Analyzing the Impact of Shifting Private Vehicles to Public Transport on Oil Consumption. A Study of Islamabad, Pakistan

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Analyzing the Impact of Shifting Private Vehicles to Public Transport on Oil Consumption. A Study of Islamabad, Pakistan

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Certificate

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Zainish Riaz

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List of Abbreviations

CO2	Carbon dioxide
Cons.	Consumption
Pvt. Veh.	Private Vehicles
Pub. Trans.	Public Transport
M.T	Metric Ton
L	Liters
T.N	Total Number
M. Rs.	Million Rupees
Km	Kilometers
TD	Travel Distance
P	Passengers
OC	Oil Consumption
FC	Fuel Cost
CE	Carbon dioxide Emissions
PT	Public Transport
PV	Private Vehicles
T.MT	Total Metric Tons
T.L	Total Liters
T. Rs.	Total Rupees
T.Km	Total Kilometers
DIV	Difference in Values
T.N.V	Total number of Vehicles
Rd.	Road

GOP	Government of Pakistan
PVF.DW	Day-Wise Private Vehicles Flow
Std. dev	Standard Deviation
PVF.TW	Time-Wise Private Vehicles Flow

Abstract

The present study investigates the impact of shifting private vehicles to public transport on oil consumption and CO_2 emissions. The study uses one week of peak-hours private vehicle flow data from fifteen intracity locations in Islamabad and provides eleven shifting scenarios of the private vehicles to public transport. The study collects average passenger per private vehicle, public transport seating capacity, average travel kilometers, average oil consumption, average fuel price, and CO_2 emitted per liter of oil consumption data of private vehicles and public transport through primary and secondary data. The study employs novel techniques and methodologies that have not been previously used in the transport sector, particularly in the context of Pakistan. This study utilizes the SPSS software to analyze data through descriptive statistics, an independent samples t-test, and a one-way analysis of variance (ANOVA). Additionally, the study employs formulas and bar charts in Microsoft Excel to calculate impacts and represent the results pictorially. The results provide descriptions of the data, pre-shifting impacts, and post-shifting analysis. The findings reveal that shifting all private vehicles to public transport decreases oil consumption by 87.6%, CO_2 emissions by 86.4%, the number of vehicles by 95.7%, and fuel costs by 88.1%. The study also suggests and analyzes various shifting scenarios and demonstrates the corresponding reductions in vehicles, oil consumption, fuel costs, and CO_2 emissions. The findings suggest that shifting a significant portion of private vehicles to public transport can have substantial positive impacts on oil consumption and CO_2 emissions. Finally, the study proposed that officials can test the effectiveness of presented scenarios in a specific location before implementing them city-wide or countrywide.

Keywords: Private vehicles, public transport, oil consumption, CO_2 emissions, shifting.

CHAPTER 1

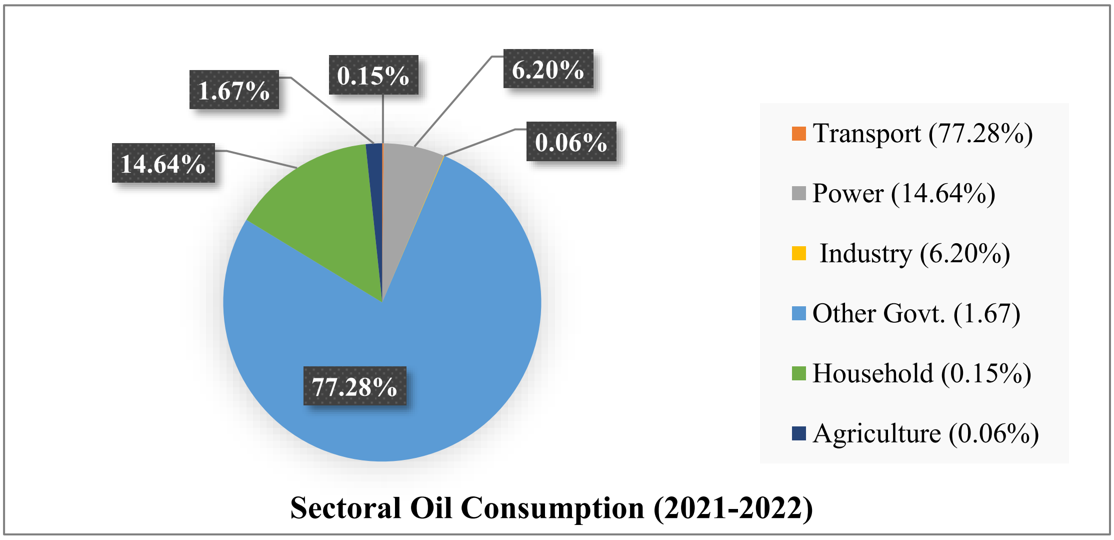
INTRODUCTION

1.1. Introduction

This chapter aims to introduce the primary purpose of the study in detail. The current section (section 1.1) explains the main purpose and structure of this chapter. Section 1.2 illustrates the background of the study. Section 1.3 elaborates the problem statement of this study. Section 1.4 discusses the research questions of this study. Section 1.5 describes the research objectives of this study. Section 1.6 illustrates the research gap of this study in detail. Section 1.7 elaborates the research significance briefly. Section 1.8 describes the summary of this chapter and the organization of the study.

1.2. Background of the Study

Pakistan primarily meets its energy requirements through the utilization of gas and oil. Meanwhile, gas is the largest source of energy, followed by oil as the second-largest source of energy in Pakistan (Lin & Raza, 2020). The predominant use of oil i.e. petroleum products, in Pakistan is used in three major sectors for energy consumption, namely, industry, transport, and power generation. Among these three sectors, the transport sector consumes the major portion of petroleum products, constituting approximately 60% of the total usage. The energy sector, specifically electricity production, follows with a consumption rate of 32%, while the industrial sector utilizes approximately 8% of petroleum products (Akram et al., 2021). However, in recent years (2018 to 2022), the portion of transport sector oil consumption reached an average of 78 percent of total oil consumption in the country (GOP, 2023)



Data Source: Economic Survey of Pakistan (2021-2022)

Figure 1.1 Sectoral Oil Consumption (2021-2022)

In the fiscal year 2021-2022 transport sector consumed approximately 76 percent of the total oil consumption in the country, while other sectors consumed a very minor percentage of oil compared to the transport sector (GOP, 2023), shown in Figure 1.1. Therefore, the transport sector in Pakistan is the primary consumer of petroleum products. Further, it is the second leading consumer of the country's total energy consumption (Sohail et al., 2021). In addition, within the realm of the transport sector, the primary consumer of oil is road transport (Tanveer, 2022). Road transport accounts for over 75% of the energy consumed in the transport sector (Abbas et al., 2023). The energy products consumed in road transport amounted to 15.47 million tons in the fiscal year 2020–21. However, it increased to 17.01 million tons in the fiscal year 2021–22 (Tanveer, 2022). Additionally, 31.4% of the country's total energy consumption is consumed by the road transport sector (Khan, 2018). Approximately 80% of the country's oil consumption is consumed by transport, which includes cars, motorcycles, trucks, buses, and other vehicles. (Khan, 2022).

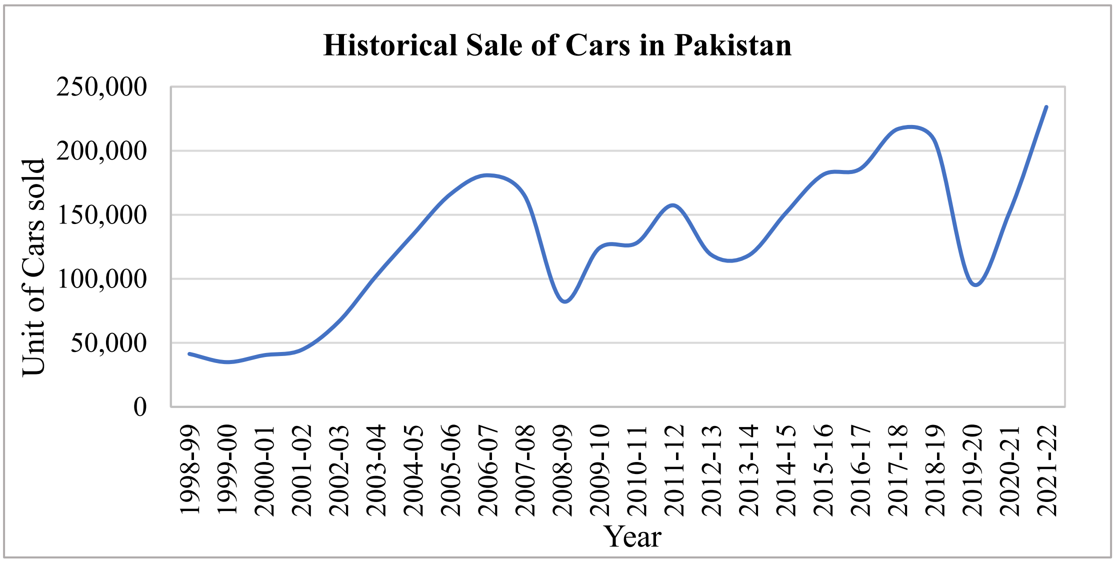
In Pakistan, road travel includes the use of both private vehicles and public transport. However, in Pakistan, there has been a notable increase in the ownership of private vehicles in recent years, resulting in a corresponding rise in the number of private vehicle trips (Rasool et al., 2019). People prefer private vehicles for their trips, i.e. commuting needs, mainly when it is within their financial affordability (Javid et al., 2014). A trip is defined as the movement of any person from one place to another using a motorized transport mode. In Pakistan's major cities, more trips are made using private vehicles rather than public transport. This trend started with the expansion of cities, which has resulted in longer trip lengths, making it difficult for urban residents to rely on non-motorized modes of transport, such as walking and cycling. As a result, many people switched to motorized transport. At that time, almost no consideration was given to enhancing the quality of public transport to satisfy the need for motorized transport. Consequently, people with higher incomes in larger cities started to opt for private vehicles such as cars and motorcycles over public transport, which was basically due to the low level of comfort, poor service, and overall inferior quality of public transport (Imran, 2009).

1.2.1. Public Transport System in Pakistan

Furthermore, public transport in Pakistan still remains inefficient and poorly developed, which is leading to a further growing demand for private vehicles (Ahmed, Mehdi et al., 2019; Rasool et al., 2019). In addition, the absence of a well-established public transport system led to a rise in reliance on personal vehicles and motorcycles (Ahmed et al., 2019a; Ahmed et al., 2019b). People tend to choose private transport instead of public transport due to various reasons. For instance, non-regulated public transport fares, accessibility issues, poor behavior of drivers such as refusing to complete their designated routes, congested seating, poor service, and difficulties for people with disabilities to access transport (Adeel et al., 2016b). Furthermore, safety concerns among women in Pakistan result in reducing the usage of public transport. These concerns are primarily driven by the prevalence of harassment and a pervasive sense of insecurity and fear that women experience while traveling on public transport (Adeel et al., 2014). In addition, the use of "informal" means of public transport, including Qinqui, wagons, and other unregulated modes, operates in a relatively disorganized manner (Fekadu, 2014; Guillen et al., 2013), and this is one of the reasons why people avoid using public transport and prefer private vehicles.

1.2.2. Historical Sale of Cars in Pakistan or Growth in Cars Sales

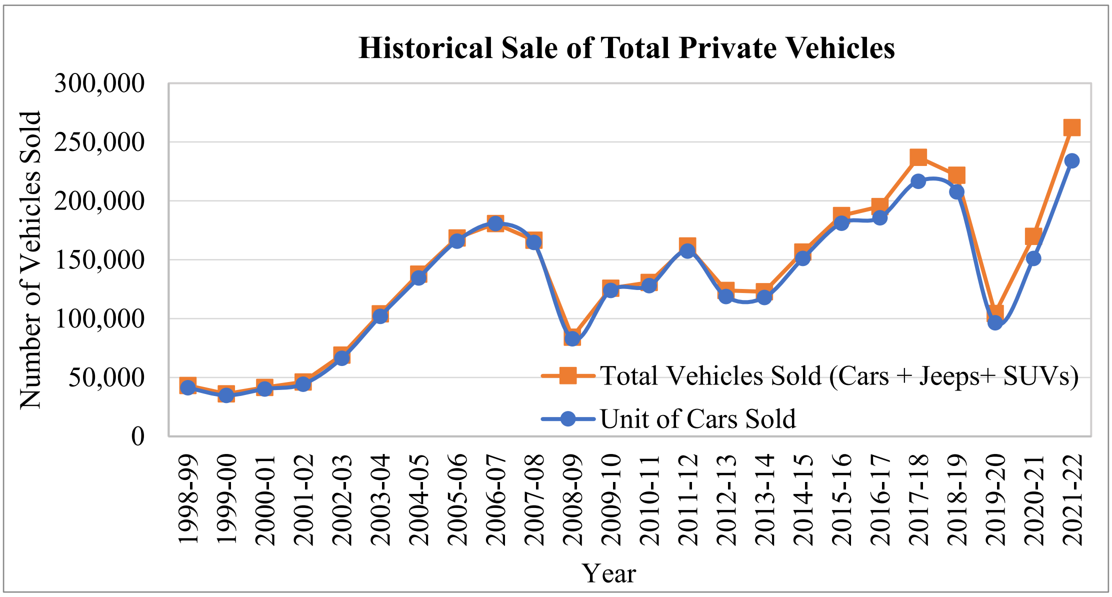
Consequently, the number of private vehicles increased over the years, leading to more congestion on the roads and increased oil consumption, which is continuously rising due to the growth of the middle class in the country. (Javid et al., 2017; Rasool et al., 2019).



Data source: Pakistan Automotive Manufacturer Association – PAMA (2022)

Figure 1.1 Historical Sale of Cars in Pakistan

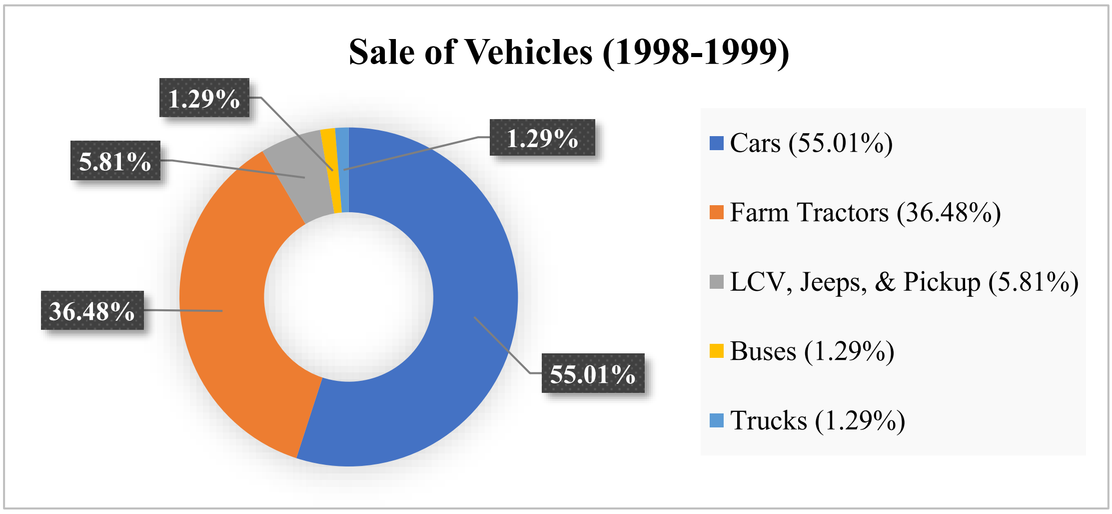
As per the data given by the Pakistan Automotive Manufacturers Association (PAMA), the unit of cars sold in Pakistan was 41,337 in the fiscal year 1998-1999. Nonetheless, over the years, car sales increased to 234,180 units in the fiscal year 2021-2022 (PAMA, 2022).



Data source: Pakistan Automotive Manufacturer Association – PAMA (2022)

Figure 1.3 Historical Sale of Total Private Vehicles

However, if other private vehicles, i.e. jeeps and sports utility vehicles (SUVs), are added to the units of cars sold, the number of private vehicles will increase to 262,261 in the fiscal year 2021-2022 (PAMA, 2022), as shown in figure 1.3.

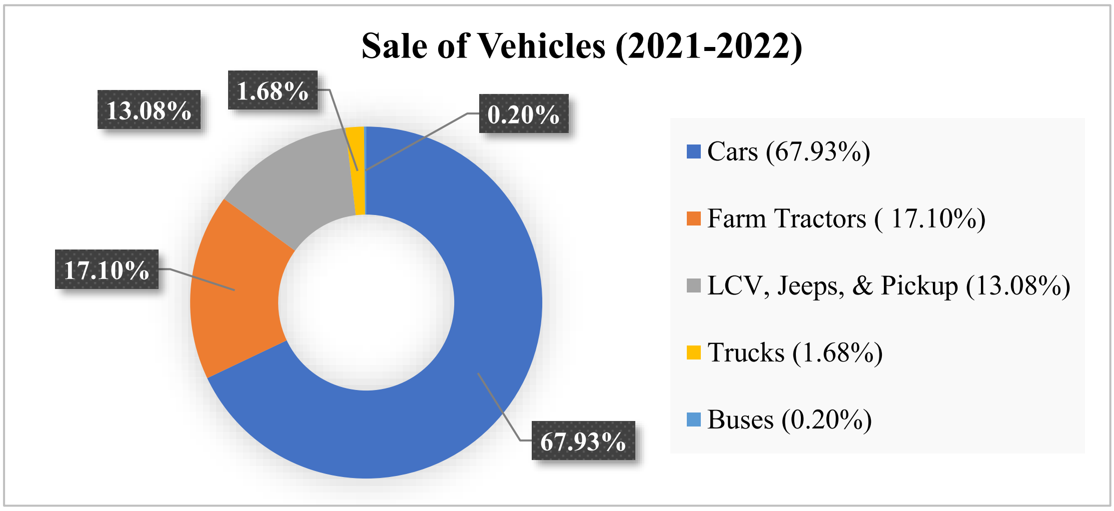


Note. Motorcycles and 3-wheelers (Qingqi) 1998-1999 sales data is not included.
Data source: Pakistan Automotive Manufacturer Association – PAMA (2022)

Figure 1.4 Sale of Vehicles (1998-1999)

In addition, the total number of vehicles sold, excluding motorcycles and 3-wheelers (Qingqi), in the fiscal year 1998–1999 was 75,148. However, cars accounted for the majority, comprising 55 percent of the total sales that year (PAMA, 2022), as shown in Figure 1.4.

However, over time, the portion of car sales increased. In the fiscal year 2021-2022, the total number of vehicles sold, excluding motorcycles and 3-wheelers (Qingqi), reached 344,712, increasing by approximately 358 percent.



Note. Motorcycles and 3-wheelers (Qingqi) 1998-1999 sales data is not included.
Data source: Pakistan Automotive Manufacturer Association – PAMA (2022)

Figure 1.5. Sale of Vehicles (2021-2022)

Car sales increased from 55 percent in the fiscal year 1998-1999 to approximately 68 percent in the fiscal year 2021-2022 (PAMA, 2022), as shown in Figure 1.5.

Based on the data presented, it is evident that there has been a steady growth in the sales of vehicles in the country over the years, with cars being the most popular choice among buyers. Furthermore, the number of cars sold in the fiscal year 2021-2022 is the highest of all-time cars sale in Pakistan (PAMA, 2022). Moreover, the growth of the transport sector has rapidly increased in Pakistan as the number of registered automobiles on the road has risen at a rate of 14 percent. However, with the increasing number of registered or sold vehicles, the demand for oil in the country also increased (Asim et al., 2022).

