public transport modes such as Marine and Rail. Rail and Marine Public

Transport modes had relatively low mean waiting times as 5.9 and 2.5 minutes, respectively. The low mean waiting time of Rail Public Transport mode can be explained by the reliability of their schedules because of their reliable travel times of these modes compared to Road Public Transport one. On the other hand, waiting times for Private Car and Taxi modes were almost zero, which was an anticipated result. The average waiting time for Service House was approximately 2 minutes.

In-vehicle travel times were the highest travel times among all segments (Table 5.4). Multi-Modal trips showed the highest in-vehicle time accounting for 57 minutes. In-vehicle travel times for Private Car, Service House, and Road Public Transport were 32.6 minutes, 36.9 minutes, and 33.9 minutes, respectively. The lowest in-vehicle travel times were calculated to be for Rail Public Transport mode. This was due to short length rail systems that Istanbul owns and high speeds of these modes that are not affected during peak hours. Taxi and Marine Public Transport indicated in-vehicle travel times of 24.1 and 28.5 minutes, respectively.

Finally, the last segment of the total trip duration is walking to destination time. Still Multi-Modal (10 minutes) trips had the highest walking to destination time. Furthermore, Road Public Transport (6.1 minutes), Rail Public Transport (8.8 minutes), and Marine Public Transport (9.1 minutes) modes had the highest walking durations from station to destination sector. For other modes like Service House, Taxi, and Private Car these values were less than 2 minutes.

Total Access-Egress time comprises walking to station time, waiting time, and walking to destination time. The penultimate column in Table 5.4 shows the total access-egress time for all modes. High capacity modes like Road (19.9), Rail (24.7) and Marine (21.5) Public Transport were discouraged and low capacity modes such as Private Car (1.1) and Taxi (3.0) were encouraged. Finally, Multi-Modal trips (31.5) showed the highest total access-egress time.

The mean walking time of the respondents that used Rail Public Transport mode was 16.4 (8.9 + 7.5) minutes, whereas the in-vehicle time was 17.4 minutes, being almost the same. As a result, Rail Public Transport Usage is discouraged because passengers will tend to use modes that need lower walking durations.

5.1.4. Car Usage Behavior When Congestion Pricing Strategies Applied

Another very beneficial data gathered from these respondents was their behavior related to different downtown congestion pricing strategies, which take into consideration the existing and improved public transport. The question was (D.5, D.6): “In order to relieve the traffic while traveling to CBD areas some congestion pricing strategies are used in some European cities. What is your car usage behavior for the Existing Public Transport Conditions if similar congestion pricing strategies were applied?” The alternatives were; giving up using their cars for any price, giving up using their cars for some amount of money, or not giving up using their cars. Note that this question was not well prepared, because the number of those who would give up using their cars for any price had to be equal to those who would give up for 1-15 YTL. However, the intended result was to count those who would give up using their cars for a fee less than one Turkish Lira.

Table 5.5 expresses car usage behavior for existing and improved public conditions both in numbers and in percentages. Approximately 36% of automobile users surveyed were ready to quit using their cars for any price, while traveling to these highly congested areas for the existing condition of public transport. Another 13% of them would not use their cars if they were required to pay a charge ranging 1-3 YTL. However, a higher percentage (43.1%) stated that they would not give up using their cars for existing Public Transportation conditions.

In the case of Improved Public Transport conditions more than the half (52.8%) of the car users would not use their cars while traveling to highly congested areas if any price is applied. Moreover, those who would give up for 1-3YTL were reduced to 11.3%. On the other hand, about 30% of car users still would use their cars. Finally, we conclude that approximately 70% (100% - 30%) of all auto-users were ready to leave using their cars for some amount of money.

The attitudes of respondents changed considerably if public transport conditions were improved. About 293 (16.5%) more respondents were ready to leave using their cars for any price if public transport conditions were enhanced. It should be noted that the public transport conditions are very important in the whole transportation system of Istanbul. If public transport is improved it will attract 16.5% more car users and thus significantly decrease the traffic congestion. This result once more points out the effect of public transport conditions to the use of automobile.

Table 5.5. Car usage behavior for the total metropolitan area

	Existing Public Transport Conditions		Improved Public Transport Conditions		Change	
	Count	%	Count	%	Count	%
Give up using the car for any price	643	36,3	936	52,8	293	16,5
Give up using the car for 1-3 YTL	232	13,1	200	11,3	-32*	-1,8
Give up using the car for 4-6 YTL	79	4,5	67	3,8	-12	-0,7
Give up using the car for 7-10 YTL	50	2,8	33	1,9	-17	-1,0
Give up using the car for 11-15 YTL	15	0,8	11	0,6	-4	-0,2
Do not give up using the car	754	42,5	526	29,7	-228	-12,9
Total	1773	100	1773	100		

* (-) sign indicates the decrease of the number or the percentage

Table 5.6 gives more detailed information for the questions D.5 and D.6. For the Existing Public Transport Conditions 19 out of 33 counties were above the mean value. Esenler (51%) and Eyüp (55%) counties showed the highest values. On the other hand, Küçükçekmece (21%) and Tuzla (20%) showed the lowest percentage. Bahçelievler, Bakırköy, and Şile were the most sensitive counties when a fee of 1-3YTL is applied. However, Küçükçekmece and Gebze showed the highest percentages for those who would not give up using their cars for any price.

For Improved Public Transport Conditions 18 out of 33 counties were above the average value. Eyüp (71%), Çatalca (75%) and Beyoğlu (71%) counties had the highest percentages. Bahçelievler and Bakırköy were still the most sensitive counties when a fee of 1-3YTL was applied. However, Tuzla (50%) and Eminönü (44%) showed the highest percentages in the category of those who would not give up using their cars for any price.

Table 5.6. Car usage behavior for each county

Quarters	Existing Public Transportation Conditions						Improved Public Transportation Conditions						Change					
	Give up using the car for any price	Give up using the car for a price of				Do not give up using the car	Give up using the car for any price	Give up using the car for a price of				Do not give up using the car	Give up using the car for any price	Give up using the car for a price of				Do not give up using the car
		1-3 YTL	4-6 YTL	7-10 YTL	11-15 YTL			1-3 YTL	4-6 YTL	7-10 YTL	11-15 YTL			1-3 YTL	4-6 YTL	7-10 YTL	11-15 YTL	
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Adalar	**50**†	0	**25**	0	0	25	**75**	0	0	0	0	25	**25**	0	**-25**	0	0	0
Beykoz	**46**	12	0	**4**	**4**	35	**65**	8	0	**4**	**4**	19	**19**	**-4**	0	0	0	**-15**
Kadikoy	33	7	**6**	**4**	0	**50**	**55**	7	**4**	1	**1**	**33**	**22**	-1	**-2**	**-3**	1	**-17**
Kartal	**38**	6	**15**	**4**	0	36	51	6	**9**	**4**	0	**30**	13	0	**-6**	0	0	-6
Maltepe	30	10	**7**	0	0	**53**	**53**	3	**10**	**7**	0	27	**23**	**-7**	**3**	**7**	0	**-27**
Pendik	29	**17**	0	0	0	**54**	**63**	8	0	0	0	29	**33**	**-8**	0	0	0	**-25**
Sultanbeyli	33	**27**	0	**7**	0	33	**60**	**13**	0	**7**	0	20	**27**	**-13**	0	0	0	**-13**
Sile	29	**43**	**7**	0	0	21	29	**29**	**7**	0	0	**36**	0	**-14**	0	0	0	**14**
Tuzla	20	10	0	**20**	0	**50**	30	10	0	**10**	0	**50**	10	0	0	**-10**	0	0
Umraniye	**36**	9	1	3	0	**51**	50	7	1	**2**	**1**	**38**	14	**-3**	0	**-1**	1	-12
Uskudar	31	8	**6**	**4**	**1**	**51**	51	10	**7**	**2**	**1**	29	**20**	**2**	**2**	**-2**	0	**-22**
Avcilar	**53**	10	0	3	0	35	**65**	8	0	**3**	0	25	13	**-3**	0	0	0	-10
Bagcilar	31	**19**	**7**	0	0	**43**	47	**12**	**9**	0	0	**33**	16	**-7**	**2**	0	0	-10
Bahcelievler	32	**40**	**6**	2	**2**	17	49	**32**	**11**	0	0	9	**17**	**-9**	**4**	**-2**	-2	-9
Bakirkoy	21	**43**	**6**	**4**	**1**	24	35	**37**	**8**	**2**	**1**	17	13	**-6**	**2**	**-2**	0	-7
Bayrampasa	**36**	**19**	0	0	**2**	**43**	52	**19**	2	0	**2**	24	**17**	0	**2**	0	0	**-19**
Besiktas	**49**	4	2	1	**1**	42	**60**	6	0	**2**	0	**32**	11	**2**	**-2**	**1**	-1	-11
Beyoglu	**49**	3	2	2	**2**	**43**	**71**	3	0	**2**	**2**	23	**22**	0	**-2**	0	0	**-20**
Buyukcekmece	26	9	**8**	**8**	0	**49**	**55**	8	**6**	**3**	0	29	**29**	-1	**-1**	**-5**	0	**-21**
Catalca	**63**	**13**	0	0	0	25	**75**	0	0	0	0	25	13	**-13**	0	0	0	0
Eminonu	**41**	6	**6**	0	0	**47**	50	3	3	0	0	**44**	9	**-3**	**-3**	0	0	-3
Esenler	**51**	**16**	3	0	0	30	**54**	**19**	3	0	0	24	3	**3**	0	0	0	-5
Eyup	**55**	12	2	2	0	29	**71**	5	0	**2**	0	21	**17**	**-7**	**-2**	0	0	-7
Fatih	**41**	6	3	3	**4**	**43**	**59**	9	1	**3**	0	28	**19**	**3**	**-1**	0	-4	**-16**
Gaziosmanpasa	30	**18**	4	1	**1**	**45**	49	10	**4**	1	0	**34**	**19**	**-7**	0	0	-1	-10
Gungoren	**41**	**19**	**6**	2	0	33	**56**	**22**	**4**	0	0	19	15	**4**	**-2**	**-2**	0	**-15**
Kagithane	**41**	9	**6**	0	**1**	43	**53**	7	1	1	**3**	**34**	12	-1	**-4**	**1**	1	-9
Kucukcekmece	21	11	**7**	1	0	**59**	43	10	**7**	1	0	**39**	**21**	-1	0	0	0	**-20**
Sariyer	**51**	**15**	0	2	0	32	**57**	**17**	0	0	0	26	6	**2**	0	**-2**	0	-6
Silivri	**50**	0	0	**50**	0	0	50	0	0	**50**	0	0	0	0	0	0	0	0
Sisli	**38**	10	2	3	**1**	**45**	52	6	1	1	0	**40**	15	**-5**	**-1**	**-2**	-1	-6
Zeytinburnu	**38**	9	**9**	**6**	**3**	35	41	**12**	3	**3**	**3**	**38**	3	**3**	**-6**	**-3**	0	3
Gebze	24	12	0	0	**6**	**59**	35	**24**	**6**	**6**	0	29	12	**12**	**6**	**6**	-6	**-29**
Mean	36	13	5	3	1	43	53	11	4	2	1	30	17	-2	-1	-1	0	-13

† Bold font style indicates the values that are equal or higher than the mean

* (-) sign indicates the decrease of the number or the percentage

5.1.5. Travel Choices after the Application of the Congestion Pricing Strategies

According to another question (D.7) respondents were asked what kind of decision they would take if they give up going into CBD areas or going through the CBD areas where the congestion pricing was applied. The answers of this question were summarized in Table 5.7.

Table 5.7. The behavior of commuters after congestion pricing strategies

Start Using Public Transport		Change Route		Park & Ride		Avoid Trip if not Required	
Count	%	Count	%	Count	%	Count	%
856	66,3	232	18,0	421	32,6	410	31,7

Approximately two thirds (66.3%) of respondents would start using public transport if some congestion pricing strategies is applied. The low percentage of those who would Change Routes (18%) was thought to be due to insufficient information of respondents for the road network of Istanbul. Park&Ride and Avoidance if not Required Trip options were selected only by one third of the respondents.

5.1.6. Travel Fees

Travel fee is another important component paid a special attention by planners and policy makers in decision making processes. How much the travel fee should be decreased to make public transport more attractive or what the minimum travel fee should be in order to minimize the expenditures and maximize the profits, has a vital importance in the enhancement and modernization of the whole transportation system.

The average Travel fees for each mode were displayed in Table 5.8. Note that, the Walking mode was not included in this type of analysis because nothing is paid to use this mode. Another mode that was excluded from the analysis is Private Car mode. This does not mean that using private cars was free. On the contrary, their usage costs per person were expected to be the highest of all modes. This was considered to be attributed to their not knowing how to calculate the direct and indirect costs (fuel, maintenance, etc) of Private Car mode trips.

Table 5.8. Travel fees for each mode

Mode	N	Minimum	Maximum	Mean	Std. Deviation
Taxi	113	2,00	35,00	8,06	5,66
Service House	220	0,94	11,25	3,80	2,02
Road Public Transport	1.881	0,50	6,00	1,27	0,43
Rail Public Transport	104	0,65	2,50	1,14	0,21
Marine Public Transport	23	0,50	2,10	1,03	0,29
Others	29	1,00	17,50	4,70	4,67
Multi-Modal	301	0,65	25,00	2,26	1,80
Total	2.671	0,50	35,00	1,91	2,17

Trips made by Taxi mode were computed to be about 8 YTL which are the most expensive ones. Using Service House mode is the second most expensive trip, averaged to 3.8 YTL. The other modes like Road, Rail, Marine Public Transport modes and Multi-Modal are calculated to be 1.27 YTL, 1.14 YTL, 1.03 YTL and 2.26, respectively.

5.2. Analysis of Orgin-Destination Data for Fulya Pilot Area

Another sample of trips made to Fulya study area was analyzed. This sample was analyzed to compare the data of the Fulya study area with the total metropolitan area. The total number of respondents traveling to Fulya/Şişli was 236. 19 questionnaire data were excluded from the calculation due to insufficient and/or unreliable information. One respondent did not write the starting and final destinations. 14 of them did not give information about walking time to the station, waiting time for the vehicle, and in-vehicle travel time. Finally, four of the respondents extracted from the analyses gave unreliable information like traveling by light metro to Fulya/Şişli where no such mode is available, or noting short trip durations like 10 minutes traveling very long distances which were very unrealistic. Thus, the final number of the cases analyzed was reduced to 217.

5.2.1. Frequencies of Trips

As it is shown in Table 5.9, Intra-Neighborhood based trips were made almost by Walking mode. 40 (97.6%) of all trips inside the Fulya neighborhood were made by

Walking mode and only one (2.4%) was made by Road Public Transport mode. On the other hand, the Walking mode was reduced when traveling from one neighborhood to another inside the Şişli County. However, for Fulya neighborhood it was still the dominant mode (38.2%) used consisting of 13 cases. The second most prevalent mode was Road Public Transport accounting for 8 (23.5%) cases. The other ones were Service House, Taxi, and Private Car modes making up 17.6%, 11.8%, and 8.8% of all Inter-quarter trips, respectively.

Table 5.9. The frequencies of each mode in continental, county, and neighborhood base (Fulya)

	Intra-Continental						Inter-Continental		Total Trips	
	Intra-County				Inter-County		Inter-County			
	Intra-Neighborhood		Inter-Neighborhood		Inter-Neighborhood		Inter-Neighborhood			
	Count	%	Count	%	Count	%	Count	%	Count	%
Walking	40	97,6	13	38,2	15	12,9			68	31,3
Private Car			3	8,8	29	25,0	11	42,3	43	19,8
Taxi			4	11,8	6	5,2	1	3,8	11	5,1
Service House			6	17,6	15	12,9	2	7,7	23	10,6
Road Public Transport	1	2,4	8	23,5	33	28,4	7	26,9	49	22,6
Rail Public Transport					6	5,2			6	2,8
Marine Public Transport										
Others					3	2,6			3	1,4
Multi-Modal					9	7,8	5	19,2	14	6,5
Total Modes	41	100,0	34	100,0	116	100,0	26	100,0	217	
% of Total Modes	18,9		15,7		53,5		12,0			
Motorized Modes	1		21		101		26		149	
% of Motorized Modes	0,7		14,1		67,8		17,4			

Trips made from other European counties to Fulya/Şişli (in European side) were mostly made by Road Public Transport which consisted of 33 (28.4%) cases. The second dominant mode type was Private Car, making up 25% of the total Inter-County trips. Other Inter-County trips, were made by Service House and Walking, Rail Public Transport, Taxi, Others and Multi-Modes consisting of 12.9%, 5.2%, 5.2%, 2.6%, and 7.8%, respectively.

The number of Inter-Continental trips (26) was the lowest among all trip types. Here we had only 26 cases where the most dominant travel modes were Private Car and Road

Public Transport composed of 11 (42.3%) and 7 (26.9%) cases, respectively. The next most dominant one was Multi-Modal accounting for 5 (19.2%).

The last column in the Table 5.9 shows the total trips made by each travel mode to Fulya pilot study area. About 31% of the respondents used Walking mode to Fulya neighborhood. Road Public Transport mode (22.6%) was calculated to be the second most dominant mode while traveling to this neighborhood. Notice that this percentage for the whole metropolitan area (19.8%) was lower. This result can be attributed to the higher Road Public Transport level in Fulya. However, Private Car mode results were higher accounting for approximately 14%.

We found that walking trips decreased as travel distances increased and finally they became zero when Inter-Continental trips were taken into account. On the other hand, Road Public Transport dominance increased by the increase of the length of distances traveled. Another very important result concluded from the Table 5.9 was that, Inter-County trips consisted of more than half of the whole trips (116/217) made by all types of modes. This is as a result of medium-length distances being mostly considered in this category.

5.2.2. Mean Travel Times

As it can be seen from Table 5.10, the average travel time of trips made by Walking mode inside the Fulya neighborhood was 16 minutes and only one trip using Road Public Transport was 45 minutes. On the other hand, trips made by Walking mode inside the Şişli County were averaged to 15 minutes. Traveling by Private Car, Taxi, Service House, and Road Public Transport lasted 25, 13, 50, and 48 minutes, respectively. The total travel times of Intra-Neighborhood trips were averaged to 17 minutes, whereas those of Inter-Neighborhood ones had a mean of 30 minutes.

The travel times of Inter-County trips were higher than Intra-County ones. The shortest trips were made by Rail Public Transport and Taxi modes averaged to 22 and 24 minutes, respectively. Walking, Private Car, and Service House, listed in increasing travel time manner, had means of 34 minutes, 42 minutes, and 45 minutes, sequentially. The longest trips in Inter-County category were made by more than one mode (69 minutes). The second one was Road Public Transport (58 minutes). All Inter-County trip durations averaged to 46 minutes. However, this value (50 minutes) was higher for the total metropolitan area (Table 5.2, p 59). The reason of this change can be attributed to the presence of Rail Public Transport (Metro) and high frequency of Road Public Transport.

Table 5.10. The mean travel times of each mode in continental, county, and neighborhood base (Fulya)

	Intra-Continental						Inter-Continental		Total Trips	
	Intra-County				Inter-County		Inter-County			
	Intra-Neighborhood		Inter-Neighborhood		Inter-Neighborhood		Inter-Neighborhood			
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Walking	0:16	0:20	0:15	0:08	0:34	0:22			0:20	0:20
Private Car			0:25	0:05	0:42	0:29	1:00	0:24	0:46	0:28
Taxi			0:13	0:02	0:24	0:08	0:45	.	0:22	0:11
Service House			0:50	0:22	0:45	0:23	1:35	0:35	0:50	0:27
Road Public Transport	0:45	.	0:48	0:21	0:58	0:25	1:13	0:31	0:59	0:25
Rail Public Transport					0:22	0:07			0:22	0:07
Marine Public Transport										
Others					0:31	0:12			0:31	0:12
Multi-Modal					1:09	0:39	1:27	0:26	1:15	0:35
Total	0:17	0:20	0:30	0:22	0:46	0:28	1:11	0:28	0:41	0:30

Furthermore, Inter-Continental trips had the longest durations. One hour and 11 minutes was the mean of all modes of Inter-continental trips. The longest trips were made by Service House mode, averaging to 95 minutes. The second highest travel time was made by more than one mode accounting for 87 minutes. The travel times of other three modes; Private Car, Taxi, and Road Public Transport, were calculated to be 60 minutes, 45 minutes, and 63 minutes, respectively.