1.2.3. Impacts of Increased Vehicle Usage

Furthermore, the increased number of vehicles on the road burdened limited resources, caused environmental deterioration (Ayaz & Majeed, 2022; Haider et al., 2021), traffic congestion, health deterioration, high pollution, degraded air quality (Hadi, 2021; Javid, Abdullah, et al., 2022), increased consumption of hydrocarbons (Tanveer, 2022), and increased costs of mobility (Hadi, 2021). Moreover, with the rising number of private vehicles, there is a corresponding escalation in health concerns and adverse environmental impacts attributable to carbon emissions (Saif et al. 2019). However, shifting private vehicles to public transport has the potential to decrease oil consumption, mitigate public health concerns, enhance environmental sustainability, and yield economic benefits (Elias & Shiftan, 2012; Saif et al., 2019; Yatskiv et al., 2017).

1.2.4. Bus Rapid Transit (BRT)

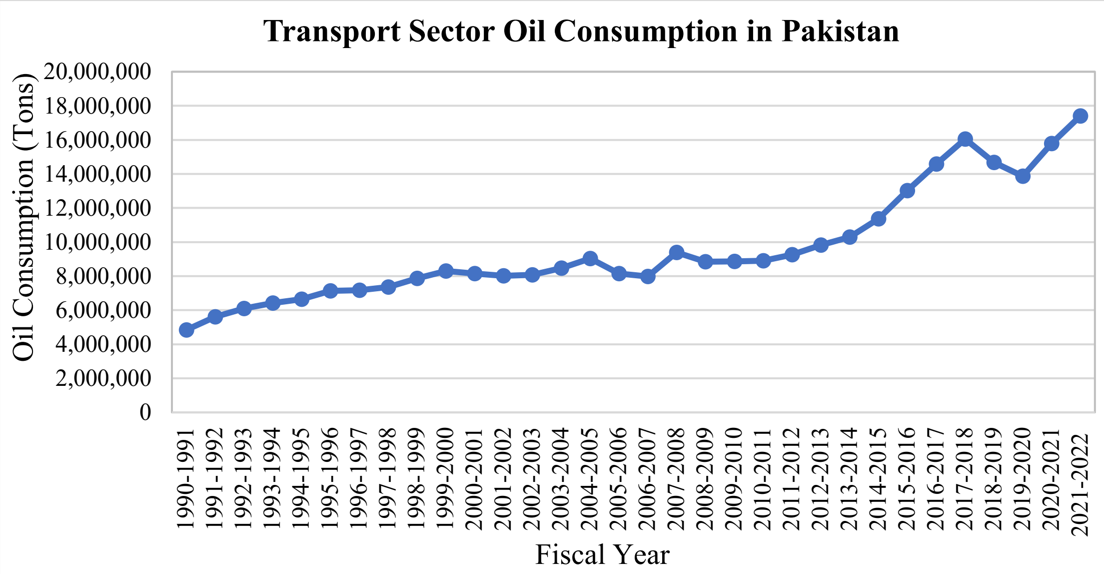
In 2014, Pakistan introduced the bus rapid transit (BRT) system as a solution to address public transport issues. The BRT system is seen as an effective way to tackle road transport-related problems (Haider et al., 2021). However, BRT is less likely to be chosen by people who opt to travel by car (Kepaptsoglou et al., 2020). Furthermore, people also have various issues related to BRT, including the spatial arrangement and positioning of BRT, the accessibility of the system throughout the city, the availability of parking at transit stations, the speed of metro buses, as well as barrier-free physical accessibility (Nadeem et al., 2021). In addition, as the Bus Rapid Transit (BRT) system has only been implemented in six to seven major cities in Pakistan, it is insufficient to cater to the transport needs of the entire nation. Moreover, such projects are prohibitively expensive for Pakistan's developing economy because they require separate infrastructure, involve high passenger and operational expenses, and necessitate daily subsidies.

1.2.5. Oil Consumption and CO2 Emissions

The rise in the number of vehicles on the road is increasing the energy demand and oil consumption within the transport sector (Lebrand & Theophile, 2022; Shahid et al., 2022; Tanveer et al., 2022). Unfortunately, this heightened consumption also results in significant carbon emissions (Asim et al., 2022). The transport sector accounts for 30 percent of Pakistan's total carbon dioxide emissions and this proportion is expected to increase annually due to the rising number of vehicles on the road and increased oil consumption (Asim et al., 2022a; GOP, 2019). For instance, in the year 2018, the transport sector's demand for oil was recorded at 14.63 million tons, which resulted in the release of 30.20 million tons of carbon emissions. However, projections estimate that the demand for oil in the transport sector will escalate to 71.63 million tons by 2030, consequently leading to the emission of an estimated 131.51 million tons of carbon (Abbas et al., 2023). Furthermore, the Oil Companies Advisory Council (OCAC), an independent organization in Pakistan that serves as a forum for projecting and establishing views of the Downstream Petroleum Industry, reported that Pakistan's transport sector is the largest consumer of hydrocarbons in the recent fiscal year (2021–2022). Approximately 17.40 million tons of fossil fuels are burned in the year, mainly due to the increase in economic activities and the transport sector (OCAC, 2022). However, carbon dioxide emissions from the transport sector are recorded 56 million tons in the year 2021(Knoema, 2021).

1.2.6. Historical Oil Consumption in the Transport Sector

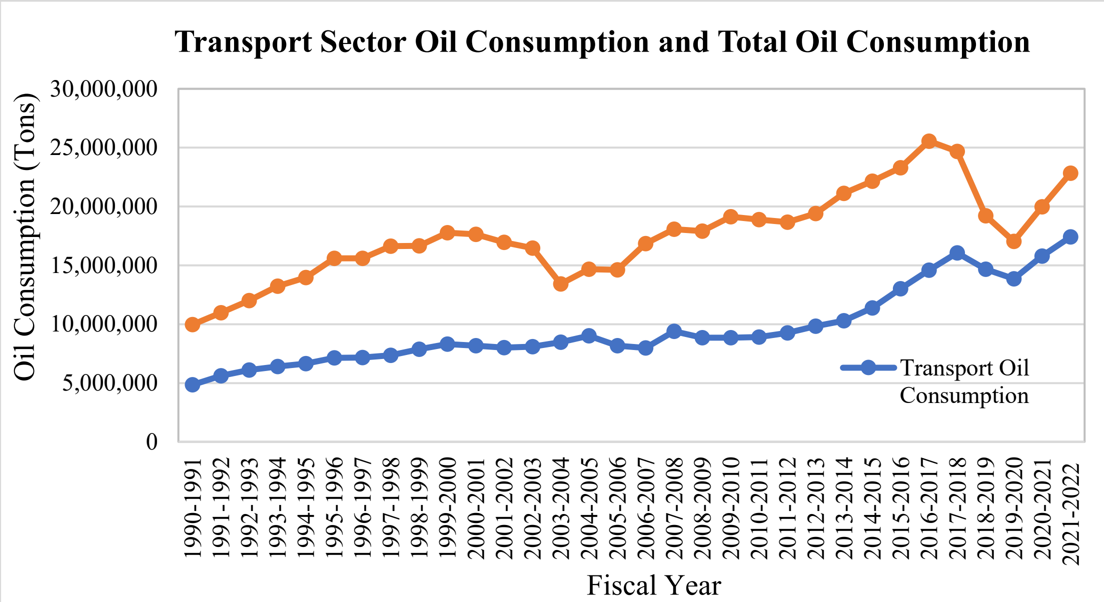
The transport sector plays a significant role in the consumption of oil and petroleum products in the country (Akram et al., 2021; GOP, 2022; Habib Khan, 2022).



Data Source: Economic Survey of Pakistan (2012-2013 and 2022-2023)

Figure 1.6 Transport Sector Oil Consumption in Pakistan

In the fiscal year 1990-1991, the transport sector of Pakistan consumed 4,841,362 tons of oil. The transport sector oil consumption increased and fluctuated over the years and reached 9,817,546 tons in the fiscal year 2012-2013. However, it continued to rise and recorded an all-time high oil consumption by the transport sector in the fiscal year 2017-2018, reaching 1,604,7392 tons of oil consumption. Following that peak, oil consumption in transport began to decline again in the fiscal year 2018-2019 due to international oil prices hike, as shown in Figure 1.6. However, its proportion in total oil consumption is increased in the same year. In addition, transport sector oil consumption increased again in the fiscal year 2020-2021, reaching 15,779,499 tons (GOP, 2013, 2022). Moreover, the latest data for 2022-2023 depicts that it further increased to 17,409,035 (GOP, 2023).



Note. Historical data on Pakistan's overall and transport sector's oil consumption is used.
Data Source: Economic Survey of Pakistan (2012-2013 and 2022-2023)

Figure 1.7. Transport Sector Oil Consumption and Total Oil Consumption

In addition, the data on the transport sectors' oil consumption and overall oil consumption shows that in recent years, the percentage of the transport sector's oil consumption rose significantly, and the space between the two became narrow, as shown in Figure 1.7. In the fiscal year 1990-1991, the transport sector consumed 49 percent of the total oil consumption in the country. Over time, the percentage of transport sector's oil consumption in total oil consumption fluctuated. The transport sector's oil consumption revolved around 44 percent to 51 percent of the total oil consumption in the fiscal years between 1992 to 2003. In the fiscal year 2003-2004, transport sector oil consumption reached 63 percent and revolved around 47 percent to 62 percent of the total oil consumption in the fiscal years between 2004 to 2017 (GOP, 2013, 2022). Although the difference between the transport sector's oil consumption and the country's overall oil consumption started to close in the fiscal year 2017-2018, the transport sector consumed 65 percent of the overall oil consumption in the country.

Moreover, in the fiscal years 2018 to 2022, the average oil consumption of the transport sector reached 78 percent of the total oil consumption (GOP, 2023)

1.2.7. Oil Import Bills of Pakistan

The rising demand for oil consumption in the transport sector not only increased carbon emissions but also increased the import bills of the country (Asim et al., 2022). Pakistan's domestic oil production falls short of meeting its daily consumption and demand, as it accounts for only a limited portion of the total oil consumption in the country. This limited domestic production is attributed to financial, technological, and technical constraints, which force the country to rely heavily on imports to meet its needs. Therefore, in order to meet a substantial portion of the country's total oil consumption, oil import is the need for the country (GOP, 2022). To fulfill the demand for oil in the country, Pakistan imports oil from different countries in the world, including Saudi Arabia, Kuwait, UAE, Oman, and South Korea on top of the list (OEC, 2020).

Table 1.2.1.1. Oil Imports of Pakistan

	Import bill (B$)			Import Quantity (MT)		
	FY'20	FY'21	Inc (%)	FY'20	FY'21	Inc (%)
Petroleum	3.87	8.55	121.15%	8.66	10.02	23.70%
Crude oil	2.41	4.22	75.34%	6.77	8.66	27.82%
Total oil	8.69	17.03	95.9%	17.63	19.92	12.69%

Note. (B$) stands for a billion US dollars. (MT) stands for million tons. FY'20 stands for the fiscal year 2020-2021. FY'21 stands for the fiscal year 2021-2022. Inc (%) stands for the percentage increase. Total oil consists of petroleum, crude oil, and other petroleum products.
Data Source: Economic Survey of Pakistan (2021-2022)

According to the Pakistan Economic Survey (2021-2022), the country's expenditure on oil imports surged by 95.9 percent and increased to 17.03 billion dollars in the fiscal year 2021-2022 compared to 8.69 billion dollars in the previous fiscal year 2020-2021. The increased oil import bills are attributed to both the rising prices of oil and the increased demand for oil in the country. Furthermore, if the petroleum imports of the fiscal year 2021-2022 compared with the previous fiscal year 2020-2021, they rose 121.15 percent in value and increased by 23.70 percent in quantity demanded. Similarly, crude oil imports increased by 75.34 percent in value and 27.82 percent in quantity demand, as shown in Table 1.1. and the Liquified Petroleum Gas increased by 39.86 percent in the same period (Energy, 2022; Tribune, 2022a).

The overall consumption of petroleum products in Pakistan surpassed 21 million tons, with 80 percent of these products being imported while the remaining 20 percent is domestically refined (Habib Khan, 2022). Given that oil and petroleum products represent the primary imported commodities of Pakistan, their import share constitutes a significant portion of the country's overall import bills (GOP, 2022). According to the information given by OEC (2020), in the year 2020, Pakistan ranked as the 35th largest importer of crude petroleum globally, with its total crude petroleum imports amounting to 1.92 billion US dollars. In the same year, crude petroleum ranked as the fourth most imported commodity in Pakistan. Furthermore, the top imports of Pakistan are refined petroleum (3.87 billion dollars), petroleum gas (2.24 billion dollars), palm oil (2.15 billion dollars), crude petroleum (1.92 billion dollars), and raw cotton (1.68 billion dollars), importing mostly from China (14.7 billion dollars), United Arab Emirates (5.34 billion dollars), United States (2.78 billion dollars), Indonesia (2.43 billion dollars), and Saudi Arabia (1.8 billion dollars). In addition, the transport sector used the major portion of imported oil in Pakistan (Sohail et al., 2021); therefore, it further inflated the high import bills. Moreover, the global economies are facing high energy prices due to the disruption of trade caused by Russia's invasion of Ukraine, leading to a significant increase in prices for energy-related products and impacting consumers and industries worldwide, particularly in emerging countries (Energy, 2022). Moreover, within the realm of the transport sector, the surge in private vehicles is also one of the major factors in the heightened demand for oil (Asim et al., 2022a). In order to attain both energy security and minimize the oil import bill, a substantial shift from private vehicles to public transport is imperative. This shift will result in a decrease in oil consumption and import bills (Habib Khan, 2022). In addition, Pakistan spends millions of dollars on the import of oil or petroleum products. This poses a regular burden on the developing economy of Pakistan. These millions of dollars can be saved by the declining demand for petroleum products in the country (Asim et al., 2022a).

The potential means of decreasing the demand for oil consumption is to curtail the number of vehicles on the road, a figure that has been rapidly increasing. A viable strategy to achieve this objective is encouraging the shifting from personal vehicles to public transport. In addition, reducing a country's reliance on imported oil can result in a reduction of its oil import bill. This, in turn, can enhance the country's resilience against unforeseen surges in the costs of these commodities (Huntington, 2015a).

1.3. Problem Statement

It is observed that due to the increased urbanization (Haider et al., 2021), rapid growth of the lower to middle-class income levels, absence of a respectable public transport, and people preference to private vehicles due to problems with public transport, the use of private vehicles has increased in the country (Imran, 2009; Kepaptsoglou et al., 2020; Rasool et al., 2019; Raza & Boqiang, 2021). Furthermore, car sales grew by 35% from 2010 to 2022, as 127,944 cars were sold in the fiscal year

2010-2011, and 234,180 cars were sold in the fiscal year 2021-2022 (PAMA, 2022). The growth in private vehicles has led to an increase in oil consumption (Tanveer, 2022) that further burdened the country's limited resources (Haider et al., 2021) and increased energy demand of the transport sector (Lebrand & Theophile, 2022; Shahid et al., 2022; Tanveer et al., 2022). Moreover, the country's transport sector oil consumption has indicated a double-digit growth (Shahid et al., 2022) due to the rise in the number of vehicles on the road, such as more than four million cars and more than 24 million motorbikes (Rasool et al., 2019; Habib Khan, 2022; Lin & Raza, 2022; PAMA, 2022). Consequently, the oil consumption in the transport sector has increased to more than 44%, as it was 8,892,268 tons in the fiscal year 2010-2011 and 17,409,035 tons in the fiscal year 2021-2022 (GOP, 2022).

Furthermore, the country's capacity for petroleum production and refining cannot keep up with this rising demand, which has led to an energy crisis. Therefore, the imports of petroleum products are used to fulfill the unmet demand (Ibrahim & Ikram, 2022; Shahid et al., 2021), and it has caused a surge in the oil import bills (Khan, 2022). Additionally, international oil price hikes and the severe depreciation of the Pakistani rupee are making oil more expensive, exerting strain upon the country's external sector, and worsening its trade imbalance (GOP, 2022) as the imports of petroleum products costing above 15 to 16 billion US dollars annually to the national exchequer, which worsens the country's economic situation (Shahid et al., 2021). Furthermore, the escalation in the number of vehicles and the consumption of oil in the country has resulted in an increase in carbon dioxide (CO2) emissions, which produce detrimental environmental effects and cause climate change (Khan & Majeed, 2023; Shahid et al., 2022; Sohail et al., 2021). The transport sector accounts for 35% of Pakistan's overall energy consumption while simultaneously responsible for 29% of the total carbon emissions. However, there will be a 52% rise in transport energy consumption by the year 2040 (Asim et al., 2022).

How to mitigate these negative effects is a big challenge for practitioners and academic scholars and this study focuses on this. It is, therefore, imperative to examine the change in oil consumption and CO_2 emissions of the transport sector by shifting private vehicles to public transport.

1.4. Research Questions

To investigate the impact of private vehicles shifting to public transport on oil consumption and CO_2 emissions, the following research questions are formulated for this research.

1. What is the impact of reducing the number of private vehicles by shifting them to public transport on oil consumption?
2. What is the effect of reducing the number of private vehicles by shifting them to public transport on carbon dioxide (CO_2) emissions?

1.5. Research Objectives

The primary objective of the study is to decrease oil consumption and CO_2 emissions in the transport sector by shifting private vehicles to the public transport system.

In order to investigate the impact of shifting private vehicles to public transport on oil consumption, and CO_2 emissions, the following research objectives are formulated for this study to examine the influence.

1. To evaluate the impact of reducing the number of private vehicles by shifting them to public transport on oil consumption.

2. To assess the effect of reducing the number of private vehicles by shifting them to public transport on carbon dioxide (CO_2) emissions.

1.6. Research Gap

Numerous studies examined oil consumption by the transport sector of Pakistan (Farooq and Ullah, 2011; Liddle and Lung, 2013; Nazir, 2015; Lin and Ahmad, 2016; Danish and Baloch, 2018; Danish et al., 2018; Rasool et al., 2019; Shah et al., 2019; Lin & Raza, 2020a; Lin and Raza, 2020b; Malik, 2020; Raza and Lin, 2020; Raza and Boqiang, 2021; Asim et al., 2022; Munir, 2022; Shahid et al., 2022; Abbas et al., 2023). Some of the studies examined oil demand by the transport sector. For instance, Shah et al. (2019) studied the demand and supply analysis of transport sector energy in Pakistan, Malik (2020) studied the fuel demand in the transport sector of Pakistan, and Abbas et al. (2023) analyzed the projection of Pakistan's transport sector demand for energy. However, the majority of the research centered on environmental quality and the reduction of oil consumption in the transport sector through alternative fuels and renewable resources (Lin and Ahmad, 2016; Danish and Baloch, 2018; Danish et al., 2018; Rasool et al., 2019; Lin and Raza, 2020a; Lin and Raza, 2020b; Raza and Lin, 2020; Asim et al., 2022; Shahid et al., 2022; Abbas et al., 2023). However, the reduction in the transport sector's oil consumption and CO_2 emissions through public transport has rarely been examined. Therefore, this study investigates the impact of public transport on oil consumption and CO_2 emissions in the transport sector of Pakistan.