Travel times were grouped in Table 5.11 in four cumulative categories as: Intra-Neighborhood, Intra-County, Intra-Continental, and Inter-Continental. Intra-Neighborhood and Inter-Continental travel times are the same as indicated in Table 5.9. Intra-County category included all Intra-Neighborhood and Inter-Neighborhood trips. The mean of these trips was calculated to be 23 minutes, where Service House and Road Public Transport were the most dominant ones by 50 minutes and 48 minutes, sequentially.

The longest Intra-Continental trips were made by more than one mode (69 minutes). The second highest value was observed for Road Public Transport lasting 56 minutes. Trips made by Walking and Taxi modes were computed to be the same (20 minutes). The other ones Private Car, Service House, and Rail Public Transport modes had means of 41, 46, and 22 minutes, respectively.

In the last column of Table 5.11 the totals of all these categories were represented. The highest travel time was observed in Multi-Modal trips accounting for 75 minutes. Trips made by Road Public Transport modes (63 minutes) had the second longest total mean travel times of 59 minutes. Surprisingly, the total mean travel time for Private Car mode traveling to Fulya was significantly high (46 minutes). On the other hand, this value (Table 5.3, p 60) was considerably low in the total metropolitan area accounting for 33 minutes. One reason for these results could be due to high traffic congestion of the Şişli County, especially during peak hours. Another reason for the high total mean travel time while traveling to Fulya neighborhood could be attributed to illegally on-street parked vehicles, thus reducing the capacities of the streets and slowing down the traffic movement.

Table 5.11. The cumulative travel times of each mode in continental, county, and neighborhood base (Fulya)

	Intra-Neighborhood		Intra-County		Intra-Continental		Inter-Continental		Total Trips	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Walking	0:16	0:20	0:16	0:18	0:20	0:20			0:20	0:20
Private Car			0:25	0:05	0:41	0:28	1:00	0:24	0:46	0:28
Taxi			0:13	0:02	0:20	0:08	0:45	.	0:22	0:11
Service House			0:50	0:22	0:46	0:23	1:35	0:35	0:50	0:27
Road Public Transport	0:45	.	0:48	0:19	0:56	0:24	1:13	0:31	0:59	0:25
Rail Public Transport					0:22	0:07			0:22	0:07
Marine Public Transport										
Others					0:31	0:12			0:31	0:12
Multi-Modal					1:09	0:39	1:27	0:26	1:15	0:35
Total	0:17	0:20	0:23	0:22	0:37	0:28	1:11	0:28	0:41	0:30

5.2.3. Travel Time for Each Segment of the Trip

Table 5.12 shows the averages of different trip sectors like Walking to Station Time, Waiting Time, In-Vehicle Time, and Walking to Destination time, for different mode types. Walking mode was excluded from the computation in this table because it consisted of only one sector, walking, however it is expressed in the Table 5.9 and Table 5.10.

As it can be seen from Table 5.12 Multi-Modal trips showed the longest Walking to Destination time accounting for 8.4 minutes. Furthermore, Road Public Transport mode showed the second longest Walking to Station time consisting of 6.3 minutes. The other values for this segment were; for Private Car mode 0.7 minutes, for Taxi mode 0.4 minutes, and for Service House mode 1.3 minutes, and for Rail Public Transport mode 4.3 minutes. The total average of Walking to Station time was 3.5 minutes.

Waiting Time for Multi-Modal (15.3 minutes) trips was much higher than other modes. The second highest Waiting Time was for Road Public Transport mode (8.2 minutes). This result shows that the most widely used mode was less frequent than the other modes. The Rail Public Transport mode had a mean value of about 2 minutes. The other values like Service House, Taxi, and Private Car had mean values of almost zero.

Table 5.12. Average segment times for different modes (Fulya)

Mode	Walking to Station Time (minutes)	Waiting Time (minutes)	In-Vehicle Time (minutes)	Walking to Destination Time (minutes)	Total Access-Egress Time (minutes)	Total Travel Time (minutes)
Private Car	0,7	0,1	44,8	0,6	1,4	46,2
Taxi	0,4	0,1	21,4	0,5	0,9	22,3
Service House	1,3	0,2	46,0	3,4	5,0	51,0
Road Public Transport	6,3	8,2	35,9	8,7	23,3	59,2
Rail Public Transport	4,3	1,5	9,2	7,5	13,3	22,5
Marine Public Transport						
Others	0,0	0,0	31,7	0,0	0,0	31,7
Multi-Modal	8,4	15,3	48,0	12,4	36,1	84,1
Total	3,5	4,3	38,9	5,1	12,8	51,7

Secondly, the third segment, In-Vehicle Time, had the largest mean value. Here we observed that the highest In-Vehicle Time was Multi-Modal of about 48 minutes. Service

House with 46 minutes was the second highest In-Vehicle Time. The average In-Vehicle Time for the Private Car mode was calculated to be 44.8. Road Public Transport, Taxi, and Rail Public Transport had means of 35.9, 21.4, and 9.2 minutes, respectively. The total average time in this segment was 38.9 minutes.

Finally, Multi-Modal trips had the highest Walking to Destination Time accounting for 12.4 minutes. Road Public Transport (8.7 minutes) and Rail Public Transport (7.5 minutes) had the second highest values as far as the last sector, Walking to Destination Time, was considered. The average in this segment was calculated to be 5.1 minutes. Notice that the total walking time of respondents who used Rail Public Transport mode was 13.3 minutes (4.4 + 7.9). On the other hand in-vehicle time (9.3 minutes) was less than waiting time (13.3 minutes). This result confirmed that Rail Public Transport was discouraged.

It was also calculated that 14 trips out of 217 were made by two modes, and 2 out of 217 were made by 3 modes. While calculating the average values of these types of trips, we changed them to one mode travel, adding the same segments with each other. For instance, in two mode trips (bus and metro), we combined walking times, waiting times, and in-vehicle times of the bus and metro.

5.2.4. Car Usage Behavior When Congestion Pricing Strategies Applied

Another very beneficial data gathered from these respondents was their behavior related to different downtown congestion pricing strategies, which take into consideration the existing and improved public transport. The question was (D.5, D.6): "In order to relieve the traffic while traveling to CBD areas some congestion pricing strategies are used in some European cities. What is your car usage behavior for the Existing Public Transport Conditions if similar congestion pricing strategies were applied?" The alternatives were; giving up using their cars for any price, giving up using their cars for some amount of money, or not giving up using their cars.

In Table 5.13, car usage behavior for existing and improved public conditions was expressed both in numbers and in percentages. About the half (46.2 %) of automobile users surveyed were ready to quit using their cars for any price, while traveling to these highly congested areas for the existing condition of public transport. Another 6% of them would not use their cars if they were required to pay a charge ranging 1-3 YTL. On the other hand, 41.8% stated that they would not give up using their cars for Existing Public Transportation conditions. Whereas for the Improved Public Transport Conditions those who would give up using their cars for any price raised to 71.4% resulting in a 25.3% increase. About one fifth (22%) of the respondents still did not change their minds even when public transport conditions were improved.

Table 5.13. Car usage behavior for existing and improved public conditions (Fulya)

	Existing Public Transportation Conditions		Improved Public Transportation Conditions		Change	
	Count	%	Count	%	Count	%
Give up using the car for any price	42	46,2	65	71,4	23	25,3
Give up using the car for 1-3 YTL	5	5,5	4	4,4	-1	-1,1
Give up using the car for 4-6 YTL	3	3,3	2	2,2	-1	-1,1
Give up using the car for 7-10 YTL	2	2,2	0	0	-2	-2,2
Give up using the car for 11-15 YTL	1	1,1	0	0	-1	-1,1
Do not give up using the car	38	41,8	20	22,0	-18	-19,8
Total	91	100,0	91	100,0		

5.2.5. Travel Choices after the Application of the Congestion Pricing Strategies

According to another question (D.7) respondents were asked what kind of decision they would take if they give up going into CBD areas or going through the CBD areas where the congestion pricing was applied. The answers of this question were summarized in Table 5.14.

Table 5.14. The behavior of commuters after pricing and restricting strategies (Fulya)

Start Using Public Transport		Change Route		Park & Ride		Avoid Trip If Not Required	
Count	%	Count	%	Count	%	Count	%
61	67,0	12	13,2	36	39,6	23	25,3

About two thirds (67%) of them would start using public transport if some congestion pricing strategies are applied. The low percentage of those who would change routes (13.2%) was thought to be due to insufficient information of respondents for the road network of Istanbul. Furthermore, the percentage of those who would park their cars outside the CBD and then ride to their destination was about 40%. Finally, one quarter of the respondents would avoid their trips to CBD areas if they were not required.

5.2.6. Travel Fees

The average Travel fees for each mode were displayed in Table 5.15. Note that, the Walking mode was not included in this type of analysis because nothing is paid to use this mode. Another mode that was excluded from the analysis is Private Car mode. This does not mean that using private cars was free. On the contrary, their usage costs per person were expected to be the highest of all modes. This was considered to be attributed to their not knowing how to calculate the direct and indirect costs (fuel, maintenance, etc) of Private Car mode trips. It seems that drivers only consider the out of pocket cost as the travel cost.

Trips made by Taxi (6 YTL) were the most expensive. Multi-Modal was the second most expensive travel mode, accounting for 2.38 YTL. The Road Public Transport and Rail Public Transport were computed to be 1.36 YTL and 1 YTL, respectively.

Table 5.15. Travel fees for each mode (Fulya)

Mode	N	Minimum	Maximum	Mean	Std. Deviation
Taxi	10	3,00	17,00	6,07	4,77
Service House	4	1,25	3,00	1,71	0,86
Road Public Transport	48	0,70	2,60	1,36	0,54
Rail Public Transport	6	0,80	1,30	0,98	0,19
Others	1	1,30	1,30	1,30	.
Multi-Modal	14	0,80	7,50	2,38	2,03
Total	85	0,00	17,00	2,04	2,38

6. ANALYSIS OF THE PARKING DATA COLLECTED FOR THE PILOT AREA

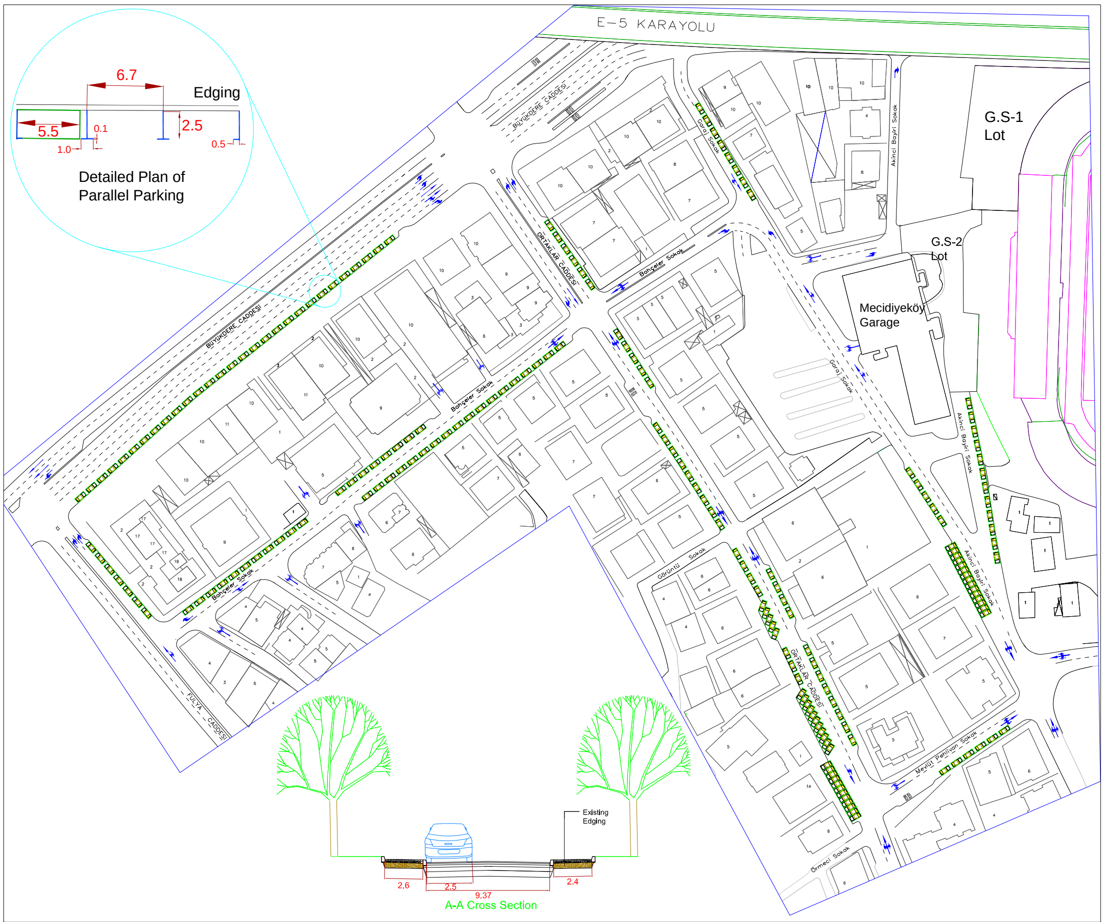
6.1. Defining the Boundaries

Fulya is a quarter of Şişli's district and is one of the most problematic regions of Istanbul in terms of traffic. This quarter has mainly three different land-uses; residential, commercial, and official, and has an area of about 139.000 m^2. The boundary of the pilot study area is highlighted by blue color. The study area is roughly bounded by Büyükdere Avenue (main artery) on the north, Mevlut Pehlivan Street on the south, Fulya Avenue on the west, and Galatasaray Stadium on the east. The parking study area consists of; 11 units or blocks (A-K), 17 on-street pockets, 2 parking lots, and 1 six-storey garage.

Figure 6.1 shows Fulya pilot study area with the number and type of parking spaces. There were; 141 parallel, five 45-degree angled, eleven 60-degree angled, and 27 perpendicular spaces, all adding up to 184 on-street spaces. As indicated above one of the land-uses of the pilot study area is commercial land-use. Hence, many commercial vehicles use on-street spaces for loading and unloading. However, there were no on-street parking spaces dedicated to commercial vehicles for loading/unloading. Furthermore, there were also no on-street spaces reserved for handicapped people in the pilot study area.

Fulya pilot study area is a very busy area not only during daytime but also during evenings. It is beside Büyükdere main artery, one of the most congested arteries of Istanbul, which is linked to E-5 Motorway. One of the largest bus stations in Istanbul is found in this area. Furthermore, the pilot study area has access to Taksim-4.Levent metro from Mecidiyeköy metro station. Hence, a high number of people change their modes of travel in this area.

The off-street facilities, such as parking lots and garage, are placed on the east side of the area. The access to the off-street facilities, especially from Büyükdere main artery, is not very easy. This becomes impossible for unfamiliar drivers with the area, because no parking signs show the direction to the off-street parking facilities.



Legend	
Parking Unit Dye	Load/Unload Parking Unit
Truck Parking Unit	Handicapped Parking Unit
Vehicle	Traffic movement direction

Type and Number of Parking Spaces						
Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
27	11	5		141		

Figure 6.1. Fulya pilot study area with physical details of parking spaces

6.2. Codifying the Study Area

After deciding about the study area some preliminary observations were conducted to understand the possible difficulties that may be encountered during the survey. The potential key points that have to be kept in mind about the way the license plate survey is conducted were noted down on a map during this preliminary observation. Then, all blocks and streets were coded. Block codes were decided to have letters from A to K, whereas streets had a letter showing the block that they belong to and a number, generally from one to four, indicating the street of the block (i.e. B-2). The map with the decided codes is given in the Figure 6.2 below.

The red color in Figure 6.2 shows all street sides legally and illegally occupied by parked vehicles. Notice that vehicles parked on B-3, D-2, E-2, and K-3 streets sides were illegally parked. All on-street spaces were not priced and had no parking duration limitations.

Finally, the survey was conducted for four weeks on Thursdays; 10th August, 17th August, 24th August, and 31st August 2006. The weather was sunny fluctuating from 30° to 35° C.

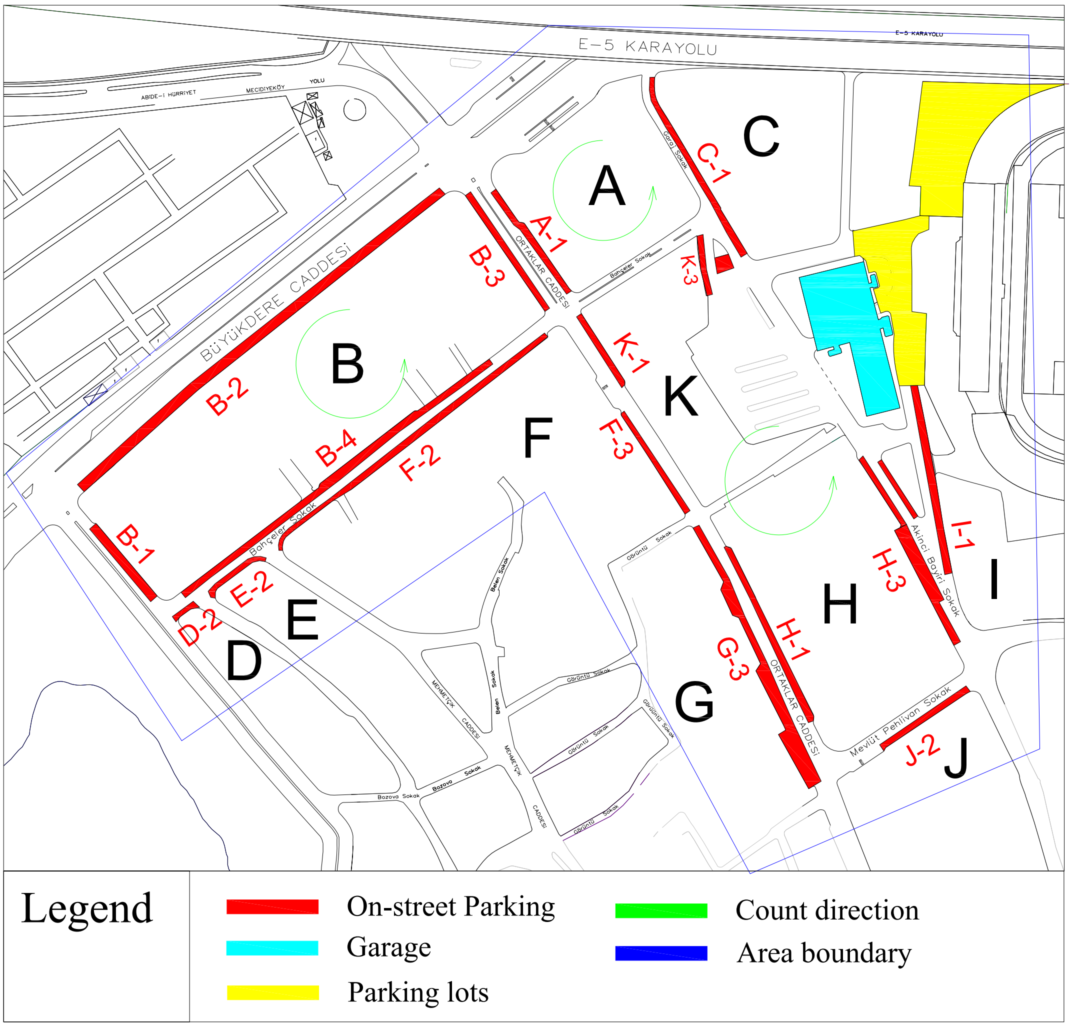


Figure 6.2. Surveyed parking facilities in Fulya pilot study area

6.3. Inventory of Parking Facilities

6.3.1. Off-street Inventory

The off-street parking facilities of the area consisted of two parking lots and a 6-storey garage, having capacities of 100, 44, and 550, respectively. The total supply of the off-street facilities was 694 spaces. Thus, the maximum vehicle-parked hours for off-street facilities for 12 hour duration were 8328 hours (12 * 694). They were located on the eastern part of the study area. Parking lots used to operate only in a twelve-hour period between 8:00 AM and 6:00 PM and only during the weekdays (Monday to Friday), whereas garage was open 24 hours a day and seven days a week. These facilities were possessed by the same owner. People with subscriptions could park wherever they wanted during the daytime, whereas during the night they had to use the garage. In addition, parking lots were paved but uncovered by roofs, which may affect parking rates in different weather conditions. Another feature of them is that, parking spaces' alignments (perpendicular, 60-degree, 45-degree, and 30-degree parking) were not marked and identified, decreasing their land-use efficiency. Furthermore, there were no parking signs in the main street or in the vicinity of parking facilities informing the unfamiliar users about the location and distance of the off-street facilities. They were generally used by commuters and residents, those being familiar with the area.

Parking rates were collected by one person at the entrance of the parking lots or garage. The parking lot fees were 5YTL ($3) for all parking types and durations. On the other hand, parking charges were different in the garage. The parking durations of 0-1 hour, 1-2 hour, 2-5 hour, 5-8 hour, 8-11 hour, and more than 11 hours had rates of 5YTL, 6YTL, 7YTL, 8YTL, 9YTL, 10YTL, respectively. Monthly subscriptions were also used in off-street facilities having a rate of 110YTL.

6.3.2. On-street Inventory

It was very difficult to exactly determine the capacities of on-street (curb) parking due to the insufficiency of signs and parking marks clearly indicating where parking is allowed or forbidden. The total number of legal on-street parking spaces in the pilot study area was 184 spaces. The supply for 12 hour duration of on-street parking in terms of vehicle-parked hours was 2208 hours. Notice that all the streets in the area were occupied by parked vehicles most of the time. The high number of parked cars led to a higher friction on the streets, thus slowing down the movement of the vehicles.

The on-street parking was used by a large variety of users including; loading/unloading, shopping and retail, residential, coffee-bars, commuters, etc. The whole on-street parking rates were free. ISPARK (Parking Management Center of Istanbul) changed some of them by making them priced for 4YTL at a maximum duration of 2 hours along Akatlar Avenue. There were different physical layouts in the on-street parking facilities of the Fulya study area such as parallel, 45 degree, 60 degree, and perpendicular.

6.4. License Plate Survey

It was decided to collect some quantitative information about parking facilities in the pilot area through a *license plate survey*. In addition, some qualitative information was also gathered during this survey.

The area was divided into four main parts. The surveys in each part were decided to be conducted on Thursdays. It was concluded that walking around a block was the most efficient way of collecting information because while rounding, the end of one count was the beginning of the next count. It was not necessary to travel back to the starting point in order to start the next count as in one street counts.

The first count was taken around the B block walking in counterclockwise manner and gathering information about B-3, B-2, B-1, B-4, D-2, E-2, and F-2 street sides. The next count was chosen around the A and C blocks, getting data from C-1, A-3, and K-3 street sides. The third count comprised K, H, J, G, and F blocks. The street sides counted were; K-1, F-3, G-3, H-1, J-2, and H-3 street sides. Counting off-street facilities was the last count made in the area, including only two parking lots. We were not allowed to conduct counts in the garage, but we were able to convince the facility officials to give us the records that they made themselves. However, this data was not used in accumulation and fluctuation analyses because they were unusable for conducting these analyses.

It was decided for the intervals of the on-street parking study to be 30 minutes and for those of off-street parking to be 60 minutes. This decision was made following other studies conducted around the world which indicated that these were the most efficient and economical intervals for manual conduction of this survey.

For fixing the study duration, some preliminary observations in the study area were made to judge the start and the end of the survey duration. It was observed that parking starts increased between 7-8 AM in mornings and decreased after 5-6 PM in evenings. A 12-hour duration license plate survey between 7 AM and 7 PM was decided to be performed for on-street parking study. On the other hand, off-street survey duration started at 8 AM and lasted 11 hours, since parking lots started operating at 8 AM.

6.5. Daily Fluctuations

6.5.1. On-street parking daily fluctuation

The total daily fluctuation of the parked vehicles was calculated to be as shown in Figure 6.3. In the morning, between 7-8 AM, the number of parked vehicles increased significantly from 100 to 180. Then it continued to increase but at a slower rate until reaching a value of 200 parked vehicles at 11:30. The number of parked vehicles fluctuated around 200 until 6 PM and then decreased significantly. It reached its maximum value of 211 parked vehicles at 14:00. Notice that on-street parked vehicles exceeded the supply of 184 spaces from 9 AM to 6 PM, meaning that on-street parking was saturated and some vehicles were parked illegally.

Other forms of summarizing daily fluctuation are % of vehicle-parked hours and % of parked vehicles. Although the data was gathered and calculated in 30-minutes interval base, we grouped it in 6 categories such as 0-30 minutes, 30-60 minutes, 1-2 hours, 2-4 hours, 4-8 hours, and more than 8 hours.

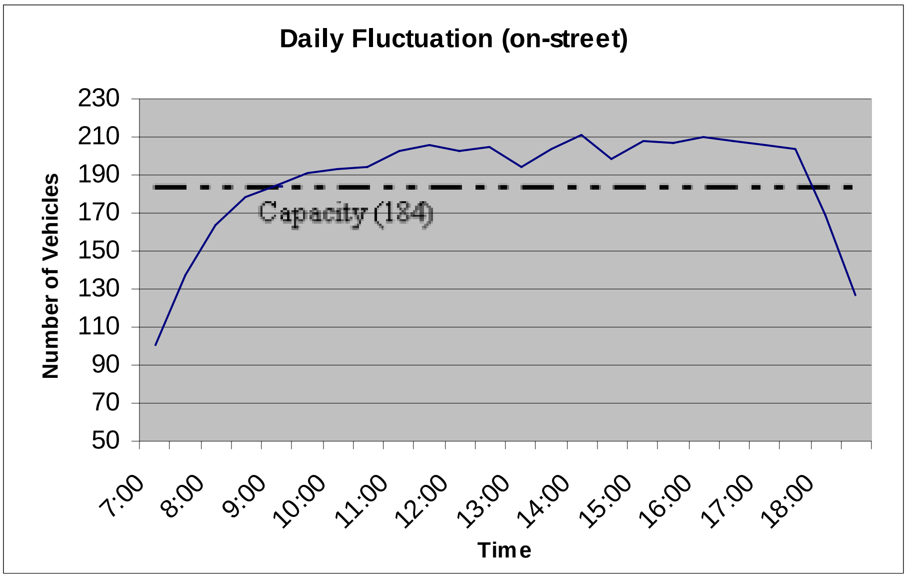


Figure 6.3. Total daily fluctuation of on-street parking

Parking duration distribution for total on-street parking spaces obtained from the survey is presented in Figure 6.4. More than the half of all parked vehicles in the study area was parked for less than 30 minutes. Drivers who parked their vehicles for more than 30 minutes but less than one hour accounted for approximately 17%. The fraction of parked vehicles between 1-2 hours was calculated to be 12%. The percentage of those who parked their vehicles between 2-4 hours and those who parked between 4-8 hours were determined to be 8% and 5%, respectively. Some drivers who chose to park their cars on the street for duration of more than 8 hours comprised 6% of all on-street parkers.

Consider the two extremes of Figure 6.4. The first extreme (left-hand side) where the vehicles were parked for duration of less than 30 minutes had a high percentage of parked vehicles (51%) but a low percentage of vehicle-parked hours (14%). In the other extreme where vehicles were parked for more than 8 hours, the low percentage of parked vehicles (6%) was accompanied with a very high percentage of parked hours (34%). This means that the higher the number of long-duration parked vehicles, the fewer is the parking space available for short-term parking duration. In other words, a small number of long-term parking durations significantly decreased the efficiency of the on-street parking facilities.

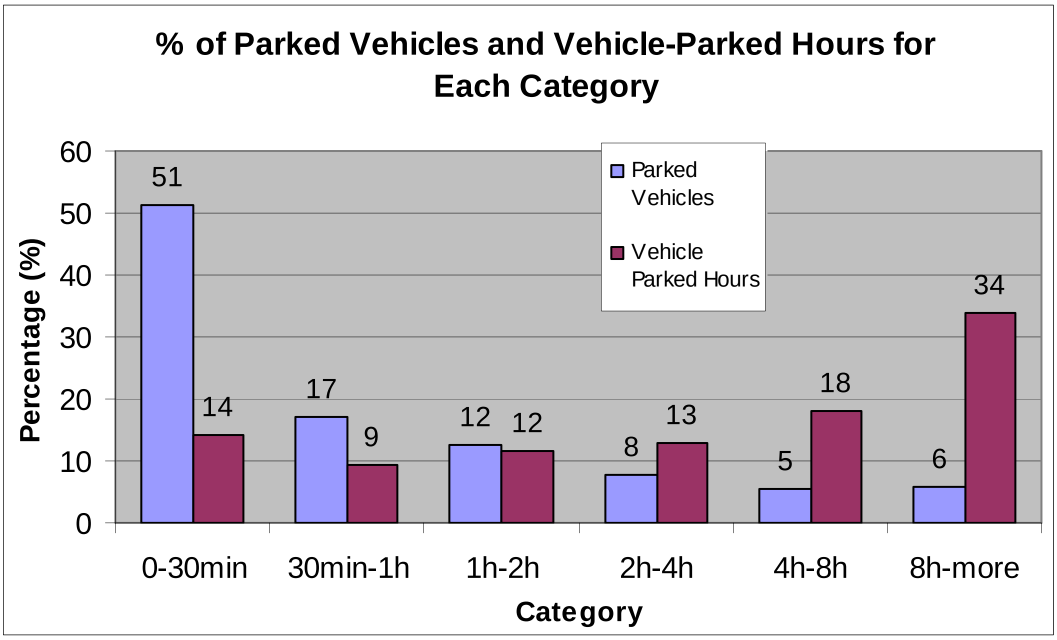


Figure 6.4. Percentage of vehicle-parked hours and % of parked vehicles (on-street)

As it is shown in the Table 6.1, vehicles that are parked for duration less than 30 minutes occupied the streets of the study area for 318 vehicle-hours during the 12-hour survey duration. Those who parked between 30 minutes and 1 hour, 1-2 hours, 2-4 hours, 4-8 hours, and more than 8 hours account for 213, 261.5, 291, 404.5, 767 vehicle-hours, respectively. Note that, this value increased significantly for the last two categories. The total hours of vehicles in the study area sums to 2255 parked hours.

Table 6.1. Vehicle-parked hours (on-street)

Category	Parked Hours (vehicle-hours)	%
0-30	318	14
30-1h	213	9
1h-2h	261,5	12
2h-4h	291	13
4h-8h	404,5	18
8h-more	767	34
TOT	2255	100

Although vehicles parked for at least 8 hours accounted for about 6% of all on-street parked vehicles (Figure 6.4), their vehicle-parked hours were 34% of the total vehicle-parked hours. Obviously, if the long-term parkers can be mobbed to off-street parking lots, the turnover for the on-street parking can be increased significantly.

6.5.2. Off-street parking daily fluctuation

The survey duration for the off-street facilities such as parking lots, was decided to be 11 hours starting from 8 AM to 7 PM. It was decided to start counting one hour later because the off-street facilities started operating and collecting tickets at 8 AM. As it is shown in Figure 6.5 the fluctuation increased significantly from 8 AM to 10 AM and this increase continued in a moderate way until 12:00 when it reached the first peak of 95 parked vehicles. We observed a decrease in the number of parked vehicles down to 88 between 1 PM and 2 PM. This result can be attributed to the fact that commuters, who generally used off-street parking facilities, used their cars during lunch break. The fluctuation reached its total maximum value of 109 parked vehicles at 4 PM. However, the total capacity of parking lots was 146 spaces, high above the maximum of parked vehicles. After 4 PM the number of parked vehicles started decreasing down to 62 until 7 AM.

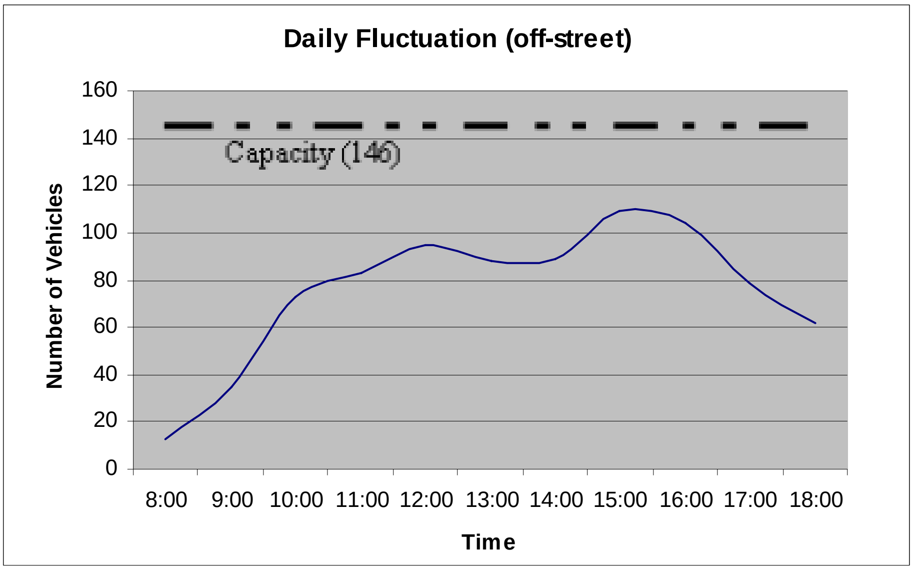


Figure 6.5. Total daily fluctuation of off-street parking

The behavior of off-street parkers during a simple weekday can be explained through Figure 6.6. About 37% of drivers using off-street parking lots, parked for duration of no more than one hour. Those who parked their vehicles between 1-2 hours, 2-4 hours, 4-8 hours, and more than 8 hours comprised 13%, 18%, 16%, and 16% of the total of the parked vehicles, respectively. Note that the percentage of parkers in the first category, 0-1 hour duration, was approximately twice as much as the other categories. Furthermore, considering the parking duration less than 2 hours as a short duration parking, we concluded that, the half (37+13 =50) of the off-street parkers used the parking lots for short parking durations.

The Table 6.2 gives both the number and the percentage values of off-street vehicle-parked hours. People who parked their vehicles only for 1 hour during the study area occupied the parking spaces for 79 vehicle-hours. The vehicle parked hours for intervals of 1-2 hours, 2-4 hours, 4-8 hours, and more than 8 hours were computed to be 54, 141, 231, and 324, respectively. The total parked hours for parking lots were calculated to be 829 hours.

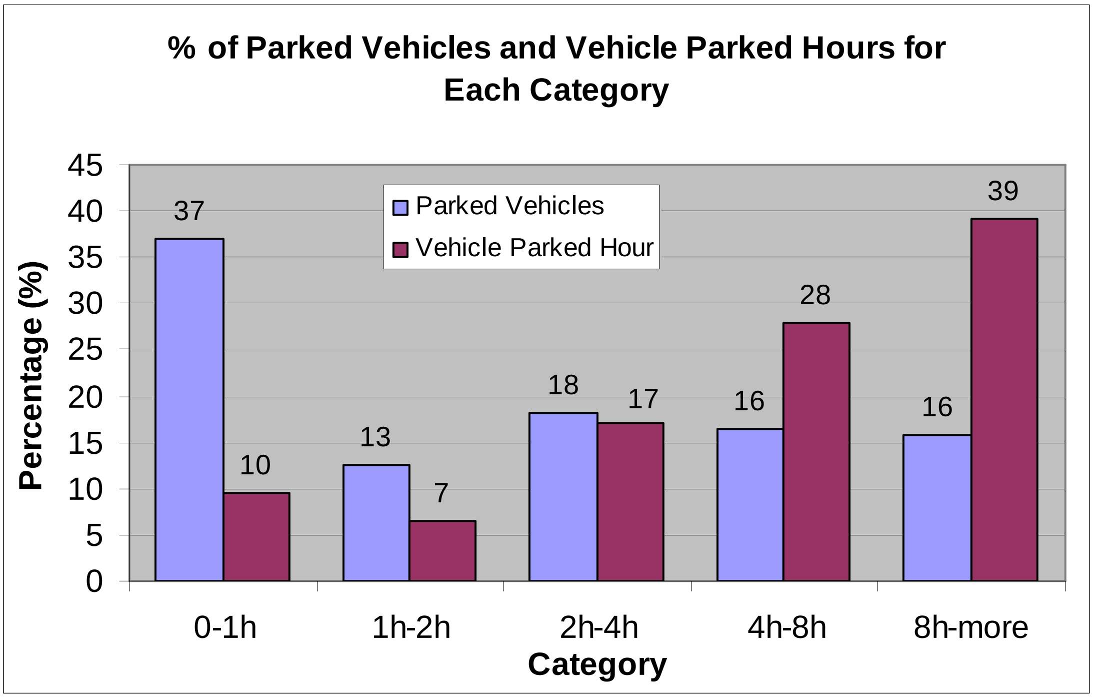


Figure 6.6. Percentage of vehicle parked hours and % of parked vehicles (off-street)

The percentage of vehicle-parked hours compared with the percentage of the number of parked vehicles clearly showed how they did change for each category. The situation was the same as in the on-street parking analysis. The number of parked vehicles decreased, whereas the parked hours increased by the parking duration.

Table 6.2. Vehicle-parked hours (off-street)

Category	Parked Hours	%
0-1h	79	10
1h-2h	54	7
2h-4h	141	17
4h-8h	231	28
8h-more	324	39
TOT	829	100

6.6. Duration Distribution

6.6.1. On-street duration distribution

Figure 6.7 shows the duration distribution for on-street parking facilities according to six park duration intervals like 0 - 30 minutes, 30 minutes – 1 hour, 1 hour – 2 hours, 2 hours – 4 hours, 4 hours – 8 hours, and more than 8 hours.

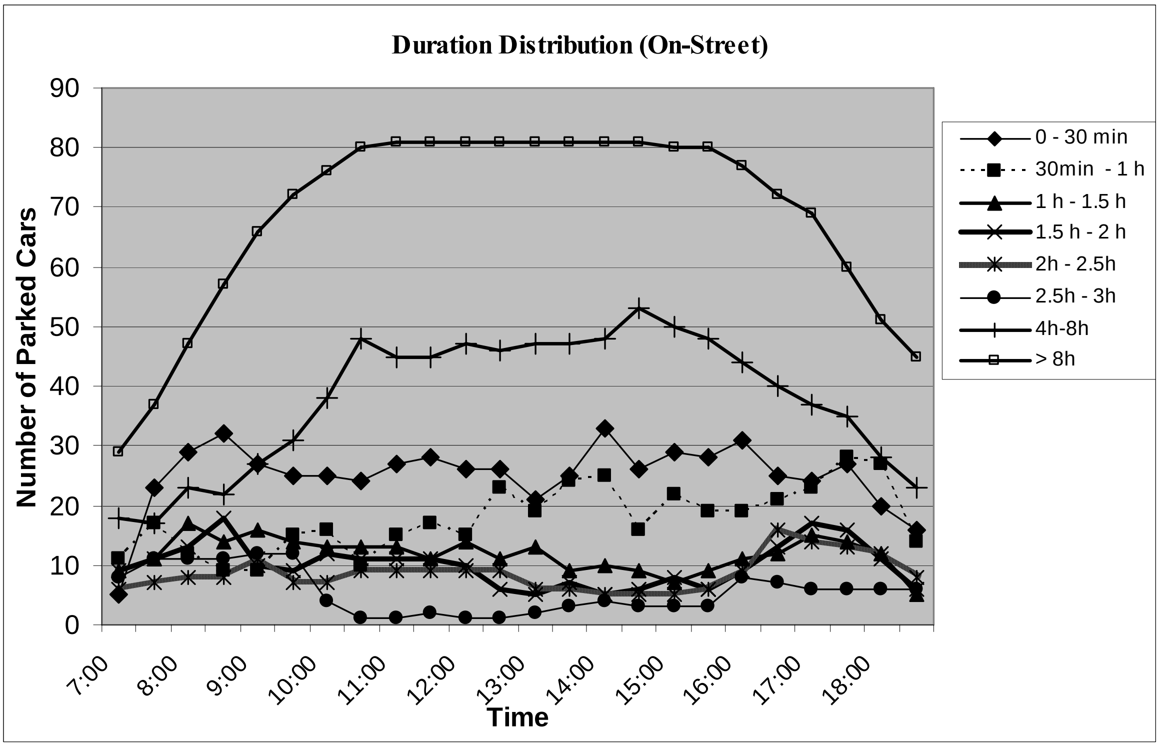


Figure 6.7. Duration distribution (on-street)

As it is shown in Figure 6.7, the number of cars parked more than eight hours showed the highest value (81 vehicles). This number had a peak from 11 PM to 4 PM, hence significantly decreasing the turnover. Furthermore, the number of vehicles parked more than four hours but less than eight hours showed a peak at 4 PM. But, like those parked more than eight hours, their number had high values between 11 AM and 4 PM. These high values may be attributed to the fact that these facilities are significantly used by commuters and residents.