Furthermore, the transport sector has experienced a surge in oil consumption due to the fast-growing number of private vehicles (Rasool et al., 2019). Previous studies highlighted the increasing use of private vehicles in Pakistan (Haider et al., 2018;

Lebrand and Theophile, 2022; Shakeel, 2022). However, most of the studies primarily focused on environmental deterioration and analyzed electric vehicle development Shakeel, 2022; Haider et al., 2018;Lebrand & Theophile, 2022). In addition, some of the studies related to the transport sector compared conventional vehicles and electric vehicles in Pakistan. Such as Ansari et al. (2021), Asim et al. (2022b), and Shahid et al. (2022). Further, previous studies focused on the behavioral intentions of commuters to shift to BRT in Pakistan (Majeed and Batool, 2016; Kepaptsoglou et al., 2020; Ahmed et al., 2022; Javid et al., 2022; Naqvi et al., 2022). However, to decrease the transport sector's oil consumption and CO2 emissions, little attention has been given to shifting private vehicles to public transport in Pakistan. In addition, the current study employs novel data collection techniques and research methodology that have rarely been used previously, particularly in the context of Pakistan. Consequently, this gap creates a significant vacuum for research that requires the attention of academic researchers to scrutinize the impact of the transport sector's shift from private vehicles to the public transport system on oil consumption and CO2 emissions.

1.7. Research Significance

The rapid increase in the use of private vehicles and growing oil consumption in the transport sector create enormous potential for new research in the transport sector to explore ways to decrease oil consumption and CO2 emissions. Therefore, the current study is a thoughtful academic attempt to reduce oil consumption and CO2 emissions in the transport sector. The present study is distinctive in the following ways.

First, this study may prove helpful in decreasing oil consumption, CO2 emission, road congestion, fuel cost, and travel kilometers in the transport sector by providing valuable guidelines for policymakers to get an advantage from the transport system.

Second, Pakistan is an oil-importing developing country (Ahmed et al., 2022), and it spends a significant amount of its budget on importing oil to meet its energy demand. The shift towards the public transport system may prove helpful to reduce Pakistan's reliance on imported oil and potentially save the country millions of dollars in foreign exchange. Moreover, the findings of the study are also valid for other oil-importing developing countries whose transport sector consumes the major portion of the overall oil consumption in the country. The present study may also prove helpful for these countries to solve the problem of high oil import bills.

Third, previous studies (Farooq & Ullah, 2011; Malik, 2020; Munir, 2022; Raza & Boqiang, 2021) examined the transport sector's oil consumption and future oil demand of Pakistan by using secondary data. However, no study investigated private vehicles' oil consumption by using primary data. Therefore, the current study is unique in data collection techniques as it collectss private vehicle flow data and it uses primary data on private vehicles' oil consumption. Furthermore, no study analyzed the change in oil consumption by shifting private vehicles to the public transport system. Therefore, the present study is distinctive as it explains the impact of private vehicles shifting to public transport on oil consumption.

Forth, the present study may also prove helpful in the transport sector to reduce congestion on roads, road accidents, road pollution, carbon emissions, and environmental deterioration and improve air quality that contributes towards a sustainable environment. Furthermore, the present study may prove helpful in introducing a proficient public transport system with minimal cost that may be beneficial in alleviating the strain on the country's limited resources.

Fifth, the study may prove helpful to the policymakers to decrease private vehicle use in the country by implementing the recommendations regarding an efficient and respectable public transport system.

Sixth, previous studies (Asim et al., 2022b; Javid, Abdullah, et al., 2022; Shakeel, 2022) focused on electric vehicles to decrease oil consumption in the transport sector. Similarly, other research studies (Adeel et al., 2016b; Ahmed, 2022; Haider et al., 2021; Nadeem et al., 2023) focused on bus rapid transit (BRT) to improve the public transport system. Nevertheless, these studies overlooked the economic and financial condition of Pakistan. However, the current study examines the efficient way to decrease oil consumption in the transport sector while considering Pakistan's economic and financial condition.

This research may prove helpful for the government to deal with the energy crisis and energy security threat, as Pakistan is dependent on other countries to fulfill its energy demand. Approximately half of Pakistan's gross income is used for imports of petroleum products, and for that reason, Pakistan has to be dependent on foreign aid. Moreover, Pakistan faces economic uncertainty, depreciation of the local currency, hikes in national oil prices, sovereign default, budget deficit, economic turmoil, and macroeconomic risk due to high import bills. Therefore, the current study may prove helpful for the government to deal with several issues that occur due to high import bills.

Hence, the current study will add to the body of knowledge and update the literature by providing detailed information regarding the change in transport sector oil consumption. Furthermore, the current study will update the literature by evaluating an efficient public transport system according to the developing economy of Pakistan.

1.8. Summary of the Chapter and Organization of the Study

This study includes 5 chapters in total. Chapter 1 discusses the brief background of oil consumption in the transport sector, its associated impacts, and the public transport system of Pakistan. Further, this chapter elaborates the problem statement, research questions, objectives, gap, and significance of the study. Chapter 2 dealswith with the existing literature regarding oil consthe umption in the transport sector and shifting private vehicles to public transport. Chapter 3 depicts the research methodology applied in this study. Chapter 4 explains data analysis and discussion to obtain the results of the study. Chapter 5 elaborates the conclusions of the overall findings, implications, and recommendations of the study.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

A step-by-step process to identify unpublished and published work related to the research topic from secondary data is known as a literature review (Sekaran & Bougie, 2017, p. 51). This chapter provides a detailed review of existing literature (published & unpublished documents, previous reports, research articles, thesis, etc.). The present section (section 2.1) illustrates the theme of the chapter and summarizes the structure of the remaining chapter. The interrelation between the energy and transport sector is demonstrated in section 2.2. The oil consumption in the transport sector is discussed in section 2.3. The relationship between transport sector oil consumption and carbon emissions in Pakistan is demonstrated in section 2.4. The relationship between transport sector oil consumption and oil import bills is elucidated in section 2.5. The growth of private vehicles in Pakistan is deliberated in section 2.6. The causes of private vehicle growth in Pakistan are explained in subsection (2.6.1). Each cause is explained in further subsections i.e. car financing schemes by banks are shown in section (2.6.1.1), rising incomes are demonstrated in section (2.6.1.2), convenience is deliberated in section (2.6.1.3), urbanization is discussed in section (2.6.1.4), and inefficient public transport system is elucidated in section (2.6.1.5). The harmful effects of private vehicle growth in Pakistan are shown in subsection (2.6.2). Each effect is explained in further subsections i.e. rise in oil demand demonstrated in section (2.6.2.1), traffic congestion is shown in section (2.6.2.2), health issues are discussed in section (2.6.2.3), air pollution is discussed in 2.6.2.4; environmental emissions are elucidated in section 2.6.2.5; and other issues are discussed in section

(2.6.2.6). Section 2.7 depicts the public transport system of Pakistan. Subsection (2.7.1) discusses the issues in the existing public transport system of Pakistan. Each issue is explained in further subsection i.e. accessibility issues are explained in subsection (2.7.1.1), safety concerns are shown in subsection (2.7.1.2), bad behavior of drivers is demonstrated in subsection (2.7.1.3), inefficient and non-regulated is shown in subsection (2.7.1.4), and informal public transport system is elucidated in section (2.7.1.5). Section 2.8 depicts the shifting of private vehicles to public transport. The transport modal shifting in Pakistan is explained in section 2.9. However, section 2.10 discusses the summary of the chapter.

2.2. Energy and Transport Sector

Numerous aspects of life depend on energy, such as transport, industries, households, agriculture, and many others (Rajput et al., 2022). However, it is unfortunate that every country globally has unequal energy reserves (Asif et al., 2022). Conventional (discover on earth) energy resources are not universally available. For instance, some countries have sufficient energy resources to fulfill their needs. In contrast, others have more energy resources than their energy demand, and still, some lack the necessary energy resources to meet their demand. Therefore, to meet their energy needs, they import energy resources from other nations (Shahid et al., 2022). Various nations worldwide possess distinct energy resources, exhibit varying energy demand levels, and demonstrate different levels of reliance on these resources (Asif et al., 2022). The transport sector ranks as the second most significant consumer of energy. It is responsible for 30% of the total global energy consumption, with 80% being explicitly utilized for road transport (Atabani et al., 2011). The energy needs of the transport sector are significantly fulfilled through the utilization of crude oil, which is made from fossil fuels that are discovered on the earth. It is refined to produce petroleum products like jet fuel, heating oil, diesel, gasoline, and hydrocarbon gas liquids (Naeem et al., 2021). The predominant energy source in the transport sector (97.6%) is derived from petroleum, primarily oil, with a minor contribution from liquified petroleum gas (Atabani et al., 2011). The transport sector consumes a considerable quantity of fossil fuel energy, which is constantly rising (Mindali et al., 2004), and it causes a notable increase in pollution levels (Jain & Tiwari, 2016). Since the year 1990, the transport sector has played a substantial role in the emission of greenhouse gases (GHGs) and has caused a rise in import expenditures for national economies. This can be attributed to its extensive reliance on liquid thermal fuels (Fernández-Dacosta et al., 2019). In 2003, transport sectors' energy consumption stood at 27% of the required amount, with projections indicating an anticipated increase of 80% by 2030 and a further increase exceeding 80% by 2050 (Mindali et al., 2004). Furthermore, the worldwide need for energy is witnessing a substantial increase due to the accelerated growth of the population (Asif et al., 2022).

Pakistan is classified as a developing nation (Khan et al., 2019), with a population of 232,048,130 people (Worldometer, 2023), and does not have enough indigenous oil resources in the country. Therefore, Pakistan imports crude oil from other countries (GOP, 2019). About 80% of Pakistan's primary energy is significantly dependent on fossil fuels, with 76% coming from imported crude oil as the country's need rises yearly. The reason behind this increasing demand is the expansion in population, transport, urbanization, industrialization, and economic growth (Raza & Boqiang, 2021). After industry, transport is Pakistan's second-largest energy consumer (Malik, 2020; Sohail et al., 2021). As Pakistan's transport sector consumes a substantial amount of fossil fuel energy, it has resulted in many issues, such as noise pollution, air pollution, CO2 emissions, and environmental degradation (Lin

& Raza, 2020b). A significant portion of energy requirements in Pakistan are met through the utilization of oil and gas resources. However, Pakistan meets only 15 percent of its national oil requirement, with approximately 22 million tons of crude oil production. The remaining 85 percent of oil demand is accomplished through imports (Asif et al., 2022).

2.3. Transport Sector Oil Consumption in Pakistan

Oil is utilized in three major energy consumption sectors: transport, industry, and power (GOP, 2019). Across all three sectors, the transport sector accounted for a significant proportion of oil consumption, averaging approximately 79 percent of the total oil consumed within the country (GOP, 2022). Transport is a significant economic sector in Pakistan, and it is almost entirely reliant on the use of oil (Malik, 2018). Within the realm of the transport sector, oil consumption and road transport play a substantial role (Raza, 2023). The data pertaining to transport reveals a consistent upward trend in the utilization of petroleum-based products within this sector (CEIC, 2017). Globally, road transport accounts for up to 80 percent of the energy consumed in the transport sector. In addition, it is the largest consumer of oil and one of the fastest-growing sectors in terms of energy consumption (Worldbank, n.d.). Similarly, in Pakistan, road transport is a significant energy consumer (Malik, 2018). Approximately 48% of the overall consumption of petroleum products is attributed to the road transport sector, making it the largest consumer in the country (Ahmad & Kumar Jha, 2008).

There is a wide array of literature on oil consumption within Pakistan's transport sector, which has emerged as a significant area of interest for researchers aiming to comprehensively examine the transport sector's oil consumption in several dimensions.

2.4. Transport Sector Oil Consumption and CO2 Emissions

According to World Air Quality Report (2022), Pakistan has been ranked as the third-worst country in the world regarding Green House Gas (GHG) emissions. This ranking is primarily due to the excessive levels of GHG emissions produced in the country (Ansari et al., 2021). In April 2020, the world witnessed a 17% reduction in daily global CO2 emissions compared to 2019 statistics. Nearly half of this reduction was attributed to the changes in road transport resulting from lockdowns (Quéré et al., 2020). However, these reductions were temporary since lockdowns in most parts of the world were lifted. This emphasizes the significant role of the transport sector in the global climate crisis (Ansari et al., 2021).

According to the findings of the International Energy Agency (IEA), the emissions stemming from oil experienced a more significant increase and exhibited a rise of 2.5% or 268 MT which resulted i(IEA, 2023). The transport sector is a significant consumer of energy i.e. oil, and causes a notable increase in pollution levels (Jain & Tiwari, 2016). The transport sector plays a significant role in Co2 emissions on a global scale (Sohail et al., 2021). It accounted for a significant portion, precisely 25%, of global energy consumption, which amounted to approximately 23% of total carbon emissions on a global scale (Mohsin et al., 2019). A 1 percent rise in per capita energy consumption results in a corresponding 1.65 percent increase in per capita CO2 emissions (Nasir & Rehman, 2011). Global carbon emissions have experienced a notable increase, rising from 15 billion tons in 1973 to 32 billion tons by the end of 2015. Furthermore, an examination of the data reveals that the transport sector ranks second in terms of carbon emissions on a global scale (Shafique et al., 2021). In 2012, the transport sector accounted for approximately 19% of global energy consumption and 23% of energy-related carbon dioxide emissions (IEA, 2023). In 2014, the transport sector globally consumed 64.5% of the worldwide oil consumption and 39.9% of the final energy consumption (World Key Energy Statistics, 2016). However, in the year 2022, worldwide carbon dioxide emissions stemming from the transport sector experienced an increase of 254 metric tons. Further, the total emissions resulting from transport experienced a 2.1% rise, equivalent to 137 metric tons in the year 2022 (IEA, 2023). Furthermore, as per the International Energy Agency (IEA), there is a projected increase of approximately 50% in energy consumption and carbon dioxide emissions from global transport by the year 2030. Furthermore, these figures are anticipated to rise by more than 80% by the year 2050 (IEA, 2009).

The transport sector in Pakistan ranks as the second-largest consumer of energy. Moreover, it is responsible for a significant proportion of the country's oil consumption, amounting to 85%. The transport sector's significant reliance on petroleum products renders it the second most prominent source of carbon dioxide emissions within Pakistan's comprehensive emissions profile (Butt & Singh, 2023). According to the Pakistan Bureau of Statistics Report, transport is essential for a nation's economic growth. The importance of railway tracks, roads, and highways to economic development cannot be overstated (Ilyas, 2010; Munir, 2022). However, transport within cities and main urban centers poses a significant environmental threat (Ilyas, 2010; Khan & Majeed, 2023). Further, Khan & Majeed (2023) stated that the role of urbanization in Pakistan is paramount in facilitating economic development. Nevertheless, it simultaneously harms the environment by amplifying energy consumption in both residential and transport sectors. In recent years, the level of air pollution caused by transport in major urban areas such as Karachi, Lahore, Faisalabad, Peshawar, Quetta, and Rawalpindi have increased significantly. Hydrocarbons, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen oxides emitted by vehicles are hazardous to human health. These pollutants have been linked to bronchitis, irritation, asthma attacks, and eye irritation. These emissions disproportionately impact urban areas, as they are predominantly produced by vehicles (Ilyas, 2010).

In Pakistan, substantial oil consumption within the transport sector is the primary cause of escalating levels of carbon emissions and subsequent environmental degradation (Rasool et al., 2019). The transport sector accounts for 35% of Pakistan's overall energy consumption while simultaneously responsible for 29% of the total carbon emissions. However, there will be a 52% rise in transport energy consumption by the year 2040 (Mohsin et al., 2019). The exponential growth in the utilization of privately owned vehicles within the country has led to a corresponding escalation in the consumption of oil, thereby exacerbating the emission of carbon compounds into the atmosphere (Shahid et al., 2022). Numerous studies have investigated the effects of oil consumption in the transport sector on environmental and carbon emissions in Pakistan. Such as,

Lin & Ahmad (2016) analyzed the oil consumption and carbon emissions in relation to substitution elasticities of input and output factors within the transport sector from 1980 to 2013 in Pakistan. The findings indicated that increased investment in the transport sector could facilitate the adoption of energy-efficient technologies, leading to the substitution of capital for energy and subsequent reduction in carbon emissions. The study further stated that consistent capital improvement could facilitate the substitution between energy and labor, thereby enabling the shift of Pakistan's transport sector from a labor-intensive to a capital-intensive system.

Danish et al., (2018) studied the relationship between the transport sector oil consumption with carbon emissions and economic growth account for foreign direct investment and urbanization. The study was conducted in Pakistan by using time series data spanning from 1990 to 2015. The study applied autoregressive distributive lag (ARDL) and vector error correction model (VECM) Granger causality for statistical analysis. The findings of the study stated that oil consumption in the transport sector has a noteworthy and influential effect on CO2 emissions. This impact can be mitigated by adopting energy-efficient and sustainable transport systems, such as public transport and hybrid buses. The study strongly suggested public transport to mitigate carbon emissions.

Haider et al. (2018) conducted an analysis to assess the influence of sustainable transport on environmental emissions in Lahore, Pakistan. This analysis involved the calculation of emissions factors for seven distinct vehicles. The study used traffic flow data from five distinct locations in Lahore. The research employed the OSPM software to estimate the emissions of NOx, CO, and benzene. The findings of the study provided support for the proposition that reducing car usage can effectively mitigate emissions. According to the results of the study, a reduction of 10 percent in the number of cars was associated with a decrease of 7 percent in NOx emissions, 33 percent in CO emissions, and 25.8 percent in benzene emissions, specifically within the city of Lahore.

Rasool et al. (2019) examined the various driving factors contributing to the production of carbon dioxide emissions within the transport sector of Pakistan. The research employed the ARDL model to investigate various factors' effects on transport sector carbon emissions. Data spanning from 1971 to 2014 was utilized for this study. The findings from the long-term analysis suggested that the escalation of “oil prices” and “economic growth” have a mitigating effect on carbon dioxide emissions in the transport sector. Conversely, the intensification of “energy consumption”, “population density", and expansion of "road infrastructure" lead to an increase in emissions, with the population being the primary contributing factor. The study suggested designating funds for sustainable energy initiatives and implementing eco-friendly transport systems, such as electric buses, light rail, and rapid transit. In addition, the study recommended implementing environmental levies in the form of subsidies on vehicles that utilize nonrenewable energy sources.

Khan et al. (2020) conducted a study to examine the correlation between energy consumption, economic growth, and Carbon dioxide emissions in Pakistan. The research employed annual time series data spanning from 1965 to 2015. The findings derived from the autoregressive distributed lag model suggested that there exists a positive relationship between energy consumption, economic growth, and carbon dioxide emissions in Pakistan both in the long term and short term. According to the projected findings, the study advised policymakers in Pakistan to endorse and encourage the utilization of renewable energy sources. The study further mentioned that shifting to renewable energy sources will help to decrease carbon dioxide emissions in the transport sector and foster environmentally friendly economic growth.

Lin & Raza (2020a) investigated energy security and explored potential reduction scenarios to decrease oil consumption in the transport sector of Pakistan by using the MARKAL model. The study assessed the BAU scenario along with three other energy import reduction scenarios from 2012 to 2040. The findings stated that the transport and other sectors are expected to exhibit peak fuel consumption, leading to a projected increase of 407.49 Mt in carbon emissions by 2040. However, this trend could be mitigated through the utilization of renewable energy resources.