The number of cars parked in the first interval, less than 30 minutes, peaked in two points, one at 8:30 and another at 14:30, but it fluctuated to a mean value of about 27 parked vehicles. This means that short parking durations like transaction and loading/unloading were made during the daytime. On the other hand, the number of vehicles parked for more than 30 minutes but less than one hour was high in the afternoon. This may be due to the fact that the most suitable time for shopping was in the afternoon. This category reaches a maximum at 6 PM.

6.6.2. Off-street duration distribution

The intervals of off-street parking consisted of one hour duration. As a result, the durations were grouped in the following five categories; less than one hour, 1 hour – 2 hours, 2 hours – 3 hours, 3 hours – 4 hours, 4 hours – 5 hours, and more than five hours.

As it is shown in Figure 6.8 the number of vehicles parked more than five fours showed the highest value with a maximum of 58 vehicles. Three categories, 0 – 1hour, 1 – 2 hours, and 3 – 4 hours, demonstrated a climax between 15:00 – 15:30. This might be due to shopping and transaction that people tried to make between afternoon and evening rush hour. Those who parked between two and three hours had a peak at noon, 12:00, which could be explained by another very busy transaction time which was followed by a decrease during the lunch break.

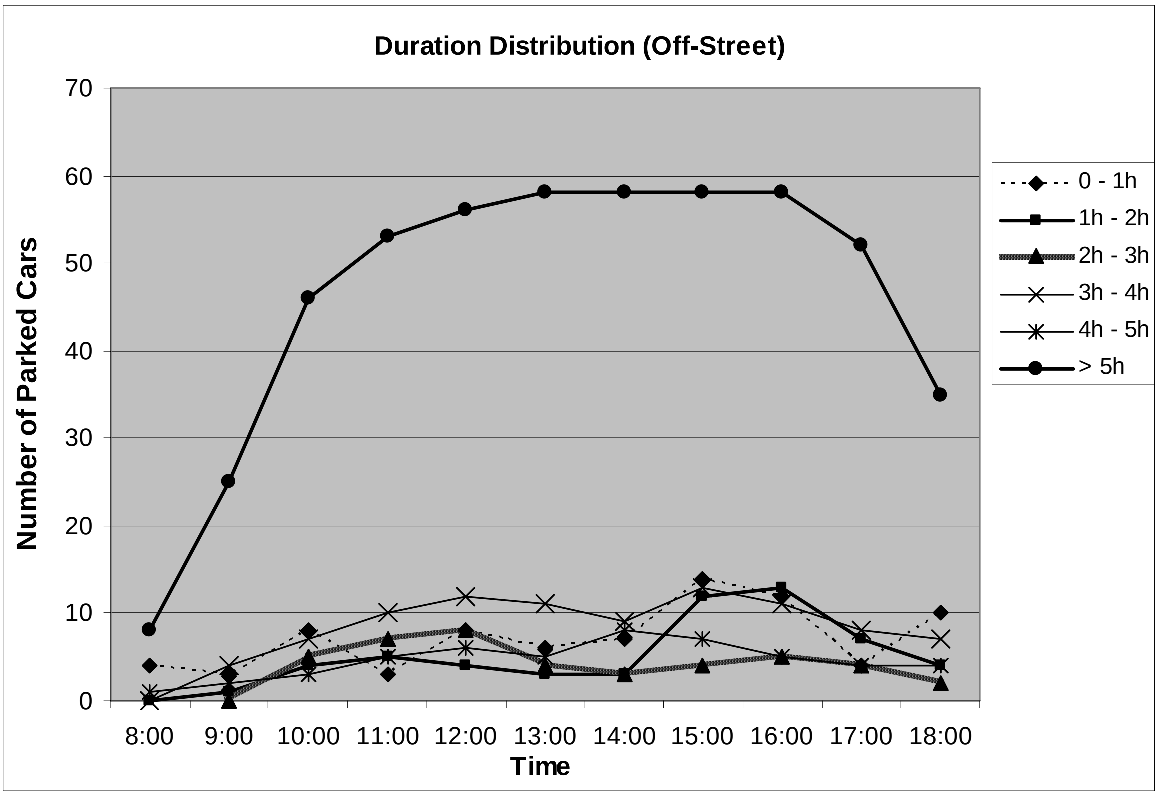


Figure 6.8. Duration distribution (off-street)

6.7. Demand Computation

Table 6.3 presents the number of cars parked and the vehicle-parked hours for each side of the streets surveyed. There were 17 street sides (pockets) where license plate survey was applied. The total number of cars counted during the on-street survey was calculated to be 1241. As it is shown in the column that indicated the number of space for each side there are four sides where cars were illegally parked. These street sides named B-3, D-2, E-2, and K-3 were used by 57, 24, 23, and 46 cars respectively during the 12-hour survey, adding up to 150 illegally parked vehicles. As a result, at least 12% (150 / 1241) of on-street parked cars were illegally parked.

The vehicle-parked hours for each curb varied from 21 hours (D-2) to 362 hours (G-3) as shown in Table 6.3. The total vehicle-parked hours for on-street parking were computed to be 2255 vehicle-parked hours. In other words, there were 1241 parked vehicles in 184 curb spaces, all summing up to 2255 vehicle-parked hours during 12 hours survey duration. The vehicle-parked hours for illegally parked vehicles were 148.5 (33.5 +

21 + 64.5 + 29.5), consisting of about 6.6% (148.5 / 2255) of the total vehicle-parked hours of on-street parked vehicles. On the other hand, the total number of illegally parked vehicles was 150 (57 + 24 + 23 + 46) vehicles. An average parking duration of one hour (148.5 / 155 = 1) was calculated to be the parking duration of illegally parked vehicles. This indicates that drivers parked their vehicles illegally for short durations, a situation that could be explained by their fear of being fined.

Table 6.3. On-street parking demand

Side No.	No. of Spaces	Number of Cars Parked	Vehicle-Parked Hours
A-1	6	66	80
B-3	Ilegal	**57‡**	**33.5**
B-2	29	255	355
B-1	7	62	66.5
D-2	Ilegal	**24**	**21**
E-2	Ilegal	**23**	**64.5**
F-2	18	111	278
B-4	19	38	102
K-3	Ilegal	**46**	**29.5**
C-1	8	73	143
I-1	10	107	292
H-3	20	26	96
J-2	6	53	63
G-3	35	128	362
H-1	12	70	113
F-3	9	58	92.5
K-1	5	44	65
TOT	184	1241	2255

‡ Illegally parked vehicles

The capacities of the off-street facilities (Table 6.4) were much higher than those of on-street ones. The 6-story garage had the highest capacity of 550 parking spaces. The Parking lot #1 and Parking lot #2 has capacities of 100 and 46, respectively.

However, off-street parking demand numbers were lower than the on-street ones. As it can be seen from Table 6.4 the number of cars parked in the garage (249) was much higher than those of parking lots. The number of Parking lot#1 and Parking lot#2 was 105 and 109 spaces, respectively. The total number of cars parked off-street was 463 cars. Furthermore, parked-vehicle hours of garage, lot#1, and lot#2 were computed to be 803, 461, and 368, respectively.

These low demand figures for off-street parking indicated an underutilization of the system. Motorists used curb parking for long durations instead of using off-street facilities. Hence, those who wanted to park their cars for short-term durations were not able to find empty space and thus tended to park their cars illegally. These illegally parked vehicles may clog one lane of the road, thus reducing the capacity of the street and decreasing the traffic flow and speed.

Table 6.4. Off-street parking demand

Parking Name	Capacity	Number of Cars Parked	Vehicle-Parked Hours
Garage	550	249	803
Parking Lot #1	100	105	461
Parking Lot #2	46	109	368
TOT	694	463	1632

6.8. Cumulative Parking Demand

The cumulative parking demands for both on-street and off-street facilities are depicted in Figure 6.9 and Figure 6.10, respectively.

As it is shown in Figure 6.9 about half of on-street parking durations was less than 30 minutes. Cumulative on-street parking demand increased significantly from 30 minutes up to 3 hours. Vehicles parked less than 3 hours comprised 85 % of all parked vehicles. The number of vehicles parked more than 3 hours increased slowly up to the end of parking study. Notice that we observed an elbow point at 3 hour on-street parking duration. In other words, drivers who parked for duration less than 3 hours constituted the majority (85% of all drivers). Hence, the strategies applied have to support this majority. This value is used as constrain in Chapter 7 in determining the parking duration limitation.

On the other hand, cumulative off-street parking demand increased moderately for all parking durations (Figure 6.10). This means that the number of drivers parking their cars for different durations were approximately the same. It has to be noted that we cannot use parking time limitation in off-street facilities because they are generally used for long-term parking durations, especially by commuters. 85th percentile duration of off-street parking was about 8.5, which indicates that these facilities were used for long-term parking mostly.

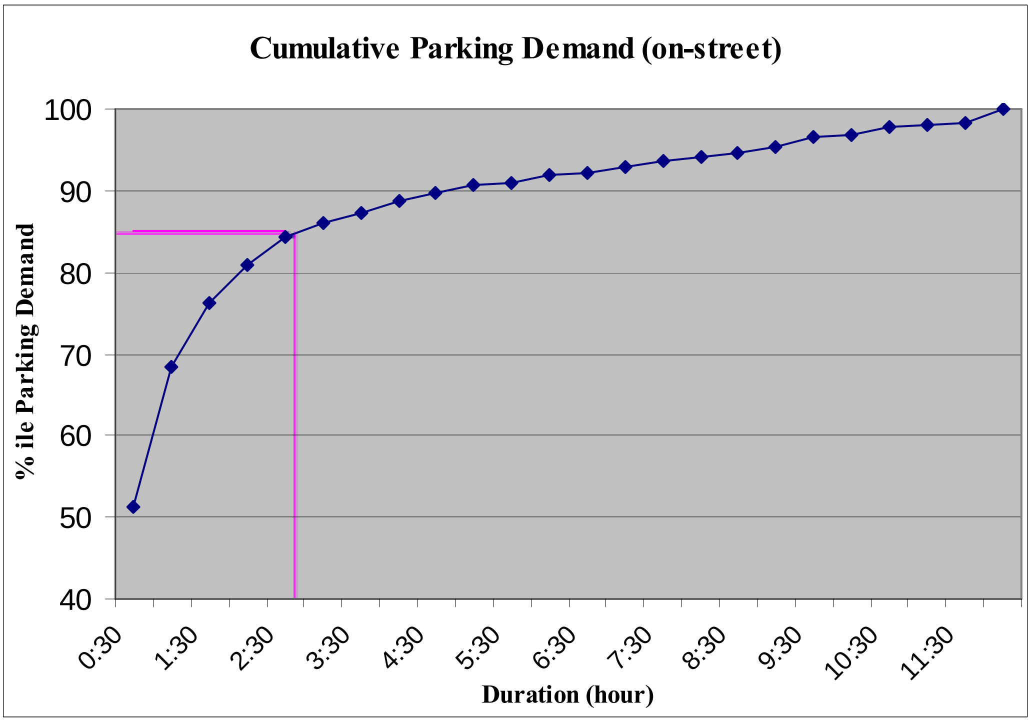


Figure 6.9. Cumulative parking duration (on-street)

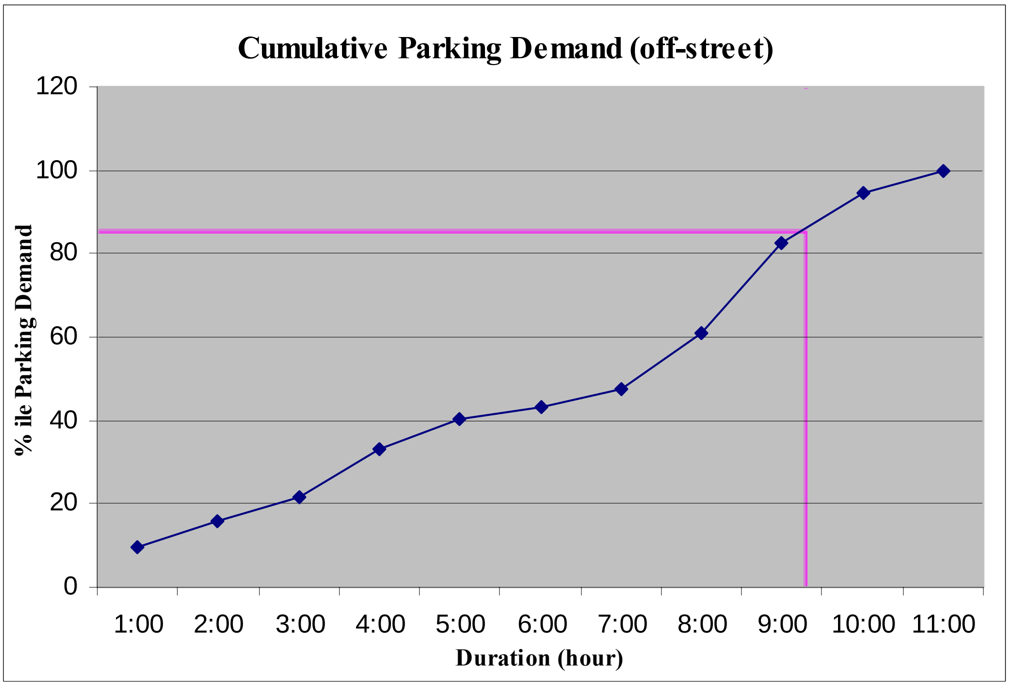


Figure 6.10. Cumulative parking duration (off-street)

6.9. Peak Parking Accumulation

Peak parking accumulation is a very good indication of the parking demand in a facility, area, or in the whole city. The total number of parked vehicles for each interval is calculated and the highest number is selected. The number then is divided by the number of spaces available. This value was given as percentage in Table 6.5.

As a rule of thumb (Shoup 2004), the parking occupation (accumulation) of more than 90% is considered to be saturated. As it is expressed in Table 6.5, only 5 out of 17 curbs in the study area, were not saturated. The other ones ranged from 100% to 150%. The total mean of on-street peak parking accumulation was 115%, meaning that a large number of cars were parked illegally.

Table 6.5. On-street peak parking accumulation

Block Number	Parked Vehicles	Parking Supply	Percentage Occupied
A-1	8	6	**133***
B-3	3	Ilegal	-
B-2	37	29	**127**
B-1	5	7	71
D-2	2	Ilegal	-
E-2	6	Ilegal	-
F-2	24	18	**133**
B-4	10	19	53
K-3	5	Ilegal	-
C-1	12	8	**150**
I-1	9	10	90
H-3	29	20	**145**
J-2	6	6	**100**
G-3	28	35	82
H-1	8	12	67
F-3	12	9	**133**
K-1	7	5	**140**
TOT	211	184	**115**

* Bold font style represents parking occupation more than 90% ile (saturated)

For the off-street parking facilities (Table 6.6), except for lot #2 (100%), the rates were far below the capacities. Because all these facilities were very near to each other they had to be considered as a whole. Parking lots were cheaper than the garage. Parking lot #2 was more convenient than parking lot #1. Thus, parking lot #2 was filled first; and those who came when it was full went to parking lot #1.

When the total occupancy values were considered for the all off-street parking facilities, only 51% of the total capacity was used at the peak accumulation. Hence, off-street facilities could accommodate twice as much as their maximum accumulations but people preferred on-street parking because was free when this study was performed.

Table 6.6. Off-street peak parking accumulation

Parking Name	Parked Vehicles	Parking Supply	Percentage Occupied
Garage	249	550	45
Parking Lot #1	63	100	63
Parking Lot #2	46	46	**100**
TOT	358	696	51

* Bold font style represents parking occupation more than 90% ile (saturated)

6.10. Average Parking Duration

Average parking duration was calculated by Equation 4.3 (p 46). Only the data from parking lots were considered in calculating the average parking duration of off-street facilities, because the data taken from the garage's officials were grouped in intervals of 1-2 hours, 2-4 hours, etc. As a result, these data were not in a usable form for calculations of the average parking duration of the garage. Notice that off-street average parking duration was more than twice of the on-street one.

On-street (from Table 6.3, p 89)

$$D = \frac{2255}{1241} = 1.82 \text{ h/veh}$$

Off-street (from Table 6.4, p 90)

$$D = \frac{829}{216} = 3.84 \text{ h/veh}$$

6.11. Turnover Rate

The average turnover rate was calculated by the Equation 4.4 (p 47). The turnover rate of on-street facilities was higher than off-street facilities. This means that more vehicles used an on-street space for one hour than an off-street one. Hence, on-street parking spaces were preferred more than off-street ones. This was mainly because the on-street parking spaces were free.

On-street (from Table 6.5, p 92)

$$TR = \frac{1241}{184*12} = 0.56 \text{ veh/stall/h}$$

Off-street (from Table 6.6, p 93)

$$TR = \frac{216}{146*11} = 0.13 \text{ veh/stall/h}$$

6.12. Supply Calculation

The calculation of supply is considered in the seventh step of the parking management flow chart (Figure 3.2, p 35). It is computed by the Equation 4.5 (p 47) basically shown as below:

$$P = \frac{\sum_{n} (NT)}{D} * F$$

Where:

P: Parking supply, vehs

N: Number of spaces of a given type and time restriction

T: Time that N spaces of a given type and time restriction are available during the study period, hrs

D: Average parking duration during the study period, hrs/veh

F: Insufficiency factor to account for turnover - values range from 0.85 to 0.95 and increase as average duration increases

6.12.1. On-street supply calculation

The number of on-street parking spaces available in the study area was calculated to be 184 stalls (Table 6.3, p 89). The time that the available on-street parking spaces were available during the study period (T) was 12 hours because there were no time restrictions in the pilot study area. Furthermore, the average on-street parking duration during the study period (D) was calculated to be 1.82 h/veh (p 93). The insufficiency factor (F) was decided to be 0.90. Thus, supply can be calculated as.

$$P = \frac{(184)*(12)}{1.82} * (0.90) = 1091 \text{ vehs}$$

6.12.2. Off-street supply calculation

The number of off-street parking spaces available in the study area was calculated to be 694 stalls (Table 6.4, p 90). The time that the on-street parking spaces were available during the study period (T) was 12 hours because no time restrictions were applied in off-street facilities. Furthermore, the average on-street parking duration during the study period (D) was calculated to be 3.84 h/veh (p 94). The insufficiency factor (F) was decided to be 0.90. Thus, supply can be calculated as:

$$P = \frac{(694)*(12)}{3.84} * (0.90) = 1952 \text{ vehs}$$

The total number of vehicles accommodated in the pilot study area during the 12-hour study period was 3043 (1091 + 1952) vehicles. Even though off-street parking stalls

(694 spaces) were about four times more than on-street parking spaces (184 spaces), off-street facilities (1952 vehicles) were able to accommodate vehicles only approximately twice as much as on-street facilities (1241 vehicles). Hence, improving the efficiency of on-street facilities is much more effective in solving the insufficiency parking problems that the pilot area and all metropolitan area of Istanbul is facing nowadays.

6.13. Other Observed Parking Problems

Many different types of problems were observed during the study. Many violations such as invasion of sidewalks by parked vehicles, usurpation of parking spaces, and illegally parked vehicles were only some of the major parking concerns detected in the study area. These main problems are very obvious in the pictures below. Two examples showing some of these problems were presented in Figure 6.12 and Figure 6.12.

Figure 6.11. Parking problems I

As it can be seen in Figure 6.11 there are “no parking” signs in two sides of the street. However, illegally parked vehicles in both sides of the street can be seen. These vehicles not only were illegally parked, but they had also invaded the sidewalks hindering pedestrian movements. The motorists parking their vehicles in this way made the movement of pedestrians difficult even in sidewalks, at a time that walking mode has to have the highest priority.

Another main problem, shown in Figure 6.12, was concluded to be related to the decreased efficiency of the recently applied on-street parking pricing strategy in Istanbul. ISPARK (Parking Management Authority for Istanbul) has started collecting parking fees on some of these on-street pockets (when the study was conducted these facilities were not operating; only the parking signs were fixed). However, these locations were in the vicinity of 10 meters from the unpriced parking places. In this situation, people will tend to park their vehicles in the unpriced facilities even on sidewalks. Thus, the efficiency of this strategy is decreased. To solve this problem, the unpriced pockets can be priced. Moreover, the unpriced pockets can be eliminated in order to increase the efficiency of the strategy, but spillover problems have to be considered. Finally, police inspections can be increased to decrease the violation and thus increasing the efficiency of the park pricing strategy.

Figure 6.12. Parking problems II

Double parking has been defined as another major problem which was pretty common in the main artery (Büyükdere Caddesi) during the rush hours. As a consequence of this double parking behavior, the capacity of the main artery was significantly decreased and thus the traffic congestion and delays were increased. Furthermore, double parking problem was also observed in local streets but generally during off-peak hours.

7. DEVELOPMENT OF PARKING STRATEGIES

7.1. Development of Parking Strategies for Istanbul Metropolitan Area

Some beneficial parking strategies that can be applied in Istanbul are described in the following paragraphs:

7.1.1. Parking Pricing

Parking pricing is a direct charge for usage of parking facilities. By directly paying for parking facility usage, drivers attempt to reduce their driving frequencies and choose other cheaper travel modes like walking, transit, carpooling, and ridesharing. As a result, vehicle traffic is reduced in these areas and other modes improve due to their share increase. Parking pricing is very efficient in areas where parking is scarce, typically in high-density areas such as Şişli, Beşiktaş, Beyoğlu, Bakırköy, etc. It is easy to apply but it needs a more intensive violation check.

Furthermore, parking pricing plays an important role as a revenue generation for other purposes. For instance, this revenue can be used for downtown and CBD areas' improvements and/or local transportation programs. By undertaking some management regulations it can reduce parking concerns in a specific location.

There are some key factors to be considered when deciding about parking prices. These can be listed as follows (Litman, 2006):

- Apply marketing principles,
- On-street parking prices should be higher than of-street ones,
- Price for short time intervals like 30-min, hourly, or daily intervals in stead of leasing by the month,
- Put higher prices for peak hours parking,

- Price the most convenient parking spaces for customers and clients, with minute or hourly rates,
- Use a progressive price structure in more convenient spaces to favor short-term users,
- Charge for parking to equal or exceed transit fares,
- Provide free or discounted parking to rideshare vehicles,
- Limit the use of on-street parking to area residents,
- Price the on-street parking in residential neighborhoods.

7.1.2. Parking Regulations

Parking regulations control who, when, and how long vehicles can use the parking facility (Litman, 2006). This strategy is very important for Istanbul and should be applied firs. First of all, parking regulations control the type of vehicles that can use the parking facility. Different spaces are dedicated to loading, service, taxis, customers, rideshare vehicles, disabled users, buses and trucks. Employer restrictions encourage employees to use less convenient parking spaces. Whereas residential permits give area residents priority uses of parking near their homes. Large vehicle restrictions are also applied because they limit on-street parking of large vehicles, such as freight trucks and trailers.

Secondly, the parking regulations control the time of parking, too. Time period restrictions, for instance, are used to prohibit occupancy at certain times, such as before 10 AM, to discourage employee use, or between 10 PM and 5 AM to discourage resident use. On the other hand, overnight parking restrictions discourage the use by residents and campers.

Finally, how long vehicles can use the parking facility can be controlled by parking regulations. Limit parking durations such as 5-minute loading zones, 30-minutes adjacent to shop entrances, 1- or 2-hour limits, are generally used for different trip purposes.

7.1.3. Shared Parking

Shared parking is one of the most effective applications in the reduction of parking spaces. Combining parking for different land uses which have different peak parking periods significantly decreases the number of parking spaces required. For example, parking facilities of offices and other employment centers (weekday) can be used by restaurants (evening); banks and public services (weekday) can be used by theatres (evening); and parking spaces of schools, banks and offices (weekday) can be used during football games (weekend).

Furthermore, sharing can involve mixing of land uses on a single site, such as a mall or campus, or by creating a sharing arrangement between sites located suitably close together. Although, shared parking might have no direct impact on transit ridership, it could indirectly encourage transit usage because the strategy would promote more compact and denser developments, as establishments “cluster” around their shared parking facilities.

Finally, developers and firms can benefit from shared parking because they save on monetary outlays in providing exclusive parking spaces. In some cases, firms might benefit from increased traffic as a result of the shared spaces. For example, commuters parking in a dinner restaurant lot might stop to have dinner after work before heading home. Shared parking may stimulate a more efficient supply of parking, thus enhancing economic efficiency.

However, there are several institutional barriers to shared parking within the current regulatory environment. It requires an analysis showing that the peak parking times of the uses occur at different times and that the parking area will be large enough for the anticipated demands of all uses. Furthermore, it cannot require adjacent developments to participate in the shared parking arrangement.

7.1.4. Unbundled Parking

Unbundled Parking means that parking is sold or rented separately. For example, rather than renting an apartment for 1200YTL per month with a parking space at no extra cost, each apartment can be rented for 1000YTL per month, plus 200YTL per month for each parking space. Occupants can only pay for the parking spaces they actually need. This is more efficient and fair, since occupants can save money when they reduce parking demand. They are not forced to pay for parking they do not need, and can adjust their parking supply as their needs change.

This strategy can be used widely in Istanbul especially in peripheries where new developments are taking place. For this to function efficiently, building owners must be able to lease or sell excess parking spaces, and local officials can regulate nearby on-street parking to avoid spillover problems that could result if residents use on-street parking to avoid paying rents for parking spaces.

7.1.5. Financial Incentives (Cashing-Out Employer-Provided Parking)

In order to encourage the alternative mode usage and reduce the use of parking especially during peak periods, commuters are offered financial incentives. Cashing-out employer-provided parking is a strategy whereby employees get the cash equivalent of any parking benefit provided, so they can then either spend that cash toward paying for the parking (rather than continuing to receive it free) or spend it toward any other modes, including transit. These benefits express the cost saving that result from reduced parking demand. Thus, the commuters consider these options because they provide positive rewards for those who reduce vehicle trips leading to a decrease in parking demand. This financial incentive stimulates businesses to implement commute trip reduction programs for their employees

However, the cash-out amount is limited only to those employees to whom employers presently offer subsidized parking. Furthermore, employers who lease parking can not benefit from from cashing-out. The reason for this can be that it is easer to impute a cash value to that parking than to parking that the employer owns.

Those who would benefit from strategy are employees to whom employers offer this option that they did not have before. The more commuters use this option, the higher the transit share will be. The higher the transit share is, the better the transit service will be.

Thus, this increase stimulates centralization over the long run making CBD retails better off. Although some spillover parking may result, cashing-out is a revenue neutral strategy that is designed to produce few negative effects.

This strategy affects only a small percentage of all commuters. It is expected to have a moderate ease of administration. While little new technology or institutional change would be required, employers would have to take on the task of administering the cash-out program.

7.1.6. Increasing the Price of Parking, Based on a Tax on Revenues

One efficient way to encourage park pricing is to tax the revenues that parking providers get. In addition to the private cost, imposing on motorists the social cost of driving is the most outstanding economic cause for applying this tax. The targets of this strategy are central business districts (CBD) and highly populated areas, those who actually generate these revenues.

This strategy will be beneficial if the application is executed in an area with high level transit service, and may even worsen the existing condition if it is applied in a region with low level of transit service. Furthermore, the size of the tax is also a very crucial indicator of the effectiveness of this strategy.

In general, this increase in transit share results in a decrease of travel and parking congestion which in essence makes travelers better off. On the other hand, motorists who cannot afford this price are badly affected by this strategy. However, policy makers can use these revenues to reimburse those who are worse off. Moreover, special attention should be kept when deciding the percentage of the tax. If the tax is low, the modal shift is very slight. On the other side, if the tax is high, it may decrease the vehicle usage but may also stimulate decentralization in long run. The tax on parking revenues appears to be primarily for revenue generation and is largely unrelated to transportation policy in general.

The tax is just an application of the regular sales tax. The tax on parking revenues appears to be primarily for revenue generation and is largely unrelated to transportation policy in general. Hence, it can be used widely in wealthy areas such as Nişantaşı, Bebek, Ortaköy, etc.

The ease of administration of this strategy is moderate to high. While little new technology would be needed, the approach does require that a monetary transaction occur, so mechanisms need to be in place for handling that transaction. Some new agencies and procedures may be necessary, as well, for levying, collecting, and enforcing compliance with the tax.

7.1.7. Increasing the Price of Parking, Based on a Tax on Parking Spaces

Taxing actual parking spaces is another way of encouraging parking pricing. The best advantage of this strategy is that it affects all parking independent of their location and density, whether CBD area or suburb. However, parking should be presently priced in order to apply this approach.

The crucial point of this model is that parking suppliers are likely to pass all or a high percentage of this tax on to automobile users, charging them directly by a higher fee. As a consequence, this situation will stimulate them to shift to other modes like walking, transit, carpooling, and ridesharing. A higher percentage of taxes is passed on drivers in CBD area than in suburb ones because there are fewer opportunities for spillover in CBD areas.

On the other hand, this approach, like the tax on parking revenues, may encourage decentralization over the long run. Thus, this may result in a shift of firms from CBD area to suburbs. Furthermore, spillover parking onto unmetered on-street spaces is another disadvantage of this approach.

This strategy may stimulate decentralization over the long term, as CBD employees and firms might find suburban locations more attractive, though this effect may be offset if firms have to absorb a larger proportion of the tax in such areas.

The ease of administration of this strategy is low. This tax would require new legislation; existing legislation authorizing a sales tax would not be adequate, because this tax would not be based on a monetary transaction. Implementation of this tax would also require new agencies and procedures for counting spaces and levying, collecting, and enforcing compliance.

7.1.8. Parking Impact Fees

Increasing the number of parking spaces by constructing new parking facilities not only creates a construction cost, but also generates a cost to the whole transportation system. Government and/or local authorities would impose a one-time fee on developers to cover this cost. The developers are charged for the number of spaces that they provide. The more spaces provided, the higher the fee will be. As a result parking impact fees encourage developers to supply only the amount of parking actually needed.

Although parking impact fees affect regions of new development only, they have a considerable influence in long run. People living in and users of already developed areas benefit most from this strategy. However, developers and users of newly developed areas would be worse off because they will compensate this cost in the form of higher prices.

Because the developers would not provide extensive parking spaces due to parking impact fees, this situation will encourage more compact development in newly grown regions. This outcome is appreciated by many policy-makers and environmentalists because it stimulates slow growth. However, parking impact fees may lead to an increase in traffic of those areas. Furthermore, this strategy may bring about spillover parking concerns if the fees result in insufficient parking supply. As a consequence, as long as parking supply standards are high; this strategy will encourage a more efficient parking supply.

The ease of administration of parking impact fees is moderate. Some institutional and legal change would probably be required for the implementation and collection of the fee. The fact that the fee is a one-time-only charge lessens any potential administrative difficulty. Ease of administration would be significantly compromised if legislative changes were necessary to modify the rational nexus provisions that limit the use of revenues resulting from impact fees.

7.1.9. Restrict Parking Supply by Changing Zoning Ordinances

To start with, a new approach is to impose parking maximums. Parking Maximums means that an upper limit is placed on parking supply, rather than a minimum, either at individual sites or in an area. They often apply to specific types of parking, like surface, long-term, free, or singe-use parking.

Furthermore, another way to regulate zoning ordinances is to diminish the minimum parking requirements. This is done in order to decrease the difference between peak and off-peak parking demands, thus bringing them closer.

Finally, sometimes local municipalities may accept conditional-use for some developers that supply a lower amount of spaces than minimum required or even no spaces. In general, in such conditions Istanbul invokes suppliers to pay money into in-lieu found or other transport modes in exchange of providing parking spaces within the building.

It is expected that these models have a great effect on other modes especially in transit share depending on the region's conditions. These changes are applied in areas of new growth and would impact a small percentage of drivers. Those who benefit from these strategies are developers that will reduce building costs as a result of reducing number of parking spaces. They may encourage a more compact development. Special attention should be drawn to spillover problems when either minimums or maximums lead to insufficient supply.

7.1.10. Combinations of the Above Strategies

Although some strategies may be very beneficial in some aspects, on the other hand they might be ineffective or harmful in some other ones. Thus, instead of applying only one strategy at a particular area, using a combination of two or three of them might show very good effects. For example, pricing parking and shared parking strategies can be applied together. Thus, they can reduce parking spaces, generate revenues, reduce traffic, and create a compact area. When deciding about these combinations the following factors have to be kept in mind:

- Other modes' improvements like transit, walking, ridesharing, and carpooling have to be a crucial component of these packages. This will be an attractive alternative for motorists who shift to this modes,
- These combinations have to address spillover parking problems, strong decentralizing trends or other negative effects from individual strategies,
- By considering these packages, at least one revenue-producing strategy has to be included to support financial requirements for implementation or compensation,
- Each combination should be applicable only in a specific geographic area and specific parking problems, not being the same package everywhere,
- Packages have to be region-wide and appropriate for the current situation.

7.2. Development of Parking Strategies for the Pilot Study Area

Parking strategies used in Fulya pilot study area were basically related to *parking pricing*, and *parking duration restriction (limit)*. Furthermore, some changes and regulations were made to the pilot study area. It is thought that these strategies are the simplest and the most easily comprehended ones by users (Litman, 2006).

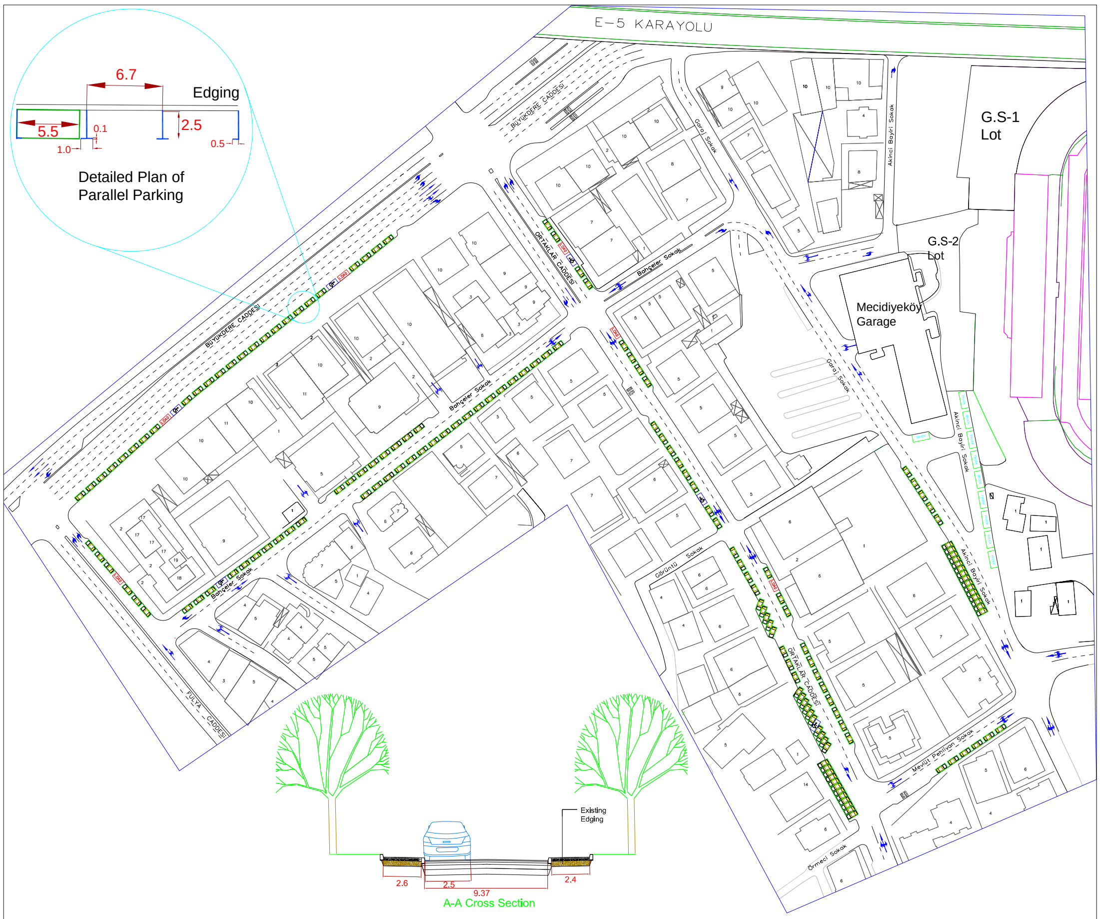
7.2.1. Regulations Suggested for the Pilot Study Area

The following changes were decided to be applied in the Fulya pilot study area:

- Eliminate C-1 on-street facility (8 spaces). This facility is very near to the off-street facilities. Furthermore, parking/unparking in this facility hinders the movement of left-turn vehicles coming from the Büyükdere main artery. Hence, the total number of on-street spaces was reduced to 176 (184-8) spaces.
- I-1 on-street facility (10 spaces) will be used by heavy commercial vehicles. Thus, the remaining number of on-street spaces was reduced to 166 (176-10) spaces.

- 6 spaces in the area were changed to loading/unloading parking spaces. The locations of these spaces were decided based on the observations made in the area. Hence, 6 more spaces were decreased resulting in a total of 160 (166–6) on-street parking spaces.
- 6 spaces were reserved for handicapped peoples. Their locations were determined from the observations.

The final number of total on-street spaces was 154 (160-6) spaces. The suggested parking regulations in Fulya pilot study area are shown in the Figure 6.1.



Legend	
Parking Unit Dye	Load/Unload Parking Unit
Truck Parking Unit	Handicapped Parking Unit
Vehicle	Traffic movement direction

Type and Number of Parking Spaces						
Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
27	10	5		111	6	6

Figure 7.1. Suggested regulations in Fulya pilot study area

7.2.2. Parking Pricing Strategy for Pilot Study Area

The reason for selecting parking pricing strategy was because parking facility users have to pay directly for the usage of these facilities, not the whole public indirectly. It is obvious that some people would give up using their cars if this strategy was used. Note that congestion pricing willingness to pay is assumed to be equivalent to parking price willingness to pay. It was calculated that (Table 5.5, p 64) 13% of the motorists would give up using their cars if they had to pay a fee between 1-3 YTL. Thus, a fraction of drivers (13%) was anticipated to leave their cars for this price range, reducing the demand required for accommodation of the vehicles.

7.2.3. Parking Duration Limitation Strategy for Pilot Study Area

Furthermore, putting some time limits was expected to shift long–duration parkers from on-street to off-street facilities. Finding the percentage of drivers who will not use on-street parking facilities due to parking duration limitation was based on the following assumptions:

- Prohibit on-street parking duration more than 4 hour (1). Four hour limits are generally applied to prevent commuters for using parking spaces. They will be forced to use off-street facilities.
- Use the 85^{th} percentile parking demand of each street side (2). Thus, the majority of parkers is supported.(p 86)
- Decide the minimum of the values above. MIN { 1 , 2 }

The calculated parking duration limitations for each on-street facility were summarized in Table 6.1. Notice that, to calculate the new number of parked vehicles and vehicle-parked hours, B-3, D-2, E-2, K-3, C-1, and I-1 on-street facilities were included in the analysis. The inclusion of these on-street facilities was required for calculating the new average parking duration and the percent reduction due to parking duration limitation strategy. However, the above mentioned on-street facilities were not changed to new parking supply.

As it can be seen from the Table 7.1, the new number of total parked vehicles was 1059 vehicles, and the new total vehicle-parked hours was 958,5 hours. The new average parking duration was computed as:

$$D = \frac{958.5}{1059} = 0.91 \text{ h/veh}$$

The existing average parking duration (1.82 h/veh, p 93) was twice as much as the new one. This means that we can accommodate two times more vehicles in the improved situations.