Lin & Raza (2020b) investigated the effect of energy substitution on the transport sector of Pakistan. The research assessed the extent of energy preservation and mitigation of carbon dioxide emissions across multiple scenarios from 2015 to 2018. The investigation analyzed the elasticity of substitution pertaining to both input and output factors spanning from 1991 to 2018. The findings of the study stated that augmenting capital and energy technologies can lead to maximum productivity. Moreover, implementing energy-efficient technologies, significant capital investment in the transport sector, substitution of capital for labor, and energy-capital substitution can significantly enhance environmental conservation efforts.

Raza & Lin (2020) examined the CO2 emissions from the transport sector in Pakistan over the period spanning from 1984 to 2018. The investigation employed the LDMI methodology to identify the influential factors. The influencing factors include the carbon coefficient, fuel consumption, total energy consumption, and turnover economy, which govern the emissions of CO2. The factors that exert an influence are utilized to formulate a theoretical strategy for mitigation. The results indicated that the carbon coefficient has a negative impact on carbon emissions, whereas the economic growth effect has a positive impact on carbon emissions. The study proposed several policy recommendations to effectively promote decoupling between transport-related carbon dioxide emissions and economic growth in Pakistan.

Asim et al. (2022) conducted an in-depth examination of energy consumption and associated carbon emissions in the road transport sector of Pakistan. The investigation utilized data on oil consumption and carbon emissions within the transport sector for the 2017-2018 period as a reference point and subsequently projected forthcoming energy requirements and emissions. The research employed the LEAP framework to generate six distinct scenarios to forecast energy and emissions trends until the year 2035. According to the study's results, the National Electric Vehicle Policy exhibits the most minor energy requirements and associated emissions. It can curtail energy consumption and related emissions by 50% within the transport sector in a relatively brief timeframe. In conclusion, the study recommends implementing Electric Vehicle policies to reduce energy consumption and carbon emissions in the transport sector through technological and policy-based measures.

Shahid et al. (2022) examined the energy demand and sustainable transport in Pakistan. The study employed the LEAP framework to forecast energy consumption and carbon emission from the transport sector by employing different energy scenarios. The findings of the study state that there is a significant and rapid increase in energy demand within the transport sector of Pakistan. Further, this increase is threefold more significant than population growth. The rise in transport demand is primarily due to the growing prevalence of privately owned vehicles such as bicycles and cars. The research proposed a transition from oil-based economies to alternative energy resources. Further, the study recommended that governments implement regulatory and taxation measures to encourage the adoption of clean technologies in the transport sector.

Abbas et al. (2023) forecasted the oil demand and the corresponding carbon emissions within the transport sector of Pakistan. The research utilized data on oil consumption in the transport sector from 2010 to 2018 and subsequently projected these trends until the year 2030. According to the study's findings, there is projected to be an average annual growth rate of 12.68% in oil demand within the transport sector, with cars specifically expected to experience a growth rate of 11.45%. Further, the results revealed that population growth is the primary driver of the escalating demand for oil, which in turn increases carbon emissions. However, technological advances can potentially reduce the demand for fuels and the resulting carbon emission. The study recommends that Pakistan transition from oil-based energy sources to renewable energy sources and promote the use of hybrid vehicles. This transition is intended to reduce both oil consumption and carbon emissions, as the rising number of vehicles on the road contributes to the transport sector's overall demand for oil. Moreover, adopting a policy that simultaneously encourages economic growth while discouraging population growth, specifically through strategies aimed at reducing the birth rate, can be viewed as a viable strategy for addressing oil consumption and the resulting emission of carbon dioxide.

2.5. Transport Sector Oil Consumption and Oil Import Bills

The rising oil consumption in the transport sector has increased the oil import bills and Worsen balance of payment in the country (Shahid et al., 2022). There is a significant disparity between crude oil production and consumption in Pakistan, as it only produces 15% of its crude oil domestically (Saqib et al., 2021). Oil imports have become an essential need of the country due to insufficient production and increasing consumption (GOP, 2022). Pakistan, therefore, imports oil from other countries to meet its oil needs (Raza & Boqiang, 2021). Further, Akram et al. (2021) stated that Pakistan's domestic oil output only provides around one-fifth of the nation's current oil requirements; the remainder is supplied by expensive imports. The primary driver of the demand for imported oil is predominantly attributed to the transport sector, which is projected to persist as the foremost consumer of this commodity (Malik, 2020; Raza & Boqiang; Asim et al., 2022). Habib Khan (2022) stated that more than 21 million tons of petroleum products are consumed annually, with 80% of those goods coming from imports and the remaining 20% being domestically processed in Pakistan. According to the Oil Companies Advisory Council, the demand for petroleum products will be doubled in 2030 compared to 2019 (OCAC, 2021). As a result, Pakistan will have to shell out a significant amount of money to meet its local requirements for petroleum products (Akram et al., 2021). The reliance on imported fuels is projected to increase even more due to the imminence of no new oil and gas recoveries and the depletion of domestic gas resources (Malik, 2020). According to the forecasted oil dependency for 2019-2035, it has been estimated that Pakistan's reliance on imported crude oil will experience an annual increase of 0.07%. It is further projected that in 2035, the country's dependency on imported oil will reach 76% (Raza & Boqiang, 2021), and the adverse effect of this dependency is that the importation of crude oil poses a financial burden on national funds (Asif et al., 2022).

Previous studies such as Farooq et al. (2020), Malik (2020), Akram et al. (2021), Asim et al., (2022), Raza & Boqiang (2021), and Unar et al., (2022) mentioned that the transport sector has a noteworthy effect on the escalation of oil import bills of Pakistan. The importation of oil and petroleum products holds considerable importance in Pakistan, as they constitute the primary imported commodities and account for the country's overall import bills. As a result, it has also contributed to a current account deficit. (GOP, 2022). Huntington (2015) stated that a rise of 10% in oil imports results in a corresponding increase of 1.4% in current account deficits. Pakistan's current account has experienced a deficit due to escalating prices and the heightened demand for imports of oil and petroleum commodities (GOP, 2022). However, the growth in personal travel due to the rising income level of middle- and high-income groups has also denoted the widening of the current account gap (Gulzar, 2008). Moreover, Asim et al. (2022) stated that within the transport sector, the surge in private vehicles is a causative factor to the heightened demand for oil.

2.6. Private Vehicles in Pakistan

Asim et al. (2022) stated that the transport sector in Pakistan has experienced significant growth, with a rapid increase in registered vehicles on the road, exhibiting a growth rate of 14 percent. The escalating rate of private ownership and its utilization is rising at a startling pace (Batool et al., 2012), and the demand for private vehicles continues to increase due to the expansion of the growing middle class in the country (Javid et al., 2017; Rasool et al., 2019). Based on the data of the Pakistan Automotive Manufacturing Association, there has been a consistent upward trajectory in the sales of vehicles in the country over the last few years, with a notable preference for cars among consumers. The number of cars sold during the fiscal year 2021-2022 in Pakistan and has reached an unprecedented peak, surpassing all previous records for car sales (PAMA, 2022).

2.6.1. Causes of Private Vehicle Growth in Pakistan

According to the literature, many factors contribute to the surge and prevalence of private vehicle ownership. These factors include:

2.6.1.1. Car Financing Schemes by Banks

The unprecedented growth of private vehicles in Pakistan started in the early 2000s due to low-interest vehicle leasing schemes and lenient car financing schemes introduced by Pakistani banks, which lacked stringent oversight mechanisms. This was the main reason behind the swift surge in private vehicle ownership and the key driver behind the compromised safety of roadway traffic operations (Batool et al., 2012).

2.6.1.2. Rising Incomes

People opt for private modes of transport, such as personal vehicles, to fulfill their commuting needs, especially when such options are within their financial means (Javid et al., 2014). The escalation of personal incomes in urban regions of Pakistan has resulted in a surge in private vehicles (Imran, 2009). This trend is particularly prominent among individuals with middle to higher levels of income residing in major cities, who prefer private vehicles due to the inadequate provision of public transport services

(Imran, 2009; Javid et al., 2017). Rasool et al. (2019) further asserted that the escalating middle class within the country has consistently augmented the desire for privately-owned vehicles.

2.6.1.3. Convenience

People perceive the convenience, adaptability, and personal autonomy provided by private cars to be of considerable significance; therefore, they prefer to use private vehicles (Beirão & Sarsfield Cabral, 2007; Vredin Johansson et al., 2006; Kaffashi et al., 2016). This preference can be attributed primarily to the substandard quality, inadequate service, and low level of comfort provided by the public transport system (Imran, 2009).

2.6.1.4. Urbanization

One of the other main reasons for the increasing usage of private vehicles originated from urbanization, wherein cities have experienced growth and expansion (Imran, 2009). The utilization of private transport has experienced a global surge attributable to urban expansion (Danish et al., 2018). The increased distances between destinations have posed challenges for urban people who wish to utilize non-motorized means of transport, such as walking and cycling. As a result, many individuals transitioned to motorized forms of transport. During that period, there was a notable lack of emphasis on improving the standard of public transport to meet the demand for motorized transport in the country. As a result, people with higher incomes residing in larger cities increasingly favored private modes of transport, namely cars, and motorcycles, as opposed to public transport (Imran, 2009). In addition, Shah et al. (2021) stated that in the last few years, the spatial distribution of population and income has transformed because of urbanization, which has contributed to the expansion of heavily reliant on private vehicles (Shah et al., 2021).

2.6.1.5. Inefficient Public Transport System

In addition, the drawbacks in the public transport system of Pakistan are also one of the main reasons behind the increasing choice of private vehicles in the country. Those drawbacks include non-regulated public transport fares, accessibility issues, poor behavior of drivers, congested seating, poor service, and unsafe for women, as well as difficulties for people with disabilities to access transport (Adeel et al., 2016b). Public vehicle drivers frequently engage in the practice of disembarking and collecting passengers from the center of the roadway while also displaying a tendency to decline to fulfill their designated routes. As a result of these various factors, people exhibit disfavor towards utilizing public transport and prefer to shift towards private vehicles (Imran, 2009; Batool et al., 2012). In addition, public transport in Pakistan remains inefficient and poorly developed, leading to a further growing demand for private vehicles (Mehdi, et al., 2019; Rasool et al., 2019).

Due to the above-mentioned issues, the number of private vehicles in Pakistan proliferated, as during the fiscal year 1998-1999, a total of 41,337 privately-owned vehicles, specifically cars, were sold. Afterward, there has been a significant and continuous increase in privately owned vehicle sales. This trend reached its highest point during the fiscal year 2021-2022, with a total sales figure of 234,180 units (PAMA, 2022).

2.6.2. Harmful Effects of Private Vehicle Growth in Pakistan

The growing number of private vehicles is associated with various adverse effects (Ruslan et al., 2020). Such as,

2.6.2.1. Oil Demand

The increasing number of registered or sold vehicles is accompanied by a corresponding surge in domestic oil demand (Asim et al., 2022). In addition, Lebrand & Theophile (2022), Shahid et al., (2022), and Tanveer et al. (2022) also provided evidence of the heightened impact of increasing private vehicles on oil demand and consumption in the country.

2.6.2.2. Traffic Congestion

The increase in privately-owned vehicles has resulted in extended wait times, amplified travel durations, and intensified traffic congestion (Ullah et al., 2019). Aftab et al. (2019) and Hadi (2021) stated that the escalating utilization of private vehicles has resulted in traffic congestion. The increase in traffic congestion has a negative effect on the ability of vehicles to move, leading to decreased speeds and restricted vehicle mobility (Ruslan et al., 2020).

2.6.2.3. Health Issues

The increased number of vehicles on the road has caused health deterioration in the country (Hadi, 2021). Moreover, with the rising prevalence of personal transport, there is a corresponding escalation in health concerns and adverse environmental impacts attributable to carbon emissions (Saif et al. 2019). People experience negative health consequences because of heightened air pollution stemming from private vehicles. The inhalation of pollutants released by vehicles, including particulate matter and nitrogen oxides, can result in respiratory complications, cardiovascular ailments, and other health-related concerns (Ullah et al., 2019).

2.6.2.4. Air Pollution

The rise in the number of private vehicles in urban areas of Pakistan has led to a considerable increase in air pollution within the cities. The primary culprit behind this pollution is the emissions released by motor vehicles (Ilyas, 2010). Further, Aftab et al. (2019) and Khan & Majeed (2023) mentioned in their studies that the escalating utilization of private vehicles has resulted in air pollution from releasing carbon emissions.

2.6.2.5. Environmental Emissions

The escalating quantity of privately-owned vehicles is accountable for a substantial portion of oil consumption, resulting in a surge in carbon emissions and subsequent degradation of the environment because of heightened greenhouse gas emissions (Ilyas, 2010; Shahid et al., 2022). Hadi (2021), Javid et al. (2022), and Abdullah et al. (2022) mentioned that the increasing number of private vehicles in the country has resulted in a deterioration of the country's environmental conditions, high pollution, and degraded environmental quality.

2.6.2.6. Other Issues

The growth of private vehicles has been linked to a substantial surge in demand for travel, thereby requiring the enlargement of road networks and the provision of supplemental capacity (Ruslan et al., 2020), heightened intercity mobility (Danish et al., 2018), increased noise pollution (Alsaidi et al., 2020), burdened limited resources (Ayaz & Majeed, 2022; Haider et al., 2021), increased mobility costs (Hadi, 2021), increased vehicular accidents, restricted parking options, and reduced productivity (Ruslan et al., 2020).

2.7. Public Transport System of Pakistan

The public transport system in Pakistan underwent deregulation in the early 1980s, leading to private operators taking charge of urban transport services. The government's role is limited to fare regulation and route authorization. To maximize profits, these operators prefer using transport vehicles that are low-cost and small. Unfortunately, due to a lack of institutional capacity to effectively supervise individual transport operators, transport authorities consistently fail to oversee the quality and efficiency of the public transport system (Imran, 2009; Adeel et al., 2016b). The predominant public transport mode in Pakistan relies on bus or wagon (minibus) transport, which offers a significantly substandard level of service and comfort (Imran, 2009). The buses frequently experience overcrowding issues, inadequate maintenance, and a deficiency in fundamental safety provisions (Imran, 2009). Therefore, intra-city travel in Pakistan is not predominantly reliant on buses, as a significant proportion of the population opts for two-wheelers and private vehicles due to the limited availability of buses and their inadequate capacity (Basit Sheikh, 2022; Tribune, 2022b). In addition, Pakistan lacks a well-established public transport system, that led to a rise in reliance on personal vehicles and motorcycles (Ahmed, et al., 2019a; Ahmed, et al., 2019b).

Numerous scholarly investigations have examined the public transport system in Pakistan from various perspectives, shedding light on the current system's deficiencies and emphasizing the advantages of adopting a public transport system over private vehicle. For instance,

Shabbir & Ahmad (2010) projected the energy demand and carbon emissions of the transport sector in Rawalpindi and Islamabad up to the year 2030. The research utilized historical data to project forthcoming trends in vehicle ownership, energy consumption, and carbon emissions associated with vehicle ownership. The research employed the Leap model and generated four distinct scenarios, with the year 2000 serving as the base. This study included four scenarios, one of which was the Business as Usual (BAU) scenario that assumed the continuation of current trends. The remaining three alternative scenarios were the Population Reduction, Public Transport, and Natural Gas Vehicle scenarios. The findings of the study revealed that out of all the scenarios examined, Public Transport Scenario demonstrated superior performance. The utilization of public transport is a crucial element in promoting environmental sustainability. The reason for this phenomenon is that a decrease in vehicle usage leads to a reduction in energy consumption and a decrease in the emission of air pollutants and greenhouse gases. The study recommended that the government should implement various measures to regulate the registration of privately owned vehicles.

Adeel et al. (2014) conducted a thorough research study centered on gender-related travel behavior in private and public transport, specifically investigating the disparities in travel behavior between males and females in urban and rural Pakistan. The study utilized the Time Use Survey 2007 dataset to investigate the gendered allocation of time toward paid and unpaid work activities. The study employed longitudinal analysis techniques on preprocessed time using a survey dataset to examine gender disparities in travel patterns. The findings of the study indicated significant gender disparities in travel proportion, travel type, time frame, and reason for travel. The results stated that 55.17 percent of women, compared to 4% of men, did not travel during the day; therefore, women are more immobile than men. Further, Women make 2.8 fewer daily journeys than men (5.4), with leisure and social trips being the most significant difference. However, 13% of women drive against 10% of men, which means women are more car-dependent than males. The findings further stated that a country's sociological, economic, and architectural contexts influence women's travel. The study recommended that the country establish gender-sensitive transport and land use regulations since it discovered that women are more likely to face immobility or reduced travel on public transport owing to safety, security, and transport quality issues.

Adeel et al. (2016a) conducted a comprehensive analysis of the challenges and drawbacks associated with public transport in the daily events and engagement of individuals in urban areas of Pakistan. Four case study communities in the twin cities of Rawalpindi and Islamabad were surveyed via a questionnaire to collect primary data for this study. Each of these communities has experienced a decline in their access to public transport. The findings indicated that there is gender-based segregation in the participation rates of out-of-home activities. The likelihood of men engaging in travel was higher across a wide range of activities. Furthermore, there was a higher propensity among individuals to engage in daily activities by means of walking or utilizing public transport. Conversely, women exhibited lower levels of participation in activities conducted outside of their homes. They exhibited a higher propensity to utilize private vehicles. Quantitative investigations demonstrated that transport considerations, such as trip costs and public transit quality, had a big impact on people's activities. Motorized activities, especially public transport, often decrease. In the research area, women were disadvantaged by limited economic resources and increased dependency on personal transport.

Adeel et al. (2016b) conducted a comprehensive examination of the limitations pertaining to formal and informal urban public transport in the twin cities of Islamabad and Rawalpindi. The paper examined three overarching limitations on urban transport modes, specifically regulatory, spatial, and demand-related constraints, by analyzing several significant system characteristics. The findings of the study indicated that the Bus Rapid Transit (BRT) system experienced a consistently 'Very High' level of constraints. In comparison, the informal paratransit mode known as 'Qinqui' faced constraints classified as 'High.' In contrast, the Suzuki and Wagon provided extensive coverage while imposing fewer constraints. The study posited that achieving inclusive urban mobility in this context is predominantly contingent upon proactive measures taken by governing entities to mitigate these limitations. It is imperative for governing bodies to undertake initiatives that integrate various modes of transport, enhance service quality and vehicle conditions, and facilitate mobility for women and non-motorized travelers.

Aftab et al. (2019) examined the impacts of limited accessibility to public transport on the urban populace. The study conducted a comprehensive analysis of the environmental effects associated with urban transport designs, as well as the corresponding escalation in traffic congestion. The research employed Landsat images to facilitate the identification of the existing public transport routes. Moreover, the evaluation of travel distances and durations was performed by utilizing a dynamic and realistic approach. The research was conducted in Hyderabad, Pakistan, and data was gathered from residential households. The frequency analysis in this study was carried out through the SPSS software. According to the findings of the study, the existing public transport system is deemed inadequate and lacks convenient accessibility. Most of the people, specifically 57 percent, opt to employ private vehicles as their primary mode of transport for their journeys, thereby causing the issue of traffic congestion and the subsequent environmental concern of air pollution. Moreover, it was found that a significant majority of 87 percent of people expressed dissatisfaction with the current public transport system within the designated study region.

Al-Rashid et al. (2020) conducted a study to investigate the influence of specific psychosocial obstacles related to public transport on the social exclusion experienced by older adults. The study was cross-sectional and carried out in Lahore, Pakistan, using the self-reported psychosocial barriers dataset of 243 senior volunteers aged 60-89. The results of the study revealed that older people's intention to use public transport is positively affected by four variables: perceived injunctive norms, attitudes, self-efficacy, and perceived behavior control. This caused social exclusion. Further, Neighborhood social limitations and public transport habits also contributed to social exclusion.

Fatima et al. (2022) examined the utilization of optimal alternative energy conservation techniques in public transport to evaluate the impact on energy efficiency and environmental emissions. The study employed a decision-making efficiency analysis approach to conduct a comparative investigation of orthodox fuel and hybrid bus systems in the context of Karachi city. The study examined the implementation of an energy-based bus system on a particular route in Karachi and compared it to conventional public transport services. Apart from a single intermediate section, the efficiency of the hybrid bus system either remained superior or was on par with the conventional value of 1. The research indicated that Bus Rapid Transit (BRT) systems are viable and sustainable alternatives for large urban areas. They can potentially replace conventional bus systems and provide an energy-efficient and environmentally friendly mode of public transport.

Ahmed (2022) conducted a comprehensive evaluation of the current urban transport system in Islamabad and Rawalpindi City. The study also examined the effects of the Covid-19 pandemic on urban mobility in these areas. Additionally, the study ascertained the Sustainable Urban Transport Index for both cities. The findings of the study stated that in recent years, people migrated from rural to urban areas in search of improved living conditions and an enhanced quality of life. Consequently, this migration has led to a surge in transport demands in both cities. Further, the ownership and utilization of cars increased in both cities due to the availability of inexpensive lease/financing options and the absence of an adequate public transport system.

Sheikh (2022) conducted an analysis of the public transport system in the cities of Rawalpindi and Islamabad. This analysis focused on the development, construction, and operations of the Mass Transit System (MTS) in cities that lack such a system. The primary aim was to determine the feasibility and sustainability of implementing this development in older and more populous cities and to examine the various stages and processes associated with the development of MTS in the Twin Cities of Rawalpindi/Islamabad. The results of the research stated that the establishment of an MTS in historical and populous cities that have evolved without such a system is an extensive undertaking that necessitates persistent governmental determination, financial allocation, and political stability. The absence of these items is commonly observed in a significant number of underdeveloped nations, posing a threat to the progress of MTS projects during their developmental stage. Alternatively, the author proposes the construction of new urban centers on the outskirts of established cities, a strategy that is deemed to be both pragmatic and environmentally sound.

2.7.1. Issues in the Existing Public Transport System of Pakistan

Several issues are given in the existing literature on Pakistan's road public transport system that causes a surge in the ownership of private vehicles (Ahmed et al., 2022). Such as,

2.7.1.1. Accessibility Issues

Pakistan's current public transport system exhibits a deficiency in convenient accessibility (Aftab et al., 2019) and a lack of adequate availability (Imran, 2009). Furthermore, individuals with disabilities encounter challenges in accessing public transport in Pakistan (Adeel et al., 2016b).

2.7.1.2. Safety Concerns

Safety concerns among women in public transport are one of the major issues in Pakistan. These concerns are primarily driven by the prevalence of harassment and a pervasive sense of insecurity and fear that women experience while traveling on public transport (Adeel et al., 2014).

2.7.1.3. Bad Behavior of Drivers

Public vehicle drivers frequently engage in the practice of disembarking and collecting passengers from the center of the roadway while also displaying a tendency to decline to fulfill their designated routes. As a result of these various factors, people exhibit disfavor towards utilizing public transport (Batool et al., 2012; Imran, 2009).

2.7.1.4. Inefficient and non-regulated

The public transport system of Pakistan is inadequate (Batool et al., 2012), inefficient, consumes extra time to cover a trip, and poorly developed (Mehdi, et al., 2019; Rasool et al., 2019). The country lacks a comprehensive, integrated transport system, resulting in each public transport company or public transporter functioning independently. The absence of a comprehensive public transport policy and inadequate oversight mechanisms contribute to establishing subpar travel standards (Batool et al., 2012). Further, it has non-regulated fairs and drivers possess the freedom to independently determine their rates (Adeel et al., 2016b).

2.7.1.5. Informal Public Transport System

The public transport system of Pakistan is "informal" which includes using Qinqui, wagons, and other unregulated modes. These informal modes operate relatively in disorganized manners (Fekadu, 2014; Guillen et al., 2013). The current informal public transport system is experiencing a persistent decline, leading to a migration of commuters towards private modes of transport. Notwithstanding the inadequate conditions and limited availability of public transport, a particular demographic of commuters, except those with limited financial resources who cannot afford private vehicles (Jain & Tiwari, 2016; Ahmed et al., 2022), continue to shift to private vehicles. The inadequacy and inefficiency of public transport systems have led to a surge in the volume of motor vehicles on roadways (Ahmed et al., 2022).

2.7.2. Bus Rapid Transit (BRT)

BRT Systems are prevalent in developing countries due to their efficiency and reliability (Fatima et al., 2022). In 2014, the government of Pakistan initiated the implementation of Bus Rapid Transit (BRT) systems, specifically metro buses, as a strategic response to address challenges associated with public transport on road networks (Haider et al., 2021). Nevertheless, the service has solely been introduced in major cities within Pakistan. Since the implementation of Bus Rapid Transit (BRT), it has garnered significant attention from many scholars who have investigated its relationship with various aspects such as the economy, performance assessment, behavioral inclination to utilize, environmental impact, air quality, residential property value, and other related factors (Haider et al., 2021; Kusar et al., 2021; Javid et al., 2022). However, also BRT in Pakistan have several issues i.e. spatial arrangement and positioning of BRT, the system's accessibility throughout the city, the availability of parking at transit stations, the speed of metro buses, and the barrier-free physical accessibility of the system (Nadeem et al., 2023). The existing literature on BRT in Pakistan demonstrated that it is an efficient public transport system that reduced carbon emissions, greenhouse gas emissions, and road congestion in the country (Haider et al., 2021; Naqvi, 2017; Shah et al., 2020) and people prefer to travel on BRT in Pakistan (Javid et al., 2022; Kepaptsoglou et al., 2020). Conversely, Abid (2020) presented evidence indicating that the metro bus project has proven to be highly detrimental to the developing economy of Pakistan, as its operational expenses surpass even those of luxury vehicles. Moreover, the operational continuity of such projects in Pakistan poses a significant burden on the country's economic resources.

2.8. Shifting Private Vehicles to Public Transport

The topic of shifting private vehicles to public transport has garnered significant attention in the past few years, primarily in response to the escalating number of private vehicles and their detrimental effects on the environment (Logan et al., 2020; Long et al., 2018; Rojas-Rueda et al., 2012; Shah et al., 2021). Various studies have also investigated the behavioral intentions of individuals who use private vehicles and have explored policy modifications aimed at assessing the impact on promoting these individuals to shift to public transport (Kaffashi et al., 2016; Wang et al., 2020: Javid, Ali, et al., 2022). Previously, numerous studies have examined the feasibility and efficacy of the shift from private vehicles to public transport to mitigate environmental pollution, particularly air pollution and carbon emissions, and address various related concerns across diverse country contexts. Such as

Rojas-Rueda et al. (2012) assessed the potential health hazards and advantages associated with shifting from private vehicle usage to cycling and utilization of public transport within the metropolitan region of Barcelona, Spain, by creating eight scenarios. The results of the study indicated that implementing interventions aimed at decreasing car usage and promoting cycling and public transport in metropolitan regions, such as Barcelona, can yield health advantages for both commuters and the overall populace of the urban area. Furthermore, these interventions have been shown to mitigate greenhouse gas emissions effectively.

Batty et al. (2015) thoroughly examined the multiple factors in shifting from private vehicles to public transport. The research examined the intricate societal, political, and economic obstacles that have hitherto impeded the realization of such a shift. The following study conducted a comprehensive examination of the influence of quality elements of public transport on promoting modal shifts, with a particular emphasis on the importance of passenger views and priorities. The study additionally examined the efficacy of strategies to regulate urban car utilization before delving into potential remedies for overcoming obstacles to achieving a significant and prosperous shift in transport modes.

Kaffashi et al. (2016) examined the impact of policy modifications on shifting private vehicles to public transport. The study investigated the potential impact of strategic policy modifications in personal and public transport on the mode selection of personal vehicle users. The study was carried out at Klang Valley, Malaysia. The research employed a random parameter logit model to investigate the effects of congestion fees on private transport modes. Additionally, the study examined the impact of factors such as access, comfort, and frequency of available public transport. The findings of the simulation suggested that the implementation of a congestion fee has a significant effect on both modal shifts and the reduction of private vehicle usage. In addition, the adoption of innovative transport policies by the government, such as pricing mechanisms and the enhancement of public transport efficiency, could potentially lead to a modal shift of 70% among current car users towards public transport.

Kenworthy (2018) examined the energy consumption trends in personal and public transport across a worldwide sample of 44 urban locations in Europe, Australia, Canada, and the United States. Additionally, the study included Singapore and Hong Kong as two prominent highly developed Asian cities. The study examined the energy consumption data pertaining to private and public transport over a decade spanning from 1995 to 2005. The results of the study stated that the per capita energy consumption of private vehicles was 20 times higher than public transport, while the private vehicle's energy consumption per passenger kilometer was approximately 2.3 times higher than public transport. The findings of the study suggested the shift of private vehicles to public transport to reduce energy consumption.

Long et al. (2018) analyzed the model shift from private vehicles to public transport and examined an Urban Transport Planning Model to prognosticate travel demand in Khon Kaen City, Thailand. The study examined how a five-line mass transit system can reduce greenhouse gas (GHG) emissions. The study also evaluated the suggested scenarios and provided policy implications based on the findings. Four-step Urban Transport Planning Model predicted travel demand. Hence, a bottom-up two technique was used to predict GHG emissions from each scenario in 2016–2046. The findings of the study stated that the proposed initiative is expected to result in a modal shift from personal vehicles to public transit within the anticipated timeframe of thirty years. Moreover, it could also reduce vehicle kilometers, vehicle hours, Volume-to-Capacity ratio figures, average travel speed, and carbon emissions in the research area.

Logan et al. (2020) investigated the disparities in carbon dioxide emissions generated by conventionally fueled cars, conventionally fueled buses, electric cars, electric buses, and hydrogen buses from 2017 to 2050 in the United Kingdom under four distinct National Grid electricity scenarios. The study results indicated that the total emissions across all electricity scenarios were comparatively lower for scenarios involving electric buses and hydrogen buses. The findings of the study suggested that policymakers should encourage a modal shift from personal vehicles to sustainable public transport, especially electric buses, the lowest-emitting vehicle group. However, only shifting to electric cars will not achieve the zero emissions target. The UK must simultaneously replace conventionally fueled buses with electric and hydrogen buses to reach emission targets.

Wang et al. (2020) examined the push-pull-mooring framework to investigate the dynamic nature of people's behavior from shifting private vehicles to green transport i.e. public transport. The research also underscores the significance of push, pull, and mooring factors in shaping individuals' transport choices. The research was conducted in China's four most traffic-congested cities with more advanced green transport systems. The study employed a questionnaire-based survey to gather data from individuals who are daily commuters and utilize their own cars as their primary mode of transport to travel to their respective workplaces. The findings of the study stated that enhancing the quality of public transport and its services is the primary and most significant approach to encourage individuals to shift towards public transport. In addition, government policies attract individuals to public transport. However, Push factors drive people away from private cars, while pull factors attract them to green transport. Inertia, the anchoring factor, negatively impacts shifting willingness and moderates the effects of push and pull variables. Furthermore, a positive correlation exists between the willingness to shift and the behavior of shifting, which is moderated by the provision of information.

Al-Msari et al. (2021) examined the effects of policies to shift private vehicles to public transport. The study analyzed the impact of policies to reduce bus dwell time, increase parking fees, and raise private vehicle fuel costs. The objective of these policies was to alleviate issues such as congestion, carbon emissions, greenhouse gas emissions, air quality, and various other factors in Kuala Lumpur, Malaysia. The study was carried out at the Kuala Lumpur City Centre (KLCC) and data was collected from private vehicle users. The analysis in this study employed a logit model. The findings of the study indicated that a 33% fuel price rise will move 99.5% of respondents to public transport. Similarly, a 25% increase in parking costs will result in a 99.5% shift towards public transport among the respondents. Upon reducing bus dwelling time to 60%, half of the participants surveyed will opt to switch to public transport. Moreover, the implementation of government policies has been found to have a positive impact on the reduction of private vehicle usage, as it encourages individuals to shift to public transport alternatives.

Shah et al. (2021) analyzed the impact of shifting private vehicles to public transport strategy along with avoid and improve strategy on reduction of carbon emission in transport sector. The study further examined the factors that should be considered when implementing green transport for global sustainability. An investigation was conducted into a three-step strategy (so-called ASI strategy, or avoid, shift, and improve strategy) that had been proposed to surmount the obstacles and challenges. For greening the public transport system, innovative technologies and management strategies have been proposed. Finally, some well-known success tales of the ASI strategy were presented, in which Avoid can reduce CO2 emissions by 146–312 kg CO2/y, Shift can reduce CO2 emissions by 0.27 kgCO2/vehicle revolution and improve can reduce CO_2 emissions by 12.4%. This analysis directs effective urban planning with a sustainable transport system.

Huboyo et al. (2022) examined the implementation of Bus Rapid Transit (BRT), the success of shifting private vehicles to Bus Rapid Transit (BRT), and the number of emissions generated through BRT operations. The study constitutes a regional case analysis carried out in Semarang, Indonesia, employing questionnaires and observations of BRT vehicles. The results of the study stated that 30 percent of public transport users switched to BRT users. However, Motorcycle riders are significantly more likely to transfer to BRT than car users. Moreover, the implementation of the BRT application has not resulted in a significant decrease in the utilization of private cars.

Atabaki et al. (2023) explored the feasibility of shifting to public transport and active mobility modalities while considering advancements in transport electrification and fuel efficiency enhancements. The study investigated the various pathways that can lead to the establishment of an ecologically sustainable road passenger transport system in the province of British Columbia (BC), Canada. Secondary data of BC from the years 2015-2050 and the MESSAGE model is used to evaluate the impact of modal shifts and the proliferation of electric vehicles (EVs) on greenhouse gas emissions by the year 2050. The analysis found that BC would not meet the Climate Change Accountability Act's 80% emissions reduction goal unless transport electrification increases. To meet the goal, a minimum 70% electric car adoption rate and 35% public transport passenger kilometer contribution are needed.

2.9. Transport Modal Shifting in Pakistan

The extant body of literature pertaining to modal shifting in Pakistan's transport sector diverges significantly from the context examined in the present study. In Pakistan, there are a few studies on shifting transport modes; however, these studies focused on shifting private vehicles from dirty fuels to alternative cleaner energy sources i.e. shift to green transport to mitigate the environmental impacts (Kiran & Khan, 2022; Shahid et al., 2022), a shift from private vehicles to BRT and behavioral intentions of commuters to shift to metro-bus service or BRT (Kepaptsoglou et al., 2020; Ahmed et al., 2022; Javid, Ali, et al., 2022; Naqvi et al., 2022), commuters' preference to shift from fuel-based vehicles to electric vehicles (Abdullah, et al., 2022), shifting non-electric vehicles to electric vehicles to analyze its impact on greenhouse gas emission (Shakeel, 2022) and shifting to substitute fuels and its impact on transport sector (Lin & Ahmad, 2016). In addition, (Batool et al., 2020) analyzed the proportion of commuters who shifted from private or personal vehicles to BRT. Majeed & Batool (2016) analyzed the factors affecting the modal shifting to metro bus service. The findings stated that shifting from non-electric vehicles to electric vehicles in Pakistan has the potential to mitigate greenhouse gas emissions and tackle various environmental concerns associated with mobility (Shakeel, 2022). In addition, efficient combustion and hybrid vehicles can potentially reduce carbon emissions in the transport sector (Shahid et al., 2022). However, the shift from using polluting fuels to cleaner alternatives in the transport sector necessitates a substantial financial investment for engine conversion and it has the potential to yield long-term economic advantages while in the short term, this shift may increase costs for the sector and related services (Kiran & Khan, 2022). In addition, the findings regarding commuters' behavior towards shifting to BRT indicated that social and personal travel limitations affect commuters' behavior. In addition, family commuters prefer private cars, regardless of their income level. However, three income groups i.e. (lower, middle-class, and high-level), have different mobility incentives and parking limit behaviors. The ethical responsibilities of mitigating traffic congestion, air pollution, and preservation of natural resources differ among three distinct income groups (Javid et al., 2022).

2.10. Summary of the Chapter

The current chapter of the dissertation explicates the detailed literature about energy usage, specifically oil consumption, in the transport sector. Further, this chapter provides extensive literature on the transport sector oil consumption in Pakistan and its impact on environmental emissions i.e. carbon emissions and oil import bills. Furthermore, this chapter provides historical background on the causes of private vehicle growth and the harmful effects of private vehicle growth in Pakistan. The current chapter also elucidates the public transport system of Pakistan, issues in the existing public transport system of Pakistan, and Bus Rapid Transit in Pakistan. In addition, this chapter provides extant literature on shifting private vehicles to public transport, as well as previous studies on transport modal shifting in Pakistan.

CHAPTER 3

METHODOLOGY

3.1. Introduction

Research Methodology is a process for solving research problems in a systematic manner. Significantly, it is the scientific study of how research is conducted. In it, we examine not only the logic but also the methodology of the various stages a researcher typically takes when examining his research problem (Kothari, 2004, p. 8). Further, methodology is the overall approach to research linked to the theoretical framework or paradigm while the methods refer to systematic modes, tools, or procedures, applied for gathering or assessment of data (Mackenzie & Knipe, 2006).

This chapter is all about the research methodology followed, explained, and linked to this research. This chapter is divided into sections. The present section (section 3.1) illustrates the methodology and summarizes the structure of the rest of the chapter. Section 3.2 demonstrates the study area description. The study's research design is elucidated in section 3.3. Further research design is divided into sub-sections. Section 3.3.1 elaborated on the purpose of the study. Section 3.3.2 explains the methods of the study. Section 3.3.3 describes the research approach. The unit of analysis is discussed in section 3.3.4. Section 3.3.5 explains the study population. Section 3.3.6 depicts the sampling frame. Section 3.3.7 portrays the sampling size. Section 3.3.8 briefly discusses the sampling technique. Section 3.3.9 provides the sample locations map. Section 3.3.10 explains the types, sources, and collection of data. Section 3.3.10 is further divided into sub-sections to explain the data collection process of each variable separately. Section 3.3.10.1 depicts the registered vehicles in Islamabad. Section 3.3.10.2 shows the private vehicle countdown. Section 3.3.10.3 depicts the road lengths of intracity points. Section 3.3.10.4 explains the private vehicles' average oil consumption. Section 3.3.10.5 explains the private vehicles' average passengers. Section 3.3.10.6 provides the public transport average oil consumption. Section 3.3.10.7 illustrates the CO2 emissions and fuel prices. In addition, Section 3.3.11 provides a methodology process diagram. Section 3.3.12 explains the data analysis tools. Section 3.3.12.1 demonstrates the data description, in which further sub-sections 3.3.12.1.1 and 3.3.12.1.2 illustrate the day-wise and duration-wise data description. Section 3.3.12.3 depicts an independent sample t-test. Section 3.3.12.4 explains the one-way ANOVA test. Furthermore, Section 3.4 demonstrates shifting scenario calculations, and it is further divided into 13 sub-sections. Section 3.4.1, 3.4.2, 3.4.3, 3.4.4, and 3.4.5 elucidates the road lengths, average passengers per vehicle, average oil consumption, average fuel cost, and CO2 emissions. Section 3.4.6 demonstrates the features of private and public transport. Section 3.4.6, 3.4.7, 3.4.8, and 3.4.9 illustrates the pre-shifting, post-shifting, differences in values and percentage difference calculations. Sections 3.4.10, 3.4.11, 3.4.12, and 3.4.13 explain scenario 1, scenario 2, scenario 3, and other scenarios calculations. Finally, section 3.5 summarizes the whole chapter summary.