Table 7.1. Parking duration limitations for each street side

Number of spaces	Side no	Decided time limit	Parked Intervals								No. of Tot vehicles	% ile
			0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00		
6	A-1	1-hour	49	7							56	85
Ilegal	B-3	1-hour	47	10							57	100
29	B-2	2-hour	149	45	12	11					217	85
7	B-1	2-hour	33	16	5	2					56	90
Ilegal	D-2	2-hour	13	6	4	0					23	96
Ilegal	E-2	4-hour	8	2	3	1	1	0	2	2	19	83
18	F-2	4-hour	42	27	11	4	3	2	2	0	91	82
19	B-4	4-hour	12	5	1	4	6	1	0	0	29	76
Ilegal	K-3	1-hour	36	7							43	93
Eliminated	C-1	4-hour	39	8	5	7	3	1	0	0	63	86
Heavy veh.	I-1	4-hour	51	15	9	4	3	1	1	1	85	79
20	H-3	4-hour	7	6	2	0	1	1	0	0	17	65
6	J-2	2-hour	23	18	5	2					48	91
35	G-3	4-hour	40	19	13	11	8	7	0	4	102	80
12	H-1	4-hour	35	6	11	5	1	1	5	1	65	93
9	F-3	2-hour	31	9	6	3					50	86
5	K-1	2-hour	21	7	6	3					38	86
TOT Parked Vehicles			636	213	93	57	26	14	10	8	1059	
TOT Vehicle-Parked Hours			318	213	140	114	65	42	35	32	958,5	

The number of cars parked for the existing situation was 1241 vehicles, whereas for the improved conditions this number was 1059 vehicles (Table 7.1). Hence, the number of vehicles moved from on-street facilities to off-street facilities was 182 (1241 – 1059) vehicles. In other words, about 15% (182 / 1241) reduction was estimated to be due to parking duration limitation strategy decided for the pilot study area.

7.2.4. Demand Reduction

The decided strategies in the pilot study area were *parking pricing* and *parking duration limitation*. The reduction due to parking pricing strategy was estimated to be 13% when a 1-3YTL parking fee was used. In addition, a 15% reduction of the on-street parking demand was calculated to be due to decided parking duration limitations. Hence, the reduced demand as a result of applied *parking pricing* and *parking duration limitation* strategies was calculated by Equation 4.6 (p 48) as:

$$D_R = N_T * (1 - S_1) * (1 - S_2)$$
$$D_R = 1241 * (1 - 0.13) * (1 - 0.15)$$
$$D_R = 918 \text{ vehicles}$$

Where:

D_R: Demand reduction due to applied strategies, vehs

N_T: Total number of parked vehicles observed, vehs

S_1: Fraction reduction due to the parking pricing strategy

S_2: Fraction reduction due to the parking duration limitation strategy

The number of vehicles that needed to be accommodated on-street in Fulya pilot study area was 918 vehicles. Notice that the supply (1091 vehicles, p 95) was much higher than the demand (918 vehicles). In other words, there were more parking spaces than parked cars.

7.2.5. Demand-Supply Comparison

The number of on-street parking spaces in the pilot study area was 184 spaces (Table 6.3, p 89). Furthermore, the number of on-street parked vehicles fluctuated from 101 (at 7 AM) to 211 (at 14 PM) parked vehicles, during the survey duration. Hence, sometimes the number of spaces was adequate, whereas some other times it became insufficient to accommodate all vehicles. As a result, sometimes we observed spillover problems in the study area. Notice that, the above result "parking supply was much higher than the demand" may be misleading, because these results are based on the total number of vehicles during the study period. These results do not consider the peak accumulation period. Hence, the hourly supply had to be compared with the peak hourly parking demand.

7.2.6. Peak accumulation analysis

The peak hourly parking demand was 211 vehicles (Table 6.3, p 89). Equation 4.6 was used for peak the accumulation analysis. The reduction percentages due to parking pricing (13%) and parking duration limitation (15%) strategies were used again. Demand reduction was calculated as:

$$D_R = N_T * (1 - S_1) * (1 - S_2)$$
$$D_R = 211 * (1 - 0.13) * (1 - 0.15)$$
$$D_R = 156 \text{ vehicles}$$

The number of total on-street parking spaces for the pilot study area was 154 spaces. Hence, the peak demand exceeded the supply only by two spaces (156 – 154). Note that the peak accumulation analysis is conservative because peak accumulation exists only in one interval during the study period. Hence, we were able to accommodate all legally and illegally parked vehicles even though we decreased the number of parking spaces by 30 (184 – 154) spaces, when *parking pricing* and *parking duration limitation* strategies were applied.

7.2.7. Off-street parking capacity check

The number of vehicles moved from on-street facilities to off-street facilities was 182 (1241 – 1059). The peak accumulation and the capacity of the off-street facilities were 358 vehicles and 696 spaces, respectively. Hence, the total number of vehicles accommodated in the off-street facilities was 540 (358 + 182) vehicles. 156 (696 – 540) spaces, or in other words 22% of the spaces, were still empty in the off-street facilities.

7.2.8. Financial Benefits

Financial benefits are very important for the operation and maintenance of the facilities. The financial benefits can be used to improve the services and modernize the system. The financial benefits are also used to widen the parking management application area.

The parking charges for 1-hour, 2-hour, and 4-hour were decided to be 2YTL, 4YTL, and 6YTL, respectively. We decided a higher price rather than using a fee between 1-3 YTL. Hence, the percent reduction in car users is expected to be higher than 13%. Notice that, on-street facilities with 4-hour parking duration limitations were found in less congested streets. Thus, 6YTL parking charge for 4-hour parking duration limitation was decided to encourage drivers to use less congested streets.

Table 7.2. 12-hour earnings

Block No.	Parking Duration Limitation	Parked Vehicles	Charges (1-hour = 2YTL), (2-hour = 4YTL), (4h-hour = 6 YTL)
A-1	1-hour	56	112
B-3	1-hour	57	114
B-2	2-hour	217	868
B-1	2-hour	56	224
D-2	2-hour	23	92
E-2	4-hour	19	114
F-2	4-hour	91	546
B-4	4-hour	29	174
K-3	1-hour	43	43
C-1	4-hour	63	378
I-1	4-hour	85	510
H-3	4-hour	17	102
J-2	2-hour	48	192
G-3	4-hour	102	612
H-1	4-hour	65	390
F-3	2-hour	50	200
K-1	2-hour	38	152
TOT		1241	4823

Table 6.2 the total 12-hour earnings were approximately computed to be 4,823YTL. The monthly earnings are 96,460 (3341*20), and yearly 1.16 million YTL.

Furthermore, indirect financial benefits come from the reduction of vehicles usage in the traffic. If the car usage is reduced fuel consumption is reduced, too. As a result the household expenditures will decrease, thus increasing the economy of the country.

7.2.9. Environmental Benefits

Approximately 13% of parked vehicles were considered not to be used for trips to the study area. The lesser the number of vehicles used, the lesser the fuel consumption will be. The lesser the fuel consumption is, the lesser the environment will be polluted.

Furthermore, when the parking spaces are reduced those spaces can be changed to sidewalks or to green spaces. Thus, the surrounding environment becomes more friendly and relaxing for the people.

Last but not least, as the number of vehicles in the traffic is reduced the number of congested roads is decreased. Less congested roads mean less travel times and thus a better public transport service. Hence, these policies improve the environmental conditions.

7.2.10. Social Benefits

Social benefits are very important in the medium and long run. The reduction of parking spaces and thus the number of used personal vehicles will lead to more compacted areas with different land use. A more relaxing and safer environment for children and elderly people is also very common in these applications.

The walking mode is very much encouraged in these well mixed areas. People find more time to socialize with each other, when the number of green spaces is created for their relaxation.

8. CONCLUSIONS AND RECOMMENDATIONS

Road Public Transport mode (19.8%) was the second (after Walking mode) most dominant mode in Istanbul. This result indicates that the trips made in Istanbul were generally based on Road Public Transport mode. The next two most widely used modes in Istanbul were Private Car (14.0%) and Service House (12.3%) which also became more useful for long trips. However, the mode shares of Rail (1.2%) and Marine (0.3%) Public Transport modes were very low for this highly populated city. Hence, to solve the traffic congestion problem in Istanbul very high occupancy travel modes like Rail and Marine Public Transport have to be encouraged.

Road Public Transport which was the most dominant mode in Istanbul had a mean travel time of 53 minutes. The mean travel times for other Public Transport modes were also high. On the other hand, low occupancy travel modes like Private Car mode (33 minutes) and Taxi mode (27 minutes) had low mean travel times. These results showed that the high capacity modes such as Service House and Public Transport are discouraged and lower priority modes like Private Cars and Taxi are encouraged.

Road Public Transport mode, which has a wide network, showed a mean Walking to Station time of 6.3 minutes. It should be noted that walking durations of Private Car mode (30 seconds) were the lowest ones. This low walking duration indicates that private car users park their cars very near to their destination, hence, creating parking problems all around Istanbul.

The highest waiting time was spent by those who used more than one mode (14.6 minutes). Rail and Marine Public Transport modes, however, had relatively low mean waiting times being 5.9 and 2.8 minutes, respectively. This can be explained by the reliability of these modes compared to other ones.

Approximately 36% automobile users surveyed were ready to quit using their cars and use the existing Public Transport, if automobile usage restricting and pricing strategies were used. Another 13% of them stated that they would quit using their cars for a charge of

1-3YTL. However, the attitudes of respondents changed considerably if public transport conditions were improved. 17.3% more respondents were ready to leave using their cars for free if public transport conditions were enhanced. Hence, this result pointed out that the public transport condition is very crucial in the transportation system of Istanbul.

The total mean travel time for Private Car mode traveling to the pilot study area, Fulya, was significantly high (46 minutes). On the other hand, this value was considerably lower in the total metropolitan area with an average value of 33 minutes. One reason for these results could be due to high traffic congestion of the Şişli County, especially during peak hours. Another reason for this high mean travel time while traveling to Fulya could be attributed to illegally parked vehicles in every street, thus reducing the capacities of the streets and slowing down the traffic movement.

A small number of long-term parking durations significantly decreased the efficiency of the on-street parking facilities significantly. Obviously, if the long-term parkers could be mobbed to off-street parking lots, the turnover for the on-street parking would have been increased significantly.

Based on the rule of thumb (Shoup 2004) where a parking occupation (accumulation) more than 90% is considered saturated, only 5 out of 17 curbs in the study area, were not saturated. On the other hand, only 51% of the total capacity of off-street facilities was used at the peak accumulation. Hence, on-street parking spaces were used more than off-street ones, manly because they were free at the time of this study and were near to the final destination of the travelers.

This low demand for off-street parking compared to on-street one is an indication of low parking efficiency in the system. Motorists use curb parking for long durations instead of using off-street facilities. Hence, those who want to park their cars for short-term durations are not able to find empty spaces and thus tend to park their cars illegally. These illegally parked vehicles, consisting of 12.5% of total on-street parked vehicles, may clog one lane of the road, which reduces the capacity of the street and thus decreases the traffic flow and speed.

Improving the efficiency of on-street facilities by means of pricing and time limitations rather than increasing the number of off-street facilities (by building new garages and parking lots) seems to be a more effective solution of parking problems that the pilot area and all metropolitan area of Istanbul are facing at present time.

Many violations such as invasion of sidewalks by parked vehicles, usurpation of parking spaces, and illegally parked vehicles were only some of the major parking concerns detected in the study area.

Parking strategies decided in Fulya pilot study area were basically parking pricing and parking duration limitation. Congestion pricing willingness to pay was assumed to be equivalent to parking price willingness to pay. It was estimated that 13% of the motorists would give up using their cars if they had to pay a fee between 1-3 YTL. Furthermore, about 15% reduction was calculated to be due to parking duration limitation strategy decided for the pilot study area.

We were able to accommodate all legally and illegally parked vehicles when parking pricing and parking duration limitation strategies were applied, even though we decreased the number of parking spaces by 16%. Furthermore, 22% of the off-street parking spaces were still empty in the off-street facilities.

The total 12-hour earnings for on-street facilities (154 spaces) in the Fulya pilot study area were approximated to be 1.16 million YTL annually. Financial benefits can be used for the operation and maintenance of the facilities, improvement of services and modernization of the system. The financial benefits are also used for widening the parking management application area. Moreover, the number of vehicles in the traffic was approximately reduced by 13%. The lesser the number of vehicles used, the lesser the fuel consumption will be. Hence, environmental pollution will be decreased. Furthermore, as the number of vehicles in the traffic is reduced, the congestion is also reduced. Thus, less travel times and a better transportation system will be achieved. Last but not least, Social benefits are very important in the medium and long run. The reduction of parking spaces and the number of used private cars will lead to more compacted areas with different land use. A more relaxing and safer environment for children and elderly people is also very common in these applications. The walking mode is very much encouraged in these well mixed areas. People find more time to socialize with each other, when the number of green spaces is increased for their relaxation.

The suggested parking management strategies for Istanbul were: Parking Pricing, Shared Parking, Parking Regulations, Unbundled Parking, Financial Incentives (Cashing-Out Employer-Provided Parking), Increasing the Price of Parking, Based on a Tax on Revenues and Parking Spaces, Parking Impact Fees, Restrict Parking Supply by Changing Zoning Ordinances, and Combinations of the Above Strategies.

Some recommendations for further research could be:

- Detailed parking interviews have to be conducted with the required carefulness. Error in the measurement of parking price introduces errors in modeling the effect of parking price changes in the travel demand models.
- More research is needed in the areas of parking impact fees and the use of inlieu fees. More research is needed to see how the law might be changed to allow for the use of these revenues for transit improvements.
- More research is needed on how reduced parking supply affects business sales and the local economy.
- More research is needed to test the hypothesis that most parkers would rather switch to transit than spill over on to unpriced parking spaces.
- In-depth case study investigation is needed at specific locations where parking pricing has been employed in conjunction with transit improvements, carpooling incentives, and other strategies. This research should examine how the combination of such strategies as opposed to any single strategy has affected mode choice.
- More research is needed regarding the long-term impacts of transportation and parking strategies.
- Research should focus on how legal constraints and requirements could be overcome and on the kinds of incentives that might prove useful in encouraging developers to participate in a shared parking program.

APPENDIX A: QUESTIONNAIRE FORM

This section includes the questionnaire used in origin-destination interviews obtained from BİMTAŞ.

İSTANBUL O/D ARAŞTIRMASI HANEHALKI SORUKAĞIDI

14.04.08

İyi günler efendim. Adım........................ . Bildiğiniz gibi ulaşım, İstanbul'un en büyük problemlerinden biridir. İSTANBUL BÜYÜKŞEHİR BELEDİYESİ ulaşım probleminin çözülebilmesi için yeni projeler üretmek istemektedir. Bu amaçla İSTANBUL BÜYÜKŞEHİR BELEDİYESİ İSTANBUL METROPOLİTAN PLANLAMA MERKEZİ olarak ilerideki yapılacak olan ulaşım planlarında da kullanılmak üzere "İSTANBUL ULAŞIM ANA PLANI HANEHALKI ARAŞTIRMASI" yapmaktayız. Sizinle tüm hanehalkı ve yolculuk bilgilerini içeren bir anket yapmak istiyoruz. Araştırma sonunda konut adresleri, İSTANBUL METROPOLİTAN PLANLAMA MERKEZİ'ne sizi arayarak anketin yapılıp yapılmadığının kontrol edilmesi amacıyla verilecektir. Bu anket ile derlenecek bilgiler istatistik amaçlı çalışmalar için kullanılacaktır, gizlidir. Anketimiz yaklaşık 20dk sürecektir. Bu şartla bize yardımcı olursanız seviniriz. Şimdiden teşekkür ederiz.

ADRES VE ÖRNEKLEME BİLGİLERİ

A1. İL : ______	A6. BİNA / DIŞKAPI NO : ______	A11. EVTİPİ	☐
A2. İLÇE : ______	A7. BİNA İÇ KAPI NO (DAİRE NO) : ______	1. Apartman	
A3. BUCAK (BELDE) : ______	A8. BÖLGE : 1 2 3 4 5	2. Müstakil Ev	
A4. KÖY / MAHALLE : ______	A9. KÜME :	3. Site	
A5. CADDE/ SOKAK : ______	A10. ÖRNEK HANE NO :	4. Diğer (belirtiniz)......................	

ZİYARET SAYISI	1	2	3	4
ANKETÖRÜN ADI, SOYADI	______	______	______	______
KOD NUMARASI	☐☐☐	☐☐☐	☐☐☐	☐☐☐
TARİH	GÜN AY	GÜN AY	GÜN AY	GÜN AY
BAŞLAMA SAATİ SAATE BAK VE YAZ	SAAT DAK.	SAAT DAK.	SAAT DAK.	SAAT DAK.
ZİYARET SONUCU	SORUKAĞIDI TAMAMLANDI 1 GÖRÜŞME YARIM KALDI 2 EVDE KİMSE YOK 3 GÖRÜŞME ERTELENDİ 4 GÖRÜŞME REDDEDİLDİ 5 DİĞER (Belirtin)______ X	SORUKAĞIDI TAMAMLANDI 1 GÖRÜŞME YARIM KALDI 2 EVDE KİMSE YOK 3 GÖRÜŞME ERTELENDİ 4 GÖRÜŞME REDDEDİLDİ 5 DİĞER (Belirtin)______ X	SORUKAĞIDI TAMAMLANDI 1 GÖRÜŞME YARIM KALDI 2 EVDE KİMSE YOK 3 GÖRÜŞME ERTELENDİ 4 GÖRÜŞME REDDEDİLDİ 5 DİĞER (Belirtin)______ X	SORUKAĞIDI TAMAMLANDI 1 GÖRÜŞME YARIM KALDI 2 EVDE KİMSE YOK 3 GÖRÜŞME ERTELENDİ 4 GÖRÜŞME REDDEDİLDİ 5 DİĞER (Belirtin)______ X
SORUKAĞIDININ DOLDURULMASI TAMAMLANMAMIŞ İSE SONRAKİ GÖRÜŞMENİN RANDEVU GÜNÜ VE SAATİ	GÜN SAAT DAK.	GÜN SAAT DAK.	GÜN SAAT DAK.	GÜN SAAT DAK.

EKİP BAŞI (ALAN EDİTÖRÜ)	ADI SOYADI : ______	KOD ☐☐☐
DENETÇİ	ADI SOYADI : ______	KOD ☐☐☐

CEVAPLAYAN KİŞİ ______ HH FERT SATIR NO ☐☐

EK HANEHALKI SORUKAĞIDI DOLDURULDU MU?

HAYIR 0 EVET 1 →

KAÇ ADET ☐

HANE İLE İLGİLİ BÜTÜN ÇALIŞMA BİTTİĞİNDE DOLDURULACAKTIR.

DOLDURULMUŞ ANKET	1
EKSİK ANKET	2
EKSİK AMA GEÇERLİ ANKET	3
DİĞER	4

BÖLÜM I. HANEHALKI BİLGİLERİ

Kişi No	B.1. Sürekli olarak bu hanede yaşayan kişilerin isim ve soy isimlerini hane reisinden başlayarak söyler misiniz? (ÖNCE İSİMLERİ ALINIZ. DAHA SONRA DİĞER BİLGİLERİ SATIR SATIR SORUNUZ!!) (HANEHALKI ÜYELERİNİN AD VE SOYADINI YAŞI BÜYÜK OLANDAN BAŞLAMAK ÜZERE YAZINIZ.)	B.2. Kaç yaşındasınız? (SADECE TAMAMLANMIŞ YAŞLARI KAYDE DİNİZ. 1 YAŞINDAN KÜÇÜK İSE 00 YAZINIZ.)	B.3.Cinsiyet		B.4.Hane halkı reisine yakınlığınız nedir? 1.Hanehalkı reisi 2.Eşi 3.Oğlu 4.Kızı 5.Babası 6.Annesi 7.Kardeşi 8.Kayınpederi 9.Kayınvalidesi 10.Gelini 11.Damadı 12.Torunu 13.Yatılı misafir 14. Diğer (BELİRTİNİZ)	EĞİTİM DURUMU (6 YAŞ VE ÜZERİNE SORULACAK) B.5.Okuma ve yazma biliyor musunuz?		B.5.1. En son hangi okulu bitirdiniz? (EN SON DİPLOMA ALINAN OKULU İŞARETLEYİNİZ.)										ÇALIŞMA DURUMU (12 YAŞ VE ÜZERİNE SORULACAK) B.6.Geçen hafta içinde bir işte çalıştınız mı? (GEÇEN HAFTA İÇİNDE PARA VEYA MAL KARŞILIĞI BİR SAAT DAHİ ÇALIŞANLAR ÇALIŞTI OLARAK ALINACAKTIR. GEÇEN HAFTA İÇİNDE İZİN, HASTALIK, SEYAHAT VB. GİBİ NEDENLERLE VEYA MEVSİM GEREĞİ İŞİNDE ÇALIŞMAYANLAR İÇİN ÇALIŞMADI FAKAT İŞİ İLE İLGİSİ DEVAM EDİYOR İŞARETLENECEKTİR.)			B.6.1. Yaptığınız bu iş hangi sektöre girer? (İRDELEYİNİZ, İŞARETLEYİNİZ VE B.7'E GEÇİNİZ) (ÇALIŞTIĞI SEKTÖR)										B.6.2. Çalışmama sebebiniz nedir? (ÇALIŞMAMA NEDENİ)						B.7.Otomobil sürücü belgeniz var mı?(BUGÜN İÇİN GEÇERLİ OTOMOBİL SÜRÜCÜ BELGESİ 18 YAŞ VE ÜZERİNE SORULACAK.)		MAVİ KART KULLANIM DURUMU B.8. Şu anda mavi kart (Günlük, haftalık, aylık) akbil kullanıyor musunuz?		B.9. Öğrenci, öğretmen, ve 60 yaş üzeri vb. indirimli kartınız var mı?		B.10. Özürlü, basın, yaşlılık maaşı alanların kullandığı vb. ücretsiz kartınız var mı?		B.11.KİŞİSEL SEYAHAT FORMU STATÜSÜ				
			Erkek	Kadın		Evet	Hayır (GEÇİNİZ B.6.)	Hiç okul bitirmedi	İlkokul	İlköğretim	Ortaokul	Ortaokul dengi meslek okulu	Lise	Lise dengi meslek okulu	Yüksekokul	Fakülte	Y.Lisans/Doktora	Çalıştı	Çalışmadı fakat işi ile ilgisi devam ediyor	Çalışmadı (GEÇİNİZ B.6.2.)	Ziraat,avcılık, Ormancılık ve Balıkçılık	Madencilik, Taş Ocakçılığı	İmalat Sanayi	Elektrik, Gaz, Su	İnşaat	Toptan ve perakende ticaret, Lokanta, Otel, Eğlence	Ulaştırma, Haberleşme, Depolama	Mali, Sigorta, Emlak	Toplum Hizmet Sosyal, Resmi	İyi tanımlanmamış Faliyetler	Öğrenci	Hasta/Engelli	Emekli	İş arıyor	Ev hanımı	Diğer (BELİRTİNİZ)	Yok	Var	Hayır	Evet	Yok	Var	Yok	Var	1.Dolduruldu.	2.Eksik kaldı.	3.Reddetti.	4.Ulaşılamadı.	5.Diğer(Belirtiniz.)
01			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
02			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
03			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
04			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
05			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
06			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
07			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
08			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
09			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
10			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
11			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
12			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
13			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
14			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
15			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
16			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
17			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
18			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
19			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
20			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
21			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
22			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
23			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
24			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........
25			1	2		1	2	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6..........	0	1	0	1	0	1	0	1	1	2	3	4	5..........