3.2. Study Area Description

This study is carried out in Islamabad, Pakistan. The estimated population of the Islamabad metropolitan region is 1,232,000 in the current year 2023 (Macrotrends, 2023). Islamabad, the capital city of Pakistan, ranks as the tenth most populous urban area in the country with an annual population growth rate of 4 percent. It has a unique system of wide roads, medians, and verges that is not found in any other city in the world (CDA, 2017). In addition, the location is recognized as a central focus for both political and economic endeavors (Naqvi, 2017).

Islamabad is a private car-dominating city and car ownership in the city is increasing rapidly in the last few years (Ayaz et al., 2021) and the residents of Islamabad exhibit a notable reliance on private vehicles . In recent years, there has been a substantial increase in vehicle traffic, which has caused negative effects on the urban ecosystem. This is primarily the result of increased atmospheric pollution due to increased vehicle traffic and altered land use patterns (Naqvi, 2017; Ayaz et al., 2021). Prior to 2017, traffic congestion in Islamabad was uncommon due to the comparably small number of vehicles on the road. In recent years, there has been a notable increase in the number of vehicles, resulting in the emergence of traffic congestion problems (Pakistan Today, 2023; The News, 2023). According to estimates, there are approximately 700,000 daily trips that begin and conclude within the city limits of Islamabad. In addition, up to 500,000 trips occur daily between Islamabad and its neighboring urban regions. Due to the level of congestion, the deteriorating condition of Islamabad's environment and the decline in the city's quality of life are becoming evident (CDA, 2017; Naqvi, 2017). The predominant forms of public transport in Islamabad include taxis, conventional buses, Vans, and metro buses, which are extensively accessible to the general people (Zameen, 2022). The private sector supervises the operation of small wagons and minibuses in an environment that is largely unregulated and unmonitored to control the public transport system in Islamabad. They account for approximately 35 percent of the overall traffic mode share, a proportion that is decreasing due to the bad quality of service and pervasive dissatisfaction among customers (CDA, 2017).

The Rawalpindi-Islamabad Metro bus system provides transport services to the cities of Islamabad and its adjacent twin city, Rawalpindi. The current metro service in Islamabad does not provide comprehensive coverage of the entire city, hence rendering certain areas inaccessible via the Metro bus system (Zameen, 2022). The government also inaugurated the Green and Blue Line in 2022, which connects Bhara Kahu, GT Road, Koral and Rawalpindi through the Green, Orange, Blue, and Red Lines (Tribune, 2022). In addition, various government departments, private companies, schools, and other organizations provide or contract private buses and coasters for the express purpose of meeting the transport needs of their employees and students (CDA, 2017).

Source: Google Maps

Figure 3.1 Map of Islamabad

3.3. Research Design

A research design refers to the framework of conditions established for the purpose of gathering and analyzing data in a manner that effectively integrates with the research topic (Dannels, 2018). The construction of a research design entails a meticulous evaluation and selection of a suitable methodology (Mackenzie & Knipe, 2006). Furthermore, the research design is the blueprint or plan of the study that is used to gather, measure, and analyze the data in order to answer the research questions (Sekaran & Bougie, 2017, p. 396). The research design of the current study provides detailed information about research methods (quantitative or qualitative), research approach (deductive or inductive), unit of analysis (individuals, groups, organizations, or countries), types, sources, or collection of data, population of the study, sampling frame, sampling size, sampling techniques (random, cluster, or convenience sampling), data analysis tools (MS Excel, SPSS, E Views, or Stata).

3.3.1. Purpose of the study

The present study intends to examine the change in oil consumption and CO2 emissions by shifting private vehicles to public transport by employing exploratory data collection techniques and methods. Only Haider et al. (2018) in Pakistan, used the same data collection technique i.e. traffic count data of five locations in Lahore for the purpose of analyzing the air quality in Lahore. The exploration of shifting private vehicles to public transport and its impact on oil consumption and other associated variables by employing new data collection techniques makes it an exploratory study (Neuman, 2014, p. 38). Therefore, the utilization of the exploratory approach is deemed appropriate for the present study given that the issue being examined is relatively understood yet is approached from a novel standpoint and exploratory research refers to the process of investigating a research topic with the aim of discovering novel and intriguing information (Swedberg, 2020). Furthermore, the present study describes the private vehicle traffic flow at several locations of Islamabad in its natural state. The purpose of the current research is to examine the impact of shifting private vehicles to public transport on oil consumption and CO_2 emissions based on the peak hours of private vehicle usage at different locations in Islamabad. Private vehicle countdown or flow of various intracity locations of Islamabad is described separately in different timings making the study descriptive (Siedlecki, 2020). Therefore, the current research is also considered descriptive research because the objective of descriptive studies is to describe people, events, or conditions by examining them in their natural state (Siedlecki, 2020). Moreover, the nature of the current research is applied because it is more concerned with actual life, has a direct impact on the economy, and will help formulate a policy (Bhattacharyya, 2009, p. 14).

3.3.2. Research Method

Research methods refer to a set of techniques and tools that facilitate researchers to conduct their research (Walliman, 2010). Quantitative research methods involve the systematic collection of structured data that can be expressed "numerically" and analyzed by using "mathematically based methods", particularly "statistical analysis" (Creswell, 1994). While the qualitative research method yields findings without utilizing statistical methods or "other means of quantification" (Strauss & Corbin, 1998, p. 10, 11). This study used quantitative data for private vehicle flow and shifted them to public vehicles to analyze the impact on oil consumption and CO_2 emissions. Therefore, the current research is a quantitative study.

3.3.3. Research Approach

The scientific research process deals with two approaches inductive and deductive (Neuman, 2014, p. 69). The deductive reasoning method is used to test a theory from the more general to the more specific in which a general theory is narrowed down into specific testable hypotheses. While the inductive reasoning method works in a reverse manner, whereby specific phenomena are observed, and general conclusions are drawn from them. The current study employs an inductive approach because it observes the impacts of shifting private vehicle flow to public transport at various intracity locations in Islamabad with the aim of drawing generalizable conclusions for the entire city.

3.3.4. Unit of Analysis

The unit of analysis is the specific entity that is being studied in scientific research. It includes individuals, groups, dyads, institutions, and cultures (Sekaran & Bougie, 2017, p. 102). Therefore, the unit of analysis of this research includes 2,061,336 private vehicles.

3.3.5. Study Population

The population of the study refers to the entire group of individuals, occasions, or entities that are relevant to the researcher's investigation (Sekaran & Bougie, 2017, p. 236). The shifting of private vehicles to public transport and its impact on oil consumption and CO_2 emissions is examined based on data collected from the countdown of private vehicles at different intracity locations in Islamabad, which includes cars, jeeps, station wagons, and SUVs. Therefore, flow of private vehicles on all the intracity locations of the Capital Territory of Islamabad constituted the population of this study. The population for this study is unknown.

3.3.6. Sampling Frame

The sample refers to a smaller group of individuals or objects that are selected from a larger population for the purpose of conducting research or analysis (Sekaran &

Bougie, 2017, p. 237). The most utilized sampling methods are probability sampling and non-probability sampling. The former method is employed in cases where the population size is known, while the latter method is used when the population size is unknown (Sekaran & Bougie, 2017, p. 240). Further, the sampling frame refers to the set of individuals belonging to the population of interest, from which a probability sample is drawn. It does not always contain every member of the target population (Rukmana, 2014). The list of sampling frames for this study contains the flow of private vehicles on all the intracity locations of Islamabad. Therefore, the sampling frame and population of the current study are the same.

3.3.7. Sampling Size

Sampling pertains to the process of selecting a group of participants from a larger population in order to estimate the attributes of the entire population (Singh & Masuku, 2014). The sample size consists of chosen representatives from the population (Sekaran & Bougie, 2017, p. 396). Further, sample size is the selection of the optimal quantity of observations to be incorporated into a sample. The sample size is a crucial aspect of a scientific investigation (Singh & Masuku, 2014). The methodology for ascertaining the appropriate sample size is contingent upon the specific design attributes, encompassing the type of outcome variable under investigation in the research (Suchindran, 2005). Therefore, the sample size for this study consists of all the private vehicles' peak hours countdown or flow in 15 intracity points of Islamabad.

3.3.8. Sampling Technique

Sampling techniques are commonly used for research investigation to estimate the results at a low cost, in less time, and with greater precision (Singh & Masuku, 2014). Further, the sampling process refers to a systematic approach used to choose a representative sample from a designated population (Daniel & Aroma G. Sam, 2011, p. 64). This study investigates the impact of shifting private vehicles to public transport on oil consumption and other associated variables and intends to collect data from all the intracity points of Islamabad following the census sampling technique. However, data were collected from only 15 mains frequently used intracity points owing to avoiding the repetition of the same vehicles' countdown from intersection points. The 15 frequently used intracity points were selected with the help of an Islamabad intracity route expert at Safe City Islamabad, named Ahmad Zakwan. Initially, all intracity points were selected for data collection. However, after the expert opinion, specific routes were selected on the map of Islamabad according to the traffic flow. The routes include Margalla Avenue, Jinnah Avenue, Kashmir Highway/ Srinagar Highway, IJP, Murree Road, Express Way, 9^{th} Avenue, 7^{th} Avenue, Fakeer AP Road, Golara Road, Muhammad Tufail Niazi Road, Ibn-e-Sine Road, Aun Muhammad Rizvi Road, Service Road West, and Service Road North. Therefore, the final selection of 15 intracity points of Islamabad in the sample is based on the characteristics of data for 7 days (i.e. working days and weekends). Therefore, this study selects 15 intracity city routes of Islamabad and uses a judgmental sampling technique in the first stage and census sampling technique in the second stage.

3.3.9. Sample Locations Map

Source: Authors' Deviation

Figure 3.2 Map of Selected Locations

Figure 3.2 illustrates the selected intracity areas that are chosen as a representative sample for the purpose of this study, with the objective of gathering data on the flow of private vehicles. The phrase displayed in red describes the specific geographical positions of the sample locations.

3.3.10. Types, Sources, and Collection of Data

Data utilized in research are of two types, primary and secondary. Primary data refers to information that is collected directly by the researcher in order to achieve a specific research objective and add new data to the existing information, whereas the data that is originally acquired for an alternative purpose and subsequently reutilized to address distinct research study refers to secondary data (Hox & Hennie, 2005). The current study uses both primary and secondary data. In addition, it is worth mentioning that the private vehicle countdown data is the first time used in academic research for this study.

3.3.10.1. Registered Private Vehicles in Islamabad

The data for total private vehicles registered in Islamabad from 1 January 1980 to 26 June 2023 is collected manually from the Islamabad Excise and Taxation Department, which contains the data of all registered vehicles in Islamabad (Excise Islamabad, n.d.). This data is obtained after one working day of submitting a data request application under the name of the DG Excise and Taxation Department Islamabad.

3.3.10.2. Private Vehicles Flow or Countdown

The data pertaining to the countdown of private vehicles are gathered in collaboration with the traffic police Islamabad and safe city Islamabad. The study encountered significant challenges in gathering private vehicle countdown data from multiple intracity points in Islamabad, owing to the substantial volume of traffic. Consequently, it was determined that the data would be collected through the utilization of safe city cameras and countdown devices that are strategically positioned at various intracity locations in Islamabad. In short, with the help of safe city brief cam software. Safe City Islamabad serves as the technical wing of the Islamabad Capital Police. Its responsibility is to introduce technology-led policing to make the security of Capital City a model of excellence. It employs Intelligence Video Surveillance and Vehicle Management System Cameras in ICT (Islamabad Capital Territory) with Automatic Number Plate Recognition in order to protect the city from combat crime, maintain public order, and protect the interests of Islamabad's citizens (Safe City Islamabad, n.d.). The safe city headquarters in Islamabad is visited to obtain data-related information. They described the legal process in which they requested an official letter from the study's (author's) supervisor or department, as well as an official data request confirmation letter from the SSP Traffic Police Islamabad. Therefore, the supervisor of the author drafted an official data request letter addressed to Dr. Syed Mustafa Tanveer, SSP Traffic Police, Islamabad. Subsequently, the study's author convened with the SSP Traffic Police at his official premises and personally delivered a letter requesting data, while also elucidating the purpose of the study. The SSP composed an official confirmation data requesting letter addressed to DG safe city Muhammad Shoaib Khurram, Islamabad, and assigned an officer named Saqib to assist the author in the data collection process and ordered him to stay in touch with the study's author to verify the data request process. After one day, the author subsequently visited the safe city headquarters and requested data. They refused to provide the information because they had not yet received the official letter requesting the data. The author was instructed to come again after the weekend. Therefore, the author went back to the safe city headquarters after the weekend and requested data. Madam Zahida, the office superintendent and administration incharge of safe city, arranged a meeting for the author with DG safe city, Islamabad. During the meeting, the author explained to DG the requirements of the data and the purpose of the research. In addition, the DG instructed the author to meet the DSP safe city. After a productive meeting with DSP, he designated three constables named Ahmad Zakwan, Naik Dad, and Muhammad Zohaib to process the necessary research data. Constable Zakwan assisted the author in determining the optimal locations based on the research requirements. The 18 distinct computers were utilized for data processing and anticipated that extracting the data would take two to three weeks.

However, the extraction of the data was not completed within a three-week timeframe due to the server being overloaded with a substantial volume of data. In addition, the safe city faced numerous problems during the process of data extraction. Hence, a period exceeding one month was employed for the extraction of data. Finally, after a prolonged period of effort and patience, the data were successfully acquired. The study received data from 29 May 2023 to 4 June 2023 for private vehicles flow in Excel sheets and then creates new Excel sheets according to the study requirements. In addition, the private vehicles countdown data of 15 intracity locations were received day-wise i.e. Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday. Further, the data were grouped duration-wise in three time groups, including 07:00 hours to 10:00 hours, 13:00 hours to 15:00 hours, and 16:00 hours to 20:00 hours.

3.3.10.3. Road Lengths of Intracity Points

The road length data for the 15 chosen intracity points is collected using Google Maps. The process involves utilizing Google Maps to search for each intracity point, afterward pinpointing the precise site and extracting the road length from such spot to the termination point of the specific intracity location.

3.3.10.4. Private Vehicles Average Oil Consumption & Fuel Prices

Both primary and secondary data are collected to enhance the authenticity of the information regarding the average oil consumption of private vehicles. In primary data collection, information is garnered from various private vehicle users via surveys. This information is collected from parking lots in Islamabad's offices, universities, shopping centers, and parks. However, secondary data is obtained from the official website of PakWheels, Pakistan's leading automotive portal (PakWheels, n.d.), using an online search via the google chrome web browser. However, the secondary data is collected for fuel (petrol and diesel) prices dated 29 May 2023 to 4 June 2023, from the official website of the Oil & Gas Regularity Authority (OGRA, 2023)

3.3.10.5. Private Vehicles Average Passengers

The data for average passengers per vehicle and average seating capacity is analyzed through observation from field surveys at several locations in Islamabad. This data is collected from metro bus footbridges from Srinagar Highway, Faizabad, Exchange Chowk, and 7th Avenue Interchange during June 2023. However, observation carries the risk of systematic and random error. The systematic error arises from imprecision in the process of observation or the measuring instrument. Further, it can be consistent or intermittent. Random errors in observations are caused by chance and result in inconsistent measurements and are challenging to anticipate and avoid (Siedlecki, 2020).

3.3.10.6. Public Transport Average Oil Consumption & Seating Capacity

Both primary and secondary data are collected to enhance the authenticity of the information regarding the average oil consumption and average seating capacity of public transport. In primary data collection, information is garnered from drivers of public transport through surveys. This data is collected from Faizabad Bus Terminals i.e. (Daewoo, Baloch, Faisal Movers, and Qadri Travels). However, secondary data is obtained from the official website of Yutong, a large-scale industrial group mainly specializing in the bus business (Yutong, 2023), using an online search via the google chrome web browser.

3.3.10.7. CO2 Emissions

This study estimates emissions based on survey-collected fuel/energy consumption data and standard values of emissions per unit of energy consumption given by the Energy Protection Agency (EPA, 2020) and Autolexicon (2023).

3.3.11. Methodology Process

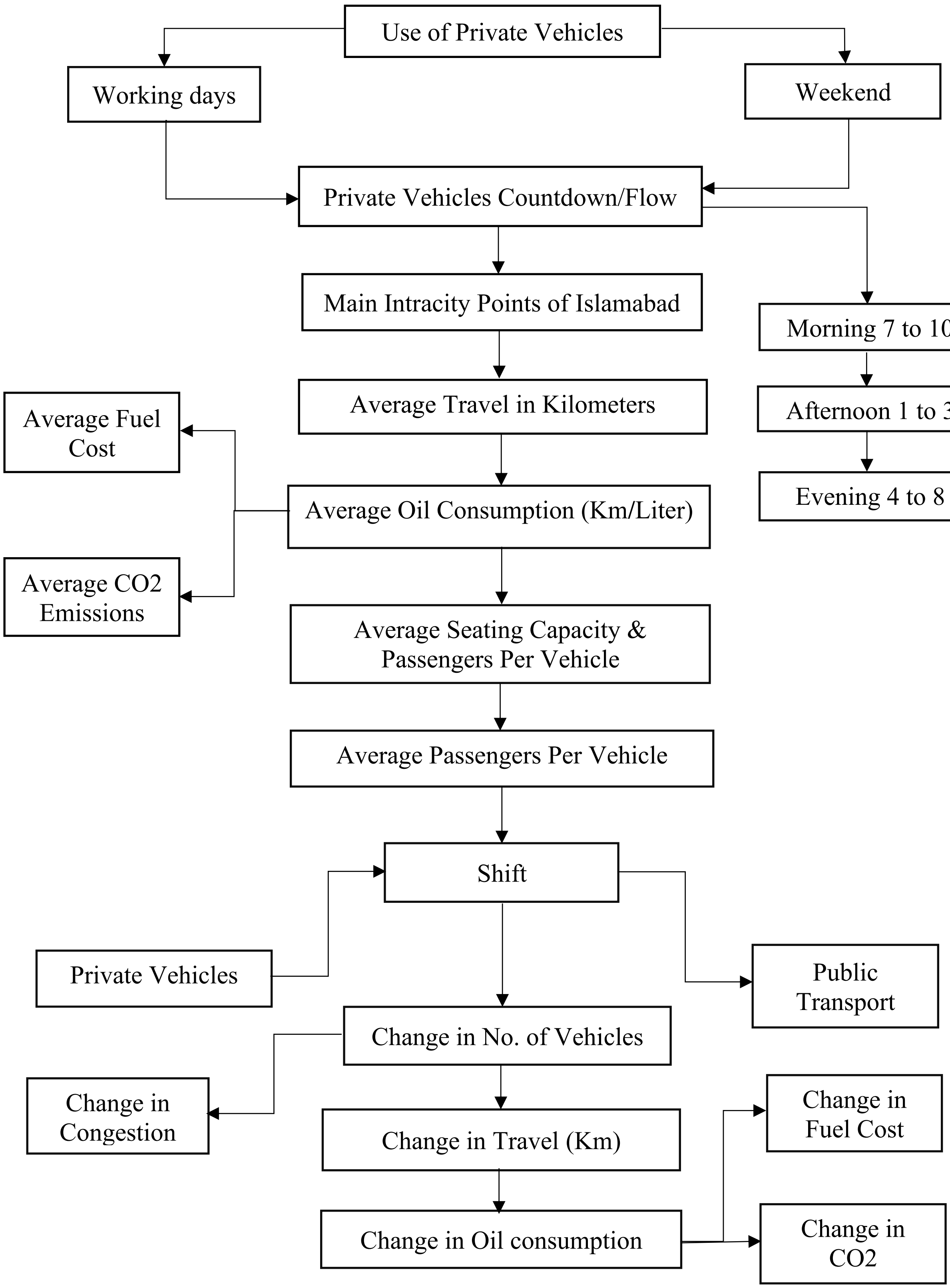


Figure 3.3 Flow Diagram of Methodology Process

3.3.12. Data Analysis Tools

The study used Statistical Products and Services Solutions (SPSS 25) software and Microsoft Excel for data description and data analysis. The study used SPSS because it does efficient analysis of scientific data (Haynes, 2022), and MS Excel is used due to its feature of array formulas, complex data charts, and graphs with trendlines and error bars (Kumar, 2010; Arya et al., 2023). The study uses the following test for data analysis.

3.3.12.1. Data Description

The data on registered vehicles in Islamabad is described in tables and the data on private vehicles flow is described in both tables and graphs. However, the data on private vehicle flow is described in two ways.

3.3.12.1.1. Duration-Wise Data Description

In time or duration-based data description, the data is organized into three distinct categories based on variations in time. In this context, bar charts visually depict day-to-day fluctuations in the count of private vehicles during each time period. The objective of these graphs is to illustrate the disparities in private vehicle flow during different days across each duration. Additionally, this category has been designed to display the days with the highest and lowest levels of traffic flow, as well as the corresponding directions, within each specified duration.

3.3.12.1.2. Day-Wise Data Description

In the context of day-wise data description, the data is arranged into seven distinct categories based on the days in a week. In this context, bar charts visually represent the duration-based fluctuations in the daily flow of private vehicles. The objective of these graphs is to illustrate the difference in private vehicle flow during different durations across the day. Additionally, this category has been designed to display the duration with the most substantial volume of private vehicle traffic, as well as the corresponding directions, within each specified day.

3.3.12.2. Descriptive Statistics

A descriptive statistic is applied to provide information about the distribution of data, including standard deviation, mean, and frequency counts (Taguchi, 2018). Descriptive statistics are used to explain the variables more generally and simplify the data more comprehensible (Yanto et al., 2021). Descriptive statistics are used in this study to provide information about the distribution of data, including standard deviation, mean, and frequency counts.

3.3.12.3. Independent Sample T-Test

An Independent sample t-test is used to check whether the mean score of the two groups is significant or insignificant (Suntusia et al., 2019). The Independent Sample T-test is applied in this study by using Levene's test for equality of Variance to check the significance between working days and off days (non-working days). The independent sample T-test in this study is run based on the following hypothesis:

H0: There is no significant difference in the Mean private vehicles flow of working and off days.

H1: There is a significant difference in the Mean private vehicles flow of working and off days.

3.3.12.4. One-Way ANOVA Test

One-way ANOVA, or Analysis of Variance, is a statistical method employed to assess and compare the means of three or more distinct groups. It is often referred to as one-factor ANOVA. The F-ratio in the analysis of variance (ANOVA) is a statistical metric that assesses the relative magnitude of variability between groups compared to variability within groups (Purnama, 2023). A one-way ANOVA test is performed in this study by creating the following hypothesis.

H0: There is no significant difference in the Mean flow of private vehicles of different timings or duration.

H1: There is a significant difference in the Mean flow of private vehicles of different timings or duration.

3.4. Shifting Scenarios Calculations

In shifting scenarios, the existing use of private vehicles in Islamabad and its impact on oil consumption, CO_2 emission, fuel cost, travel km, and congestion are created on the basis of data collection from several primary and secondary sources. However, after analyzing the impact of current private vehicle usage, different scenarios are created to analyze the impact of shifting private vehicles to public transport on oil consumption, CO_2 emissions, congestion, and fuel cost in the study. However, the description of variables are shown on next page in table 3.1.

Table 3.1 Description of Variables

Variables	Description	Source
Private Vehicles	Number of private vehicles flow at 15 intracity locations in Islamabad	Safe City Islamabad
Public Transport	Use of buses alternative to private vehicles	Yutong, 2023
Passenger	Average people travel in vehicles	Field Survey
Travel	Average travel in kilometers corresponding to road lengths of each 15 locations	Google Maps
Oil Consumption	Average km capacity as per liter oil consumed by private and public vehicles	Field Surveys, PakWheels, and Yutong
CO2 Emissions	Carbon dioxide emitted by per liter fuel consumption by private and public vehicles	Autolexicon and EPA
Fuel Cost	Average fuel cost corresponding to oil consumption by private and public transport	(OGRA, 2023)

Note. EPA stands for Energy Protection Agency. OGRA stands for Oil & Gas Regulatory Authority.

The study variables, their respective description, and corresponding sources of data are demonstrated in Table 3.1, which align with the strategy utilized by Shah & Sajid (2017).

3.4.1. Road Lengths

To measure the average travel of vehicles in each location, road lengths are described with the help of google maps. In order to quantify the mean distance traveled by automobiles in various locations, the lengths of roads are delineated utilizing the assistance of Google Maps in Table 3.2.

Table 3.2 Road Length of Each Location

Sr. #	Locations	Road Length
1	Faisal Chowk at Margalla Avenue	13 km
2	Exchange Chowk at Jinnah Avenue	7.5 km
3	Islamabad Chowk at Srinagar Highway	14 km
4	G-9 at Srinagar Highway	14 km
5	Faizabad at Murree Road	18 km
6	Naka Faizabad at Express Way Road	13 km
7	Stadium Road at 9th Avenue	8 km
8	7th Avenue	4 km
9	Police Line Signal at Faqir Aipee Road	4 km
10	Golra Road - Service Road G 13	2.8 km
11	Khyber Chowk at Muhammad Tufail Niazi Road	5.5 km
12	Project Mor at Aun Muhammad Rizvi Road	3.5 km
13	Jaffer Chowk at Service Road West	7.5 km
14	G-10/2 Corner at Ibn-e- Sina Road	4.5 km
15	7up Chowk at Service Road North (I-9)	4.5 km

Source: Google Maps

3.4.2. Average Passengers Per Vehicle

According to the data of the observation survey, the average number of passengers in private vehicles is 2. Descriptive statistics are used to find out the average number of passengers per vehicle as the results are shown in Table 3.3.

Table 3.3 Descriptives Statistics of Passengers Per Vehicles

	N	Minimum	Maximum	Mean	Std. Deviation
Passengers Per Vehicles	1144	1	5	2	1.259
Valid N (listwise)	1144				

However, a 46-seater bus is used in this study as a public transport based on the survey data and Yutong (2023).

3.4.3. Average Oil Consumption

According to the data of the observation survey and PakWheels dataset (PakWheels, n.d.), the average oil consumption in private vehicles is 11.37. Descriptive statistics are used to find out the average oil consumption per vehicle as the results are shown in Table 3.4.

Table 3.4 Descriptives Statistics of Average Oil Consumption in Private Vehicles

	N	Minimum	Maximum	Mean	Std. Deviation
Average Oil Consumption	100	6	19	11.37	2.65
Valid N (listwise)	100				

However, the average oil consumption of public transport (bus) for this study is 4 km per liter, calculated on the basis of survey data and Yutong (2023). In addition, a diesel bus normally consumes 19–24 L per 100 km (Vodovozov et al., 2022) and according to Yutong (2023), a city bus consumes 25 to 30 liters per 100km (Yutong, 2023).

3.4.4. Average Fuel Cost Per Liter

The average per liter fuel cost of private vehicles is Rs. 266, calculated on the basis of petrol price from 29 May 2023 to 05 June 2023. However, the average per liter fuel cost of public transport is Rs. 255.5, calculated on the basis of diesel price from 29 May 2023 to 05 June 2023 (OGRA, 2023).

3.4.5. CO2 Emissions

According to the Environmental Protection Agency (2020) and Autolexicon (2023), the CO_2 emission in petrol per liter is 2392 grams, and the CO_2 emission in diesel per liter is 2640 grams. In addition, the same scale is used by Naqvi (2017) in the study of transport sector environmental impact analysis.

3.4.6. Features of Private and Public Transport

Following are the characteristics of private and public transport for this study. All computations in this study are based on the features listed below in Table 3.5.

Table 3.5 Features of Private and Public Transport

	Private Vehicles	Public Transport
Type	Cars, SUVs, Jeeps, etc.	Bus
Average Seating Capacity	5	46
Average Passengers	2	46
Fuel Type	Petrol	Diesel
Average Oil Consumption	11.37 km per liter	4 km per liter
Average Fuel Cost	266 Rs.	255.5 Rs.
CO2 Emissions in Grams	2392 grams per liter petrol consumption	2640 grams per liter diesel consumption

3.4.7. Pre-Shifting

In the pre-shifting scenario, the study initially determines the average number of passengers per private vehicle, the average oil consumption of private vehicles in liters, the average distance traveled in kilometers, the average petrol price, and the CO_2 emitted by one-liter petrol consumption. After that, the present study calculates the total number of passengers, the total distance traveled in kilometers, total oil consumption, total fuel cost, and total CO2 emissions based on the private vehicle flow in each location using various formulas in Microsoft Excel.

The formulas presented in Table 3.6 are used in this study for determining the pre-shifting scenario in which the peak areeurs private vehicles flow across 15 intracity locations in Islamabad and its impact on number of passengers, travel km, oil consumption, CO2 emission, and fuel cost is created.

Table 3.6 Pre-Shifting Formulas

Variables	Formulas
Total Private Vehicles Flow	Total East to West Flow + Total West to East Flow
Travel (Km) by Private Vehicles	Total Private Vehicles × Road Length
Private Vehicles Oil Consumption	$\frac{\text{Travel Km}}{\text{Private Vehicles Average Oil Consumption}}$
CO2 Emissions in Grams	Oil Consumption × CO2 Emissions Petrol Per Liter
CO2 Emissions in Metric Tons	$\frac{\text{CO2 Emissions in Grams}}{1{,}000{,}000}$
Private Vehicle Passengers	Private Vehicles × Average Passengers Per Vehicle
Private Vehicles Fuel Cost	Oil Consumption in Liters × Average Petrol Price

Source: Author's Deviation

3.4.8. Post-Shifting

In the post-shifting phase, the study assesses the number of private vehicles replaced by one public transport, the average number of passengers per public transport, the average oil consumption of public transport in liters, the average diesel price, and the CO2 emitted per liter diesel consumption. Afterward, the present study estimates the sum of each impact and then determines the change in the number of vehicles, change in travel kilometers, change in oil consumption, change in fuel cost, and change in CO_2 emissions due to shifting private vehicles to public transport with the help of different formulas using Microsoft Excel.

The formulas presented in Table 3.7 are used in this study for determining the post-shifting scenario in which the peak hours private vehicles flow across 15 intracity locations in Islamabad is shifted to public transport and its impact on number of passengers, travel km, oil consumption, CO_2 emission, and fuel cost is created.

Number of private vehicles replaced by 1 bus = 23 private vehicles

Table 3.7 Post-Shifting Formulas

Variables	Formulas
Total Public Transport	$\frac{\text{Total Private Vehicles}}{\text{Number of Private Vehicles Replaces by 1 Bus}}$
Travel (Km) by Public Transport	Public Transport (Number of Buses) × Road Length
Public Transport Oil Consumption	$\frac{\text{Travel km by Public Transport}}{\text{Public Transport Average Oil Consumption}}$
Public Transport CO2 Emissions in Grams	Public Transport Oil Consumption × CO2 Emissions Diesel Per Liter (2,640)
CO2 Emissions in Metric Tons	$\frac{\text{CO2 Emissions in Grams}}{1{,}000{,}000}$
Public Transport Passengers	Public Transport (Number of Buses) × Passengers Per Bus
Fuel Cost	Public Transport Oil Consumption in Liters × Average Diesel Price Per Liter

3.4.9. Differences in Values

Table 3.8 Differences in Value Formulas

Variables	Formulas
Number of Passengers	Pre-Shifting Passengers - Post-Shifting Passengers
Number of Vehicles	Pre-Shifting Vehicles - Post-Shifting Vehicles
Travel in Kilometers	Pre-Shifting Travel - Post-Shifting Travel
Oil Consumption in Liters	Pre-Shifting Oil Consumption - Post-Shifting Oil Consumption
CO2 Emissions in Metric Tons	Pre-Shifting CO2 Emissions - Post-Shifting CO2 Emissions
Fuel Cost in Rupees	Pre-Shifting Fuel Cost - Post-Shifting Fuel Cost

The formulas presented in Table 3.8 are used in this study to determine the pre-shifting and post-shifting differences in values for all shifting scenarios.

3.4.10. Percentage Difference

Table 3.9 Percentage Difference Formulas

Variables	Formulas
Number of Passengers	$\frac{\text{Passengers Difference in Values}}{\text{Pre} - \text{Shifting Passengers}} \times 100$
Number of Vehicles	$\frac{\text{Vehicles Difference in Values}}{\text{Pre} - \text{Shifting Vehicles}} \times 100$
Travel in Kilometers	$\frac{\text{Travel Difference in Values}}{\text{Pre} - \text{Shifting Travel}} \times 100$
Oil Consumption in Liters	$\frac{\text{Oil Consumption Difference in Values}}{\text{Pre} - \text{Shifting Oil Consumption}} \times 100$
CO2 Emissions in Metric Tons	$\frac{\text{CO2 Emissions Difference in Values}}{\text{Pre} - \text{Shifting CO2 Emissions}} \times 100$
Fuel Cost in Rupees	$\frac{\text{Fuel Cost Difference in Values}}{\text{Pre} - \text{Shifting Fuel Cost}} \times 100$

3.4.11. Calculation of Scenario 1

In scenario 1, all private vehicles during peak hours in each of the 15 locations are shifted to public transport.

Scenario 1 = 100% PT (P, TD, OC, CE, FC)

Where

PT is public transport,

P is passengers,

TD is the travel distance,

OC is oil consumption,

CE is CO2 emissions,

FC is fuel cost.

In this scenario, shifting all private vehicles to public transport and its impact on associated variables i.e. P, TD, OC, CE, and FC is created.

3.4.12. Calculation of Scenario 2

In the second scenario, 90 percent flow of private vehicles during peak hours in each of the 15 locations is shifted to public transport. Nevertheless, 10 percent of private vehicles continue to be utilized in all locations.

Scenario 2 = 90%PT (P, TD, OC, CE, FC) + 10%PV (P, TD, OC, CE, FC)

Where

90%PT is 90 percent public transport,

P is passengers,

TD is the travel distance,

OC is oil consumption,

CE is CO2 emissions,

FC is fuel cost,

10%PV is 10 percent private vehicles.

In this scenario, shifting 90 percent of private vehicles to public transport and its impact on associated variables i.e. P, TD, OC, CE, and FC are added to the impact of 10 percent of private vehicles on associated variables i.e. P, TD, OC, CE, and FC, and a 90 percent post-shift scenario is created.

3.4.13. Calculation of Scenario 3

In the third scenario, the flow of private vehicles during peak hours on all five working days (Monday to Friday) in each of the 15 locations is shifted to public transport. Nevertheless, private vehicles continue to be utilized during non-working days or weekends (Saturday and Sunday).

Scenario 3 = WDPT (P, TD, OC, CE, FC) + NWDPV (P, TD, OC, CE, FC)

Where

WDPT is working days public transport,

P is passengers,

TD is the travel distance,

OC is oil consumption,

CE is CO_2 emissions,

FC is fuel cost,

NWDPV is non-working days private vehicles.

In this scenario, shifting private vehicles to public transport on working days and its impact on associated variables i.e. P, TD, OC, CE, and FC are added to the impact of non-working days or off days private vehicles on associated variables i.e. P, TD, OC, CE, and FC, and a working day's post-shift scenario is created.

3.4.14. Calculation of Other Scenarios

In other scenarios, the proportion of private vehicles corresponding to each scenario is shifted to public transport and the remaining proportion of private vehicles continues to be used.

Other Scenarios = ***(x)*** % of PT (P, TD, OC, CE, FC) + ***(y)*** % of PV (P, TD, OC, CE, FC)

Where

(x) is the percentage shifting of private vehicles to public transport corresponding to each scenario,

(y) is the remaining proportion of private vehicles continuing to be used corresponding to each scenario,

P is passengers,

TD is the travel distance,

OC is oil consumption,

CE is CO2 emissions,

FC is fuel cost.

In other scenarios, shifting ***(x)*** percent of private vehicles to public transport and its impact on associated variables i.e. P, TD, OC, CE, and FC are added to the impact of ***(y)*** percent of private vehicles on associated variables i.e. P, TD, OC, CE, and FC, and a ***(x)*** percent post-shift scenario is created.

3.5. Summary of the Chapter

The present chapter of the dissertation elucidates the study area description, research design of the study which includes the purpose of the study, research method, research approach, unit of analysis, study population, sampling frame, sample size, sampling technique, sample locations, types, sources, and collection of data, methodology process and data analysis tools. Further, this chapter deals with the shifting scenarios calculations.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Introduction

This chapter depicts the data description of registered vehicles in Islamabad and private vehicles flow in Islamabad and shows the results of descriptive statistics, independent sample t-test, and one-way way ANOVA test. In addition, this chapter demonstrates the results of shifting private vehicles to public transport by creating different scenarios. The study uses private vehicle flow data from 29 May 2023 to 4 June 2023 and the sample consists of 15 intra-city locations in Islamabad. However, this study receives data on private vehicle flow from Safe City Islamabad brief cam software (Safe City Islamabad).

The present section 4.1 illustrates the theme of the chapter and summarizes the structure of the rest of the chapter. Section 4.2 demonstrates the data description section. Further section 4.2.1 shows the description of registered vehicles in Islamabad and section 4.2.2 provides the data description of private vehicle flow and is divided into sub-sections 4.2.2.1 and 4.2.2.2 which shows duration-wise and day-wise data description of private vehicles. Sub-section 4.2.2.3 demonstrates the data normality graphs and sub-section 4.2.2.4 illuminates the outliers in the data. Section 4.4.3 depicts the data analysis and is divided into further 2 sub-sections. The descriptive statistics and independent sample t-test results in 4.4.3.1 and descriptive statistics and one-way ANOVA test results in 4.4.3.2. In addition, section 4.4 illuminates the shifting scenario results. The results of the weekly pre-shifting scenario are in section 4.4.1 and shifting of all private vehicles to public transport results in 4.4.2. Sub-section 4.4.2.1 describes the weekly pre- and post-shifting graphs of 100 percent shifting. Sub-section 4.4.2.2

depicts the weekly impacts of 100 percent shifting. Sub-section 4.4.2.3 demonstrates the daily impacts of 100 percent shifting. Sub-section 4.4.2.4 shows the annual impacts of 100 percent shifting. Further, section 4.4.3 illustrates the results of 90 percent shifting to public transport. Sub-section 4.4.3.1 provides the weekly pre- and post-shifting graphs of 90 percent shifting. Sub-section 4.4.3.2 demonstrates the weekly impacts of 90 percent shifting. Sub-section 4.4.3.3 elaborates on the daily impacts of a 90 percent shift. However, ub-section 4.4.3.4 illuminates the annual impacts of 90 percent shifting.