(GEREKİRSE EK FORM KULLANINIZ.)

B.11.1.Hanedeki 6 yaşından büyük kişi sayısı.............................

B.11.2.Kişisel yolculuk formu doldurulan kişi sayısı...................

(CEVAPLAYANA ONAYLATINIZ.)

BÖLÜM II. 24 SAATLİK YOLCULUK BİLGİLERİ

ANKET NO	☐☐☐☐ ☐☐ ☐☐ (ilçe, hane, kişi)	Görüşme tarihi	☐☐ / ☐☐ / 2006 (gün, ay)	Görüşmenin başlangıç saati ve dakikası	☐☐ : ☐☐ (saat, dakika)	Görüşmenin bitiş saati ve dakikası	☐☐ : ☐☐ (saat, dakika)
ANKETÖR NO	.... ☐☐☐	Hane listesindeki kişi no	☐☐	Adı soyadı	....	Seyahat Bilgisinin Ait Olduğu Gün	1 PZT 2 SAL 3 ÇAR 4 PER 5 CUM 6 CTS 7 PZR

C.0.Yolculuk belirli bir amaç için bir noktadan başka bir noktaya hareket etmektir. Şimdi size dün sabah 06:00'dan bu sabah 06:00'ya kadar yaptığınız tüm yolculukların detaylı bilgilerini soracağım. Dün sabah 06.00'dan bu sabah 06.00'ya kadar belirli bir amaç için evden dışarı çıktınız mı?

- Hayır çıkmadım. 0 (BÖLÜM III'E GEÇİNİZ!)

- Evet çıktım. 1 **Toplam yolculuk adedi:** ☐☐

C.1. Yolculuk No	Başlangıç: C.2. (İLK YOLCULUK İÇİN SORUNUZ)**Dün sabah 06:00 itibariyle nerdeydiniz?** 1.Ev 2.İş 3.Okul 4.İş takibi 5.Alışveriş 6.Sosyal, spor ve eğlence 7.Sağlık 8.Diğer (BELİRTİNİZ) (DİĞER YOLCULUKLAR İÇİN; PEKİ SONRA)	Başlangıç: **C.3. Hareketinizin başlangıç noktasının açık adresini veya ilçe ve mahallesini söyler misiniz?** (MAHALLENİN BİLİNMEDİĞİ DURUMLARDA BİLİNEN EN YAKIN BİR NOKTA (KAVŞAK, OKUL, CAMİ, OTOBÜS DURAĞI VEYA BİLİNEN BİR BİNA) İÇİN REFERANS BİLGİLER EDİNİLECEKTİR)	Başlangıç: **C.3.1. Hareketin başladığı Mah. Kodu**	Başlangıç: **C.4. Hareketinizin başlangıç saatini tam olarak söyleyebilir misiniz?**	Varış: **C.5. Hangi amaçla /nereye gittiniz?** 1.Ev 2.İş 3.Okul 4.İş takibi 5.Alışveriş 6.Sosyal, spor ve eğlence 7.Sağlık 8.Diğer (BELİRTİNİZ)	Varış: **C.6. Gittiğiniz yerin açık adresini veya ilçe ve mahallesini söyler misiniz?** (AÇIK ADRESİN BİLİNMEDİĞİ DURUMLARDA BİLİNEN EN YAKIN BİR NOKTA (KAVŞAK, OKUL, CAMİ, OTOBÜS DURAĞI VEYA BİLİNEN BİR BİNA) İÇİN REFERANS BİLGİLER EDİNİLECEKTİR.)	Varış: **C.6.1. Hareketin bittiği Mah. Kodu**	Varış: **C.7. Gittiğiniz yere tam olarak saat kaçta vardınız?**	Kullanılan Ulaşım Türleri Kombinasyonu: **C.8. Ulaşım Türü Sırası**	**C.9. Oraya giderken sırası ile hangi ulaşım araçlarını/ türlerini kullandınız?*** (YAYA VE BİSİKLET İSE C17'YE GEÇİNİZ.)	**C.10. Araca/ durağa kaç dakika yürüdüğünüzü söyler misiniz?** (Süre yoksa "0" yazınız)	**C.11. Araç için kaç dakika beklediğinizi söyler misiniz?** (Süre yoksa "0" yazınız)	**C.12. Araç içinde kaç dakika seyahat ettiğinizi söyler misiniz?**	**C.13. Araçtan /duraktan gideceğiniz yere kaç dakika yürüdüğünüzü söyler misiniz?** (Süre yoksa "0" yazınız)	**C.14. Araç ücreti olarak ne kadar ödediğinizi söyler misiniz?** (AKBİL KULLANANLAR İÇİN: SINIRSIZ KULLANDIYSA "S" ÜCRETSİZ KART KULLANDIYSA "Ü", AKTARMA YAPTIYSA "A" KUTUSUNU İŞARETLEYİNİZ !!)(SERVİS KULLANDIYSA E KUTUSUNU İŞARETLEYİNİZ.) (YTL) — Sınırsız Akbil, Aktarma, Ücretsiz Kart, Servis, YTL, KRŞ	**C.15. Özel oto kullandıysanız ödediğiniz park ücretini söyler misiniz?** (AYLIK ÖDEME YAPILIYORSA "A"İŞARETLEYİNİZ. PARK ÜCRETİ YOKSA 0 YAZINIZ.) (YTL) — Aylık, YTL, KRŞ	**C.16. Özel otomobille ya da taksiyle seyahat ettiy-seniz araçta sürücü ile birlikte toplam kaç kişiydiniz ? YOLCULUK BOYUNCA ARAÇTA BULUNAN EN FAZLA KİŞİ SAYISINI YAZINIZ.**	**C.17. Kendi şahsi imkanlarınızı ve mevcut ulaşım alternatiflerini düşündüğünüz de bu yolculuğunuzu başka hangi ulaşım türleriyle yapabilirdiniz ?** (ULAŞIM ARACI KODU GİRİNİZ. BAŞKA ALTERNATİF YOK İSE "YOK" YAZINIZ.EN ÇOK ÜÇ TANE BELİRTİNİZ)
1		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
									4						S A Ü E ,	A ,		
		Mah: .... İlçe:		dakika		Mah: .... İlçe:		dakika	5						S A Ü E ,	A ,		
2		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
									4						S A Ü E ,	A ,		
		Mah: .... İlçe:		dakika		Mah: .... İlçe:		dakika	5						S A Ü E ,	A ,		
3		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
									4						S A Ü E ,	A ,		
		Mah: .... İlçe:		dakika		Mah: .... İlçe:		dakika	5						S A Ü E ,	A ,		
4		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
									4						S A Ü E ,	A ,		
		Mah: .... İlçe:		dakika		Mah: .... İlçe:		dakika	5						S A Ü E ,	A ,		
5		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
									4						S A Ü E ,	A ,		
		Mah: .... İlçe:		dakika		Mah: .... İlçe:		dakika	5						S A Ü E ,	A ,		

C.1. Yolculuk No	Başlangıç				Varış				Kullanılan Ulaşım Türleri Kombinasyonu									
	C.2. (İLK YOLCULUK İÇİN SORUNUZ)Dün sabah 06:00 itibariyle neredeydiniz? 1.Ev 2.İş 3.Okul 4.İş takibi 5.Alışveriş 6.Sosyal, spor ve eğlence 7.Sağlık 8.Diğer (BELİRTİNİZ) (DİĞER YOLCULUKLAR İÇİN, PEKİ SONRA)	C.3. Hareketinizin başlangıç noktasının açık adresini veya ilçe ve mahallesini söyler misiniz? (MAHALLENİN BİLİNMEDİĞİ DURUMLARDA BİLİNEN EN YAKIN BİR NOKTA (KAVŞAK, OKUL, CAMİ, OTOBÜS DURAĞI VEYA BİLİNEN BİR BİNA) İÇİN REFERANS BİLGİLER EDİNİLECEKTİR)	C.3.1. Hareketin başladığı Mah. Kodu	C.4. Hareketinizin başlangıç saatini tam olarak söyleyebilir misiniz?	C.5. Hangi amaçla /nereye gittiniz? 1.Ev 2.İş 3.Okul 4.İş takibi 5.Alışveriş 6.Sosyal, spor ve eğlence 7.Sağlık 8.Diğer (BELİRTİNİZ)	C.6. Gittiğiniz yerin açık adresini veya ilçe ve mahallesini söyler misiniz? (AÇIK ADRESİN BİLİNMEDİĞİ DURUMLARDA BİLİNEN EN YAKIN BİR NOKTA (KAVŞAK, OKUL, CAMİ VEYA BİLİNEN BİR BİNA) İÇİN REFERANS BİLGİLER EDİNİLECEKTİR.)	C.6.1. Hareketin bittiği Mah. Kodu	C.7. Gittiğiniz yere tam olarak saat kaçta vardınız?	C.8. Ulaşım Türü Sırası	C.9. Oraya giderken sırası ile hangi ulaşım araçlarını/ türlerini kullandınız?* (YAYA VE BİSİKLET İSE C17'YE GEÇİNİZ)	C.10. Araca/ durağa kaç dakika yürüdüğünüzü söyler misiniz? (Süre yoksa "0" yazınız)	C.11. Araç için kaç dakika beklediğinizi söyler misiniz? (Süre yoksa "0" yazınız)	C.12. Araç içinde kaç dakika seyahat ettiğinizi söyler misiniz?	C.13. Araçtan /duraktan gideceğiniz yere kaç dakika yürüdüğünüzü söyler misiniz? (Süre yoksa "0" yazınız)	C.14. Araç ücreti olarak ne kadar ödediğinizi söyler misiniz? (AKBİL KULLANANLAR İÇİN: SINIRSIZ KULLANDIYSA "S" ÜCRETSİZ KART KULLANDIYSA "Ü", AKTARMA YAPTIYSA "A" KUTUSUNU İŞARETLEYİNİZ !!)(SERVİS KULLANDIYSA E KUTUSUNU İŞARETLEYİNİZ.) (YTL) Sınırsız Akbil / Aktarma / Ücretsiz Kart / Servis — YTL KRŞ	C.15. Özel oto kullandıysanız ödediğiniz park ücretini söyler misiniz? (AYLIK ÖDEME YAPILIYORSA "A"İŞARETLEYİNİZ PARK ÜCRETİ YOKSA 0 YAZINIZ.) (YTL) Aylık YTL KRŞ	C.16. Özel otomobille ya da taksiyle seyahat ettiyseniz araçta sürücü ile birlikte toplam kaç kişiydiniz ? YOLCULUK BOYUNCA ARAÇTA BULUNAN EN FAZLA KİŞİ SAYISINI YAZINIZ.	C.17. Kendi şahsi imkanlarınızı ve mevcut ulaşım alternatiflerini düşündüğünüzde bu yolculuğunuzu başka hangi ulaşım türleriyle yapabilirdiniz ? (ULAŞIM ARACI KODU GİRİNİZ, BAŞKA ALTERNATİF YOK İSE "YOK" YAZINIZ,EN ÇOK ÜÇ TANE BELİRTİNİZ)
6		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
		Mah:				Mah:			4						S A Ü E ,	A ,		
		İlçe:		dakika		İlçe:		dakika	5						S A Ü E ,	A ,		
7		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
		Mah:				Mah:			4						S A Ü E ,	A ,		
		İlçe:		dakika		İlçe:		dakika	5						S A Ü E ,	A ,		
8		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
		Mah:				Mah:			4						S A Ü E ,	A ,		
		İlçe:		dakika		İlçe:		dakika	5						S A Ü E ,	A ,		
9		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
		Mah:				Mah:			4						S A Ü E ,	A ,		
		İlçe:		dakika		İlçe:		dakika	5						S A Ü E ,	A ,		
10		Adres:				Adres:			1						S A Ü E ,	A ,		
									2						S A Ü E ,	A ,		
				saat				saat	3						S A Ü E ,	A ,		
		Mah:				Mah:			4						S A Ü E ,	A ,		
		İlçe:		dakika		İlçe:		dakika	5						S A Ü E ,	A ,		

Ulaşım türü kodları

1. Yaya	7. Minibüs	13. Hafif metro (Aksaray -Havaalanı)
2. Özel oto yalnız sürüş	8. Belediye otobüsü	14. Tramvay
3. Özel oto paylaşılan sürüş	9. Özel halk otobüsü	15. Tünel
4. Taksi	10. Motosiklet	16. Vapur
5. Servis aracı	11. Bisiklet	17. Deniz otobüsü
6. Dolmuş	12. Metro(Taksim-4.Levent)	18. Deniz motoru
19. Banliyo	20. Diğer (Belirtiniz)	

NOT.

1. 6 YAŞ VE ÜZERİNDEKİ HER KİŞİ İÇİN AYRI BİR YOLCULUK FORMU DOLDURULACAKTIR.
2. 6 YAŞ VE ÜZERİNDEKİ KİŞİLERİN 24 SAATTE YAPTIKLARI TÜM YOLCULUKLAR KAYDEDİLECEKTİR.
3. 6 YAŞ VE ÜZERİNDE OLUP YOLCULUK YAPMAYAN KİŞİLERİN FORMUNA "Hayır çıkmadım" İŞARETLENECEKTİR

BOLUM III HANEDEKI ARAÇ BILGILERI

Şimdi hanedeki araç bilgileriyle ilgili bazı sorular soracağım.

	D.1. Sayacağım ulaşım araçlarınız var mı?		D.2. Aracı akşamları nereye park ediyorsunuz? (BİRDEN ÇOK CEVAP ALABİLİRSİNİZ!!)				D.3. Araca ait bilgiler		
	Yok	Var	1. Cadde/sokak kenarı	2. Kendi garajı (Site/apartman garajı vb)	3. Ücretli Açık otopark	4. Ücretli kapalı/katlı otopark	1. Araç Yapım Yılı	2. Araç Motor Hacmi	3.Motor yakıt tipi
1. Hane halkına ait özel otomobiliniz var mı?	0 (4'E GEÇ)	1	1	2	3	4			1. Benzinli 2. Dizel 3. LPG
2. Hane halkına ait ikinci bir özel otomobiliniz var mı?	0 (4'E GEÇ)	1	1	2	3	4			1. Benzinli 2. Dizel 3. LPG
3. Hane halkına ait üçüncü bir özel otomobiliniz var mı?	0 (4'E GEÇ)	1	1	2	3	4			1. Benzinli 2. Dizel 3. LPG
4. Hane halkı tarafından kullanılan -ve akşamları kullanan kişide kalan- şirket aracı gibi başka bir araç var mı?	0 (6'YA GEÇ)	1	1	2	3	4			1. Benzinli 2. Dizel 3. LPG
5. Hane halkı tarafından kullanılan -ve akşamları kullanan kişide kalan- şirket aracı gibi ikinci bir araç var mı?	0 (6'YA GEÇ)	1	1	2	3	4			1. Benzinli 2. Dizel 3. LPG
6. Hane halkına ait başka motorlu araç var mı?	0 (D.4.'E GEÇ)	1	1	2	3	4			
6.1 –Varsa- diğer Motorlu aracın türü/türleri nedir? (ŞIKLARI OKUYUNUZ VE VARSA BİRDEN ÇOK ŞIK İŞARETLEYİNİZ)	1. Kamyon, 2. Kamyonet, 3. Minibüs, 4. Ticari Taksi, 5. Otobüs, 6. Traktör, 7. Diğer :Belirtiniz:								1. Benzinli 2. Dizel 3. LPG

(DİKKAT !, D.4, D.5, D.6 VE D.7 SORULARI OTOMOBİL SAHİPLERİNE SORULACAKTIR)

D.4. Trafiğin çok yoğun olduğu Şişli, Beşiktaş, Taksim, Eminönü, Bakırköy, Fatih, Kadıköy, Üsküdar merkezlerine otomobilinizle haftada kaç kez gidiyorsunuz?

0	1	2	3	4	5	6	7	8	9	10 +

(DİKKAT !, "0" SIFIR İSE BÖLÜM IV'E GEÇİNİZ.)

D. 5. Bazı Avrupa şehirlerinde, merkez bölgelere otomobil ile girişlerde, trafiğin yoğun olduğu saatlerde ücret alınmakta ve bunun sonucunda bu bölgelerdeki trafikte rahatlama sağlanmaktadır. Benzer ücretlendirmenin, <u>Mevcut Toplu Taşıma</u> Sistemiyle İstanbul için uygulanması durumunda nasıl davranırsınız?

Ücret ne olursa olsun, otomobilimi kullanmaktan vazgeçerim	Alınacak ücretin miktarına bağlı olarak vazgeçerim (YTL) (UYGUN MİKTARI AŞAĞIDA İŞARETLEYİNİZ)				Ücret ne olursa olsun, otomobilimi kullanmaktan vazgeçmem
	1 - 3	4 - 6	7 - 10	11 - 15	
A1	B2	C3	D4	E5	F6

D.6. Peki, benzer ücretlendirmenin, <u>İyileştirilmiş</u> (Hızlı, konforlu, güvenli, temiz) bir Toplu Taşıma Sistemiyle İstanbul için uygulanması durumunda nasıl davranırsınız?

Ücret ne olursa olsun, otomobilimi kullanmaktan vazgeçerim	Alınacak ücretin miktarına bağlı olarak vazgeçerim (YTL) (UYGUN MİKTARI AŞAĞIDA İŞARETLEYİNİZ)				Ücret ne olursa olsun, otomobilimi kullanmaktan vazgeçmem
	1 - 3	4 - 6	7 - 10	11 - 15	
A1	B2	C3	D4	E5	F6 (BÖLÜM IV'E GEÇİNİZ)

D. 7. Otomobiliniz ile merkez bölgeye girmekten veya merkez bölgeden transit geçmekten vazgeçerseniz aşağıdakilerden hangisini yaparsınız? (BİRDEN ÇOK SEÇENEK İŞARETLEYEBİLİRSİNİZ.)

Toplu taşımayı kullanmaya başlarım	A1
Yolculuk güzergahımı değiştiririm	B2
Otomobilimi merkeze yakın bir yere park edip, merkeze toplu taşıma ile giderim	C3
Ücret alınan bölgelere zorunlu olmadıkça gitmem	D4

BÖLÜM IV. HANENİN MÜLKİYET VE GELİR DURUMUYLA İLGİLİ BİLGİLERİ

E.1. Bu konutta mülkiyet durumunuz nedir?

1	Ev sahibi
2	Kiracı
3	Lojman
4	Ev sahibi değil ama kira ödemiyor
5	Diğer

(DİKKAT! E.2'yi kiracı olanlara sorunuz)
E.2 Evinizin kirası aylık ne kadardır?(YTL)...

(DİKKAT! E.3.'ü ev sahibi olanlara sorunuz)
E.3. Evinizin fiziki durumunu, çevresel şartları, civardaki ortalama kira bedellerini düşündüğünüzde evinizi kiraya verseniz AYLIK ne kadar gelir getirir?(YTL)..

E.4.Hane halkı *OTURDUĞUNUZ EV DIŞINDA* sayacağım mülklerden hangilerine sahiptir?

Türü	Yok	Var
1. Apartman dairesi	0	1
2. Müstakil konut(yazlık vb.)	0	1
3. Dükkan/Büro	0	1
4. Arsa	0	1
5.Tarla/bağ/bahçe	0	1
Diğer(Belirtiniz)……………….	0	1

E.5. Hanenin tüm ev halkına ait ayni ve nakdi kazancı, gayri menkul, faiz gelirleri vb. dahil olmak üzere aylık ortalama geliri sayacağım aralıklardan hangisine girmektedir?

1	250 YTL altı	6	1251 – 1500 YTL	11	2501 – 3500 YTL
2	251 – 500 YTL	7	1501 – 1750 YTL	12	3501 – 4999 YTL
3	501 – 750 YTL	8	1751 – 2000 YTL	13	5000 – 7499 YTL
4	751 - 1000 YTL	9	2001 – 2250 YTL	14	7500 – 9999 YTL
5	1001 – 1250 YTL	10	2251 – 2500 YTL	15	10 000 YTL ve üstü

E.6. Peki hane halkının aylık gelirini tam, rakamsal olarak söyler misiniz?......................................
(Hane fertlerinin hepsinin, ayni ve nakdi bütün gelirlerini göz önünde bulundurunuz.)

ULAŞIM SORUNLARI

F. 1. Semtinizde aşağıdaki toplu taşıma araçlarından hangileri hizmet vermektedir?

	E	H		E	H
İETT Otobüs	1	2	Vapur	1	2
Halk/Özel Otobüsü	1	2	Deniz Otobüsü	1	2
Metro	1	2	Minibüs	1	2
Tramvay	1	2	Dolmuş	1	2

F. 2. Semtinizdeki toplu taşıma hatlarında aşağıda sayacağım sorunlardan hangileri yaşanmaktadır?

	Evet	Hayır	Fikrim yok
1. Otobüslerin sefer saatlerine uymaması	1	2	3
2. Sefer sayılarının yetersiz olması	1	2	3
3. Hat sayısının yetersiz olması	1	2	3
4. Yolculuk ücretlerinin pahalı olması	1	2	3
5. Akbil dolum gişelerinin yetersiz olması	1	2	3
6. Araçların kalabalık olması	1	2	3
7. Araçların kirli olması	1	2	3

F. 3. Peki bunların dışında sizce semtinizde ulaşımda yaşanan diğer sorunlar nelerdir? *(BİRDEN ÇOK CEVAP ALINABİLİR!!)*

....

....

....

Bizi kontrol etmek için sizi arayabilirler. Sakıncası yoksa telefon numaranızı alabilir miyiz?

TEL NO: □□□□ □□□ □□ □□ TEL YOK: □ NO. VERMEK İSTEMİYOR □

CEVAPLAYICIYA TEŞEKKÜR EDİNİZ VE GÖRÜŞMEYİ BİTİRİNİZ.

BİTİŞ SAATİNİ YAZIN	SAAT □□ DAKİKA □□
SİZE GÖRE YANITLARIN GÜVENİLİRLİK DERECESİ NEDİR?	ÇOK ZAYIF........ 1 ZAYIF........ 2 ORTA........ 3 İYİ........ 4 ÇOK İYİ........ 5

ANKETÖR GÖZLEMLERİ

HANE HAKKINDA GÖZLEMLER ________________

BELİRLİ SORULAR HAKKINDA GÖZLEMLER ________________

DİĞER GÖZLEMLER ________________

EKİP BAŞININ (ALAN EDİTÖRÜ) GÖZLEMLERİ

Ekip Başının Adı Soyadı:

DENETÇİNİN GÖZLEMLERİ

Denetçinin Adı Soyadı:

GÜN AY
TARİH:___/___/2006

BİTTİ

APPENDIX B: LICENSE PLATE CHECK FIELD DATA SHEET

This appendix involves a blank License Plate Check Field Data Sheet used in Fulya pilot study area (Traffic Engineering, 2004, p 275).

LICENSE PLATE CHECK FIELD DATA SHEET

City:___________ Date:____/____/____ Recorded by:_________________Side of Street:______

Street:____________________between____________________and______________________

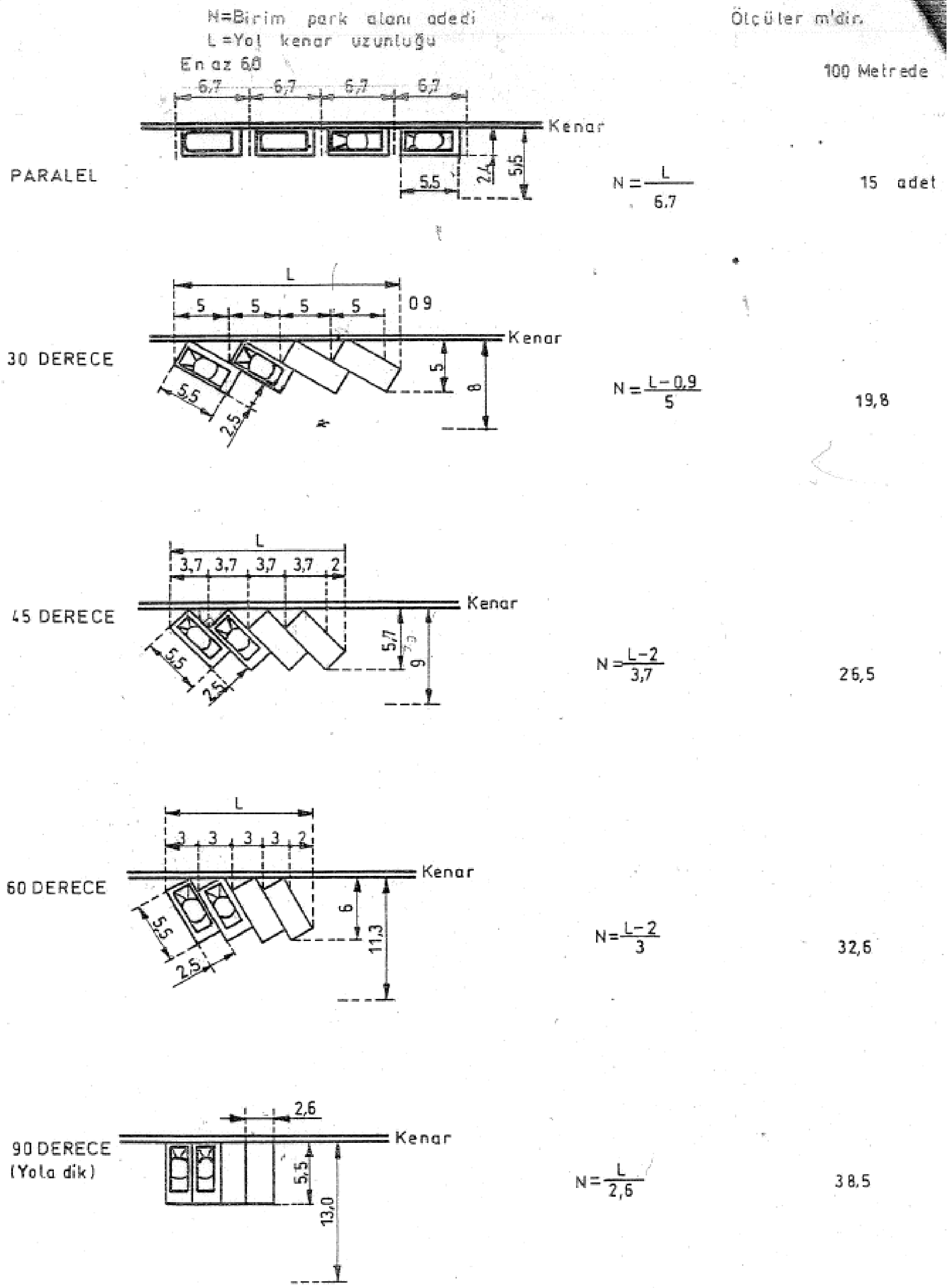
Space and Regulation	Time Circuit Begins												
	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00

Codes: 000 last three digits of license number. **T** for truck **TK** for illegally parked

✓ for repeat number from prior circuit. — for empty space.

APPENDIX C: TURKISH STANDARDS (TS 10551)

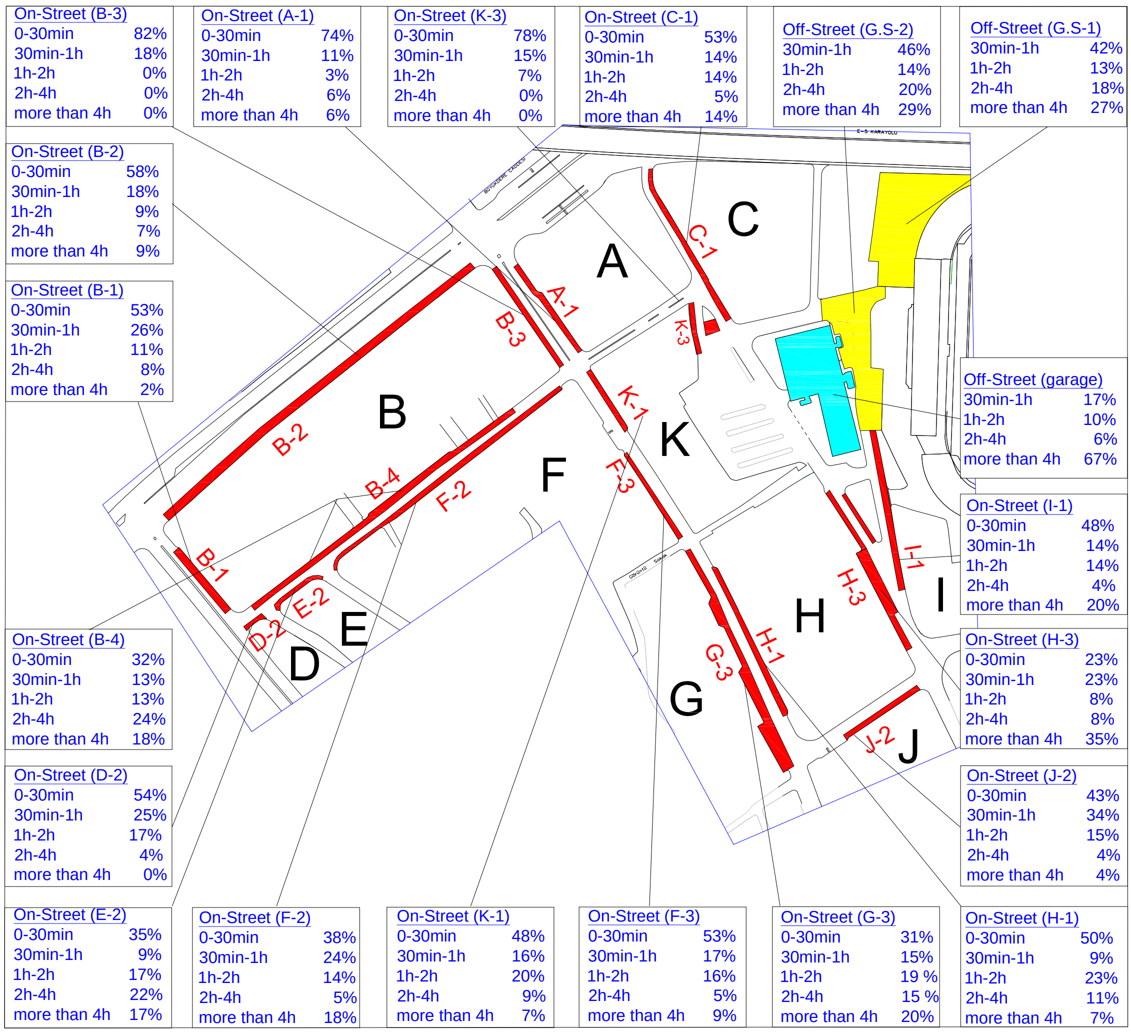
This appendix includes Turkish Standards (TS 10551) for the physical layout of different parking spaces.



ŞEKİL 1– YOL KENAR PARKINDA, PARK ETME ŞEKLİNE GÖRE TERCİH EDİLEN ÖLÇÜLER VE 100m YOL BOYUNDA BİRİM PARK ADEDİ.

APPENDIX D: PERCENTAGE OF PARKED VEHICLES FOR EACH PARKING FACILITY

This section includes the percentage of parked vehicles for each parking facility grouped in 6 categories.



APPENDIX E: THE DRAWINGS OF PHYSICAL LAYOUT OF THE PILOT STUDY AREA

This section includes the existing and suggested physical layout of the pilot study area.

Legend

Parking Unit Dye	Load/Unload Parking Unit
Truck Parking Unit	Handicapped Parking Unit
Vehicle	Traffic movement direction

Type and Number of Parking Spaces

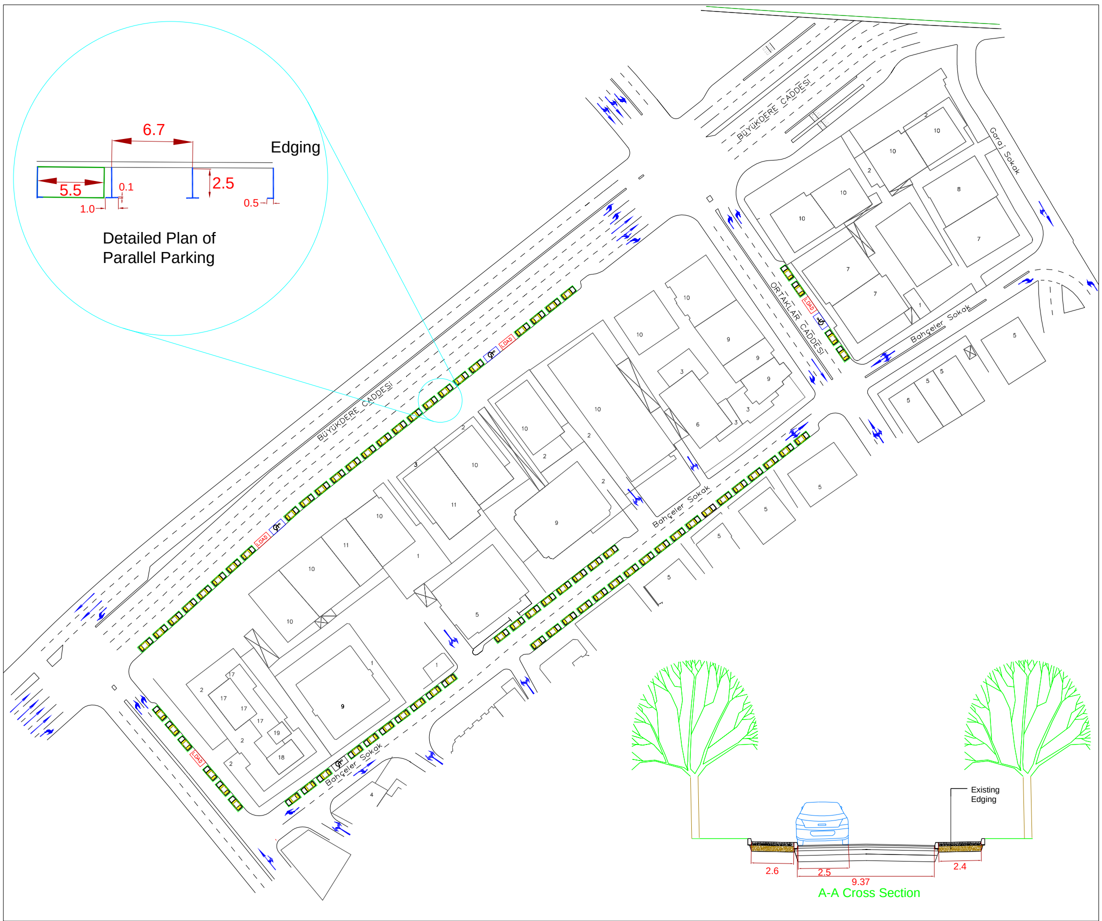
Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
				87		

Figure B. 1. The existing physical layout of A, B, C, D, E, and F blocks

Legend			
	Parking Unit Dye		Load/Unload Parking Unit
	Truck Parking Unit		Handicapped Parking Unit
	Vehicle		Traffic movement direction

Type and Number of Parking Spaces						
Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
27	11	5		54		

Figure B. 2. The existing physical layout of F, G, H, I, J, K, and H blocks



Legend	
Parking Unit Dye	Load/Unload Parking Unit
Truck Parking Unit	Handicapped Parking Unit
Vehicle	Traffic movement direction

Type and Number of Parking Spaces

Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
				74	4	4

Figure B. 3. The suggested physical layout of A, B, C, D, E, and F blocks

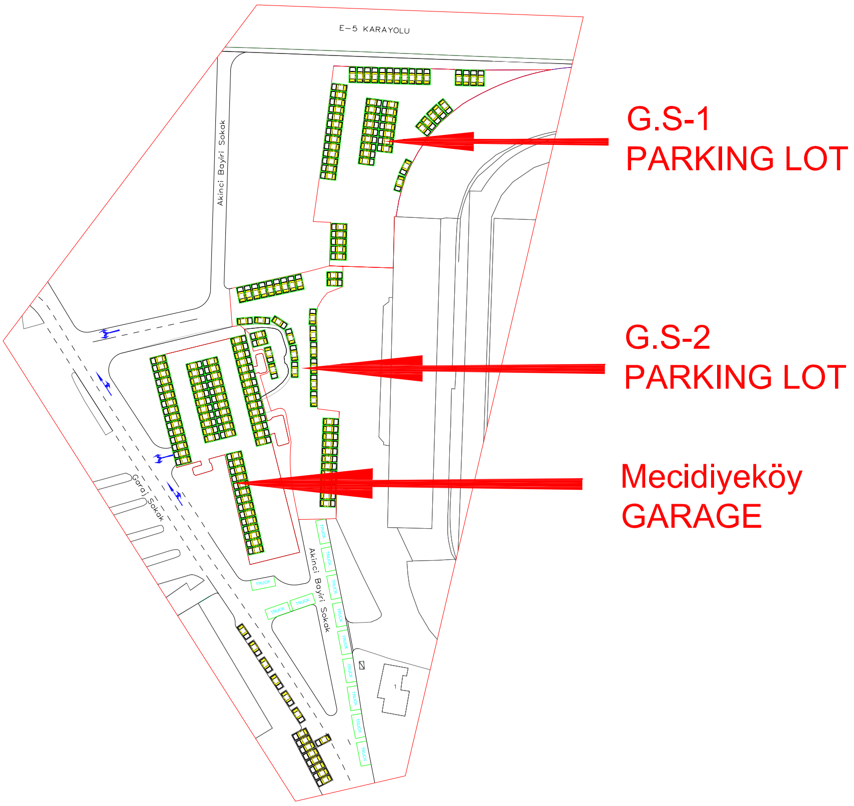
Legend

Parking Unit Dye	Load/Unload Parking Unit
Truck Parking Unit	Handicapped Parking Unit
Vehicle	Traffic movement direction

Type and Number of Parking Spaces

Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload
27	11	5		54		

Figure B. 4. The suggested physical layout of F, G, H, I, J, K, and H blocks



Legend			
	Parking Unit Dye	LOAD	Load/Unload Parking Unit
	Truck Parking Unit		Handicapped Parking Unit
	Vehicle		Traffic movement direction

Type and Number of Parking Spaces

Perpendicular	60 Degree	45 Degree	30 Degree	Parallel	Handicapped	Load/Unload

Figure B. 5. Physical layout of off-street facilities

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