Moreover, section 4.4.4 describes the weekdays (working days) shifting to public transport results. Sub-section 4.4.4.1 demonstrates the working days shifting impacts on vehicles. Sub-section 4.4.4.2 illuminates the working days' shifting impacts on travel. Sub-section 4.4.4.3 describes the working days' shifting impacts on oil consumption. Sub-section 4.4.4.4 illustrates the working days' shifting impacts on CO2 emissions and sub-section 4.4.4.5 depicts the working days' shifting impacts on fuel cost. Further, other percentage shifting scenarios are in section 4.4.5 and this section is divided into 8 sub-sections. The findings of 80 percent shifting to public transport in sub-section 4.4.5.1. The impacts of 70 percent shifting to public transport in sub-section 4.4.5.2. The results of 60 percent shifting to public transport in sub-section 4.4.5.3. However, sub-section 4.4.5.4 demonstrates the results of a 50 percent shift to public transport. Sub-section 4.4.5.5 illustrates the impacts of a 40 percent shift to public transport. Sub-section 4.4.5.6 describes the findings of 30 percent shifting to public transport. Sub-section 4.4 5.7 depicts the impacts of 20 percent shifting to public transport and sub-section 4.4.5.8 demonstrates the results of 10 percent shifting to public transport. The summary of percentage shifting key results is in section 4.4.6 and the key summary results of weekdays' shifting is in section 4.4.7. Additionally, section

4.5 provides discussions of the results. However, section 4.6 illuminates the summary of the chapter.

4.2. Data Description

The data description of registered private vehicles in Islamabad based on ownership categories is shown in Table 4.1 and Table 4.2.

4.2.1. Registered Vehicles in Islamabad

Table 4.1. Number of Registered Vehicles in Islamabad (1980 – 2023)

Category	Non-Govt.	Commercial	Government	Total
Jeep	87095	0	1877	88972
Wagon	1312	2352	850	4514
Car	741960	164	9404	751528
Taxi	11	3834	0	3845
Total	830378	6350	12131	848859

Note. Non-Govt. stands for non-government vehicles, which are basically private vehicles owned by the people for their personal use. Commercial vehicles are ones that are used as public transport. Government vehicles are ones that are provided to government officials.
Source: Excise and Taxation Department, Islamabad

Table 4.1 demonstrates the number of registered vehicles in Islamabad from 1st January 1980 to 26th June 2023. All vehicle categories described in Table 4.1 are treated as small vehicles or cars. The horizontal total values demonstrate the total vehicles based on vehicle type i.e. total jeeps, total wagons, total cars, and total taxis. However, the vertical total values depict the total vehicles based on vehicle ownership i.e. non-govt., commercial, and government. In addition, most private vehicles are non-government vehicles. However, only 11 taxis are registered as non-government (private) vehicles. The total number of registered private vehicles and cars, including taxis, is 8,48,859. The purpose of giving data on all three categories is to classify private vehicles or cars on the road.

Table 4.2 Percentage of Registered Vehicles in Islamabad (1980 – 2023)

category	Non-Govt.	Commercial	Government	Total
Jeep	97.89%	0.00%	2.11%	10.48%
Wagon	29.07%	52.10%	18.83%	0.53%
Car	98.73%	0.02%	1.25%	88.53%
Taxi	0.29%	99.71%	0.00%	0.45%
Total	97.82%	0.75%	1.43%	100.00%

Note. Non-Govt. stands for non-government vehicles, which are basically private vehicles owned by the public for their personal use. Commercial vehicles are ones that are used as public transport. Government vehicles are ones that are provided to government officials.
Source: Excise and Taxation Department, Islamabad

Table 4.2 demonstrates the categorical percentage of registered vehicles in Islamabad from 1st January 1980 to 26 June 2023. The horizontal total demonstrates the percentage of total vehicles based on vehicle type i.e. total jeeps, total wagons, total cars, and total taxis. However, the vertical total depicts the percentage of total vehicles based on vehicle ownership i.e. non-govt., commercial, and government. Above all vehicle types, cars have the most substantial percentage pertaining to 88.53 percent. However, above all vehicle ownership categories, non-govt. contains the most substantial percentage, accounting for 97.82 percent. These percentages depict that the general population owns the most significant number of cars in Islamabad. In addition, commercial vehicles constitute a relatively small fraction of the total number of vehicles in Islamabad. Consequently, most cars in Islamabad are primarily utilized for private or personal purposes.

4.2.2. Data Description – Private Vehicles Flow

Private vehicle traffic flow or countdown data is described in two ways. First, duration-wise data description, and second, day-wise data description.

4.2.2.1. Data Description: Duration-Wise

In time or duration-based data description, the data is organized into three distinct categories based on variations in time. In this context, bar charts visually depict day-to-day fluctuations in the count of private vehicles during each time period.

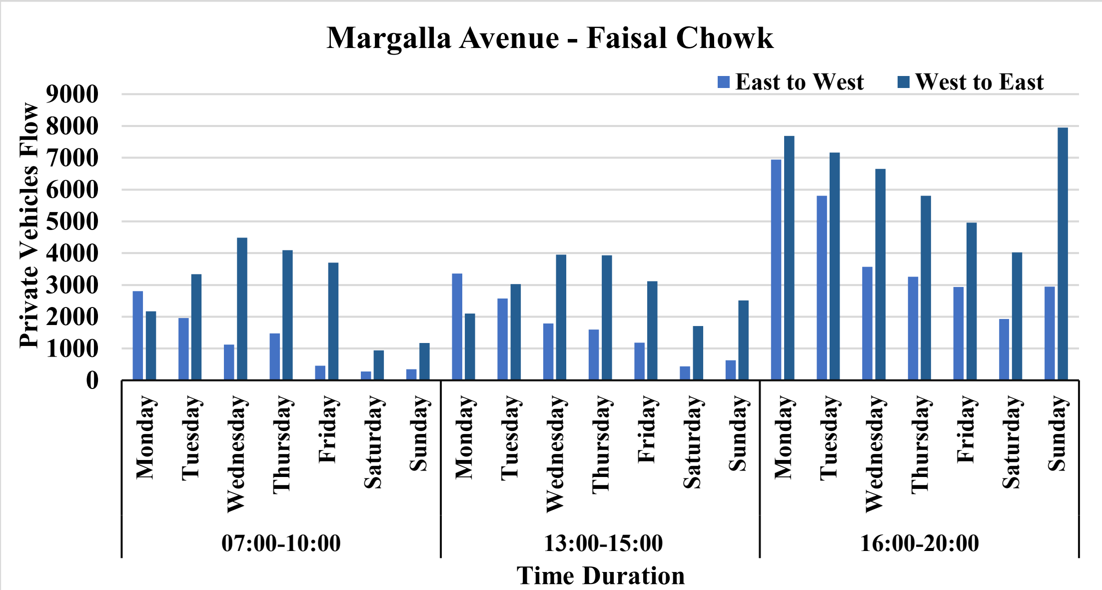


Figure 4.1 Duration-Wise Margalla Avenue – Faisal Chowk

Figure 4.1 depicts the graphical representation of private vehicle flow at Faisal Chowk, situated on Margalla Avenue in Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest level on Wednesday, reaching a peak of 4,490 vehicles from the West to East direction. In contrast, the lowest private vehicle flow exhibits on Saturday with a recorded count of 278 vehicles from the East to West direction throughout the entire week.

During the afternoon, from 13:00 to 15:00, the private vehicle flow again exhibits its highest level on Wednesday, reaching 3,951 vehicles from the West to East direction. However, the lowest private vehicle flow exhibits on Saturday with a recorded count of 437 vehicles from the East to West direction throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic volume exhibits its highest levels on Sunday, reaching a peak of 7,946 vehicles from the West to East direction. Conversely, the lowest private vehicle flow exhibits on Saturday with a recorded count of 1,925 vehicles from East to West direction throughout the entire week.

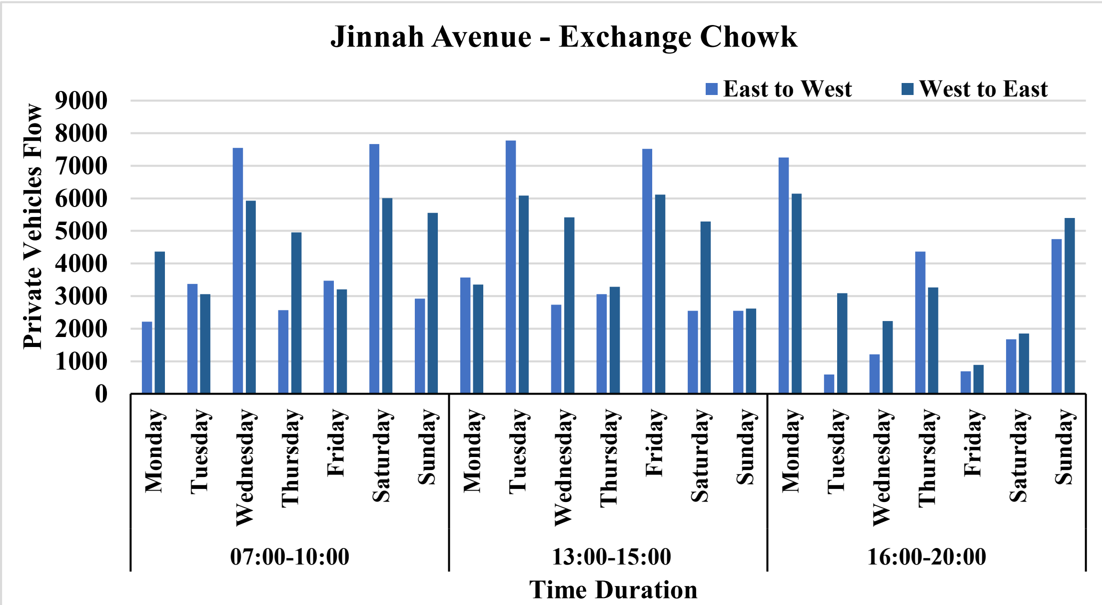


Figure 4.2 Duration-Wise Jinnah Avenue – Exchange Chowk

Figure 4.2 discloses the graphical representation of private vehicle flow at Exchange Chowk on Jinnah Avenue, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Saturday, reaching a peak of 7,663 vehicles from the West to East direction. In contrast, the East to West direction exhibits the lowest private vehicle flow, with a recorded count of 2,211 vehicles on Monday in the entire week. In contrast, the lowest private vehicle flow exhibits on Monday with a recorded count of 2,211 vehicles from the East to West direction throughout the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow is at its peak on Tuesday, reaching 7,776 vehicles from East to West direction. In contrast, the lowest private vehicle flow exhibits on Sunday, with a recorded count of 2,549 vehicles from the East to West direction throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Monday, reaching a peak of 7,255 vehicles from the East to West direction. In contrast, the lowest private vehicle flow exhibits on Tuesday, with a recorded count of 590 vehicles from the East to West direction throughout the entire week.

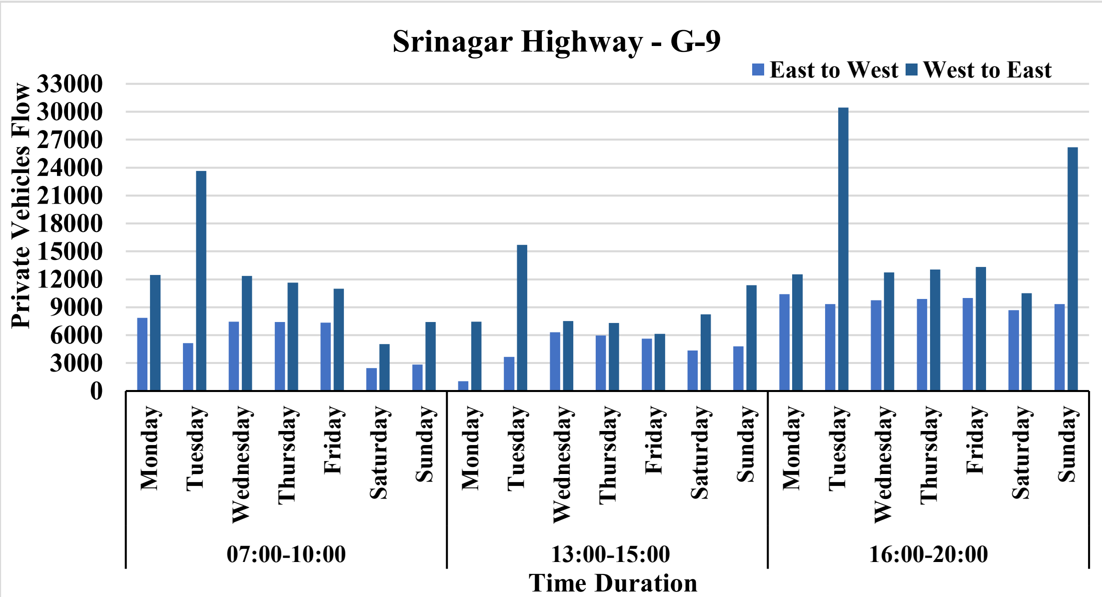


Figure 4.3 Duration-Wise Srinagar Highway – G-9

Figure 4.3 demonstrates the graphical representation of private vehicle flow at the G-9 point on Srinagar Highway, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the traffic volume of private vehicles exhibits its highest levels on Tuesday, reaching a peak of 23,659 vehicles from West to East. In contrast, the lowest private vehicle flow arises on Saturday, with a recorded count of 23,659 vehicles from West to East throughout the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow is again at its peak on Tuesday, reaching 15,687 vehicles from West to East direction.

In contrast, the lowest private vehicle flow arises on Monday, with a recorded count of 1,036 vehicles from East to West throughout the entire week.

However, in the evening, from 16:00 to 20:00, the traffic of private vehicles exhibits its highest levels on Tuesday, reaching a peak of 30,445 vehicles from West to East. In contrast, the lowest private vehicle flow arose on Saturday, with a recorded count of 8,685 vehicles from East to West throughout the entire week.

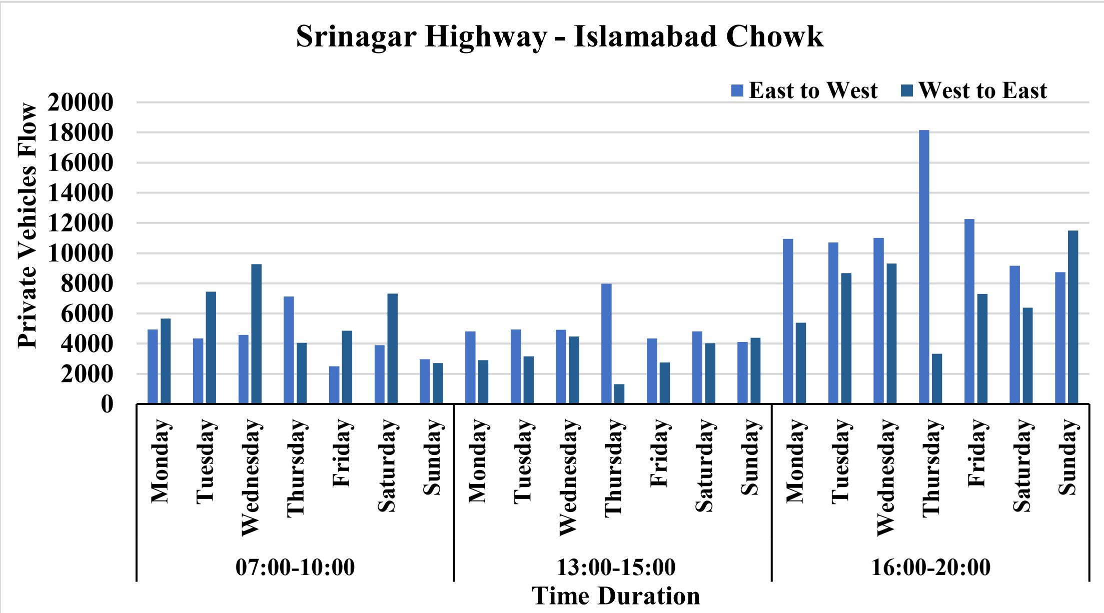


Figure 4.4 Duration-Wise Srinagar Highway – Islamabad Chowk

Figure 4.4 represents private vehicle flow at the Islamabad Chowk on Srinagar Highway, Islamabad. The bar chart reveals that between the hours of 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 9,279 vehicles from the West to East direction. In contrast, the lowest private vehicle flow occurs on Friday, with a recorded count of 2,498 vehicles from the East to West direction throughout the entire week.

During the afternoon, from 13:00 to 15:00, the private vehicle flow is again at its peak on Thursday, reaching 7,976 vehicles from East to West direction. Conversely, the lowest private vehicle flow arises on Thursday, with a recorded count of 1,304 vehicles from West to East throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibited its highest levels on Thursday day, reaching a peak of 18,163 vehicles from the East to West direction. In contrast, the lowest private vehicle flow arises on Thursday, with a recorded count of 3,318 vehicles from West to East throughout the entire week.

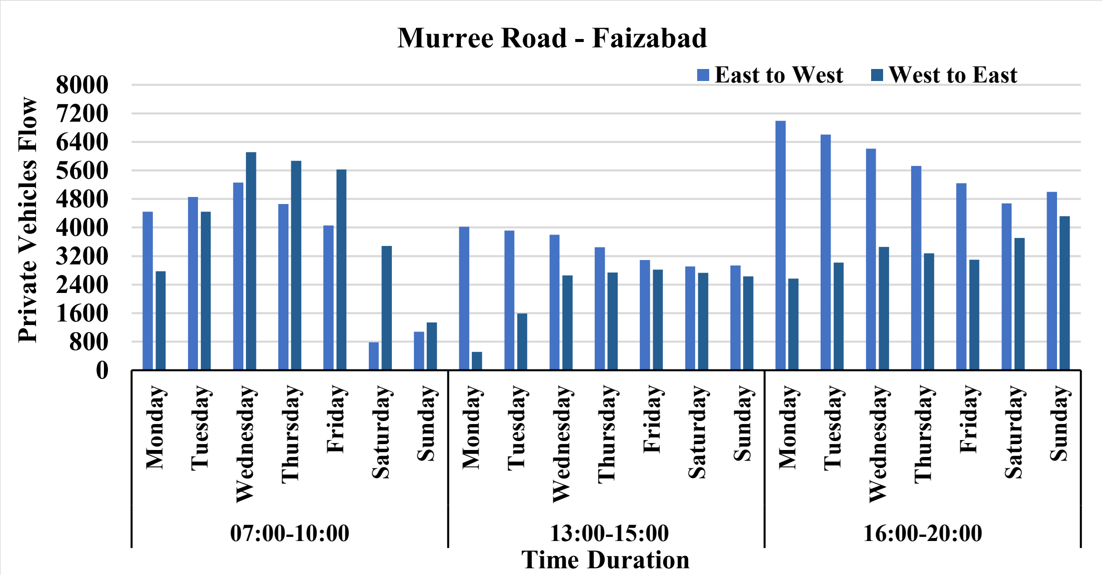


Figure 4.5 Duration-Wise Murree Road - Faizabad

Figure 4.5 discloses the graphical representation of private vehicle flow at the Faizabad point on Murree Road in Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 6,114 vehicles from the West to East direction. In contrast, the lowest private vehicle flow arises on Saturday, with a recorded count of 785 vehicles from East to West throughout the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow is at its peak on Monday, reaching 4,022 vehicles from East to West direction. In contrast, the lowest private vehicle flow arises on Monday, with a recorded count of 511 vehicles from West to East throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Monday, reaching a peak of 6,993 vehicles from the east to west direction. In contrast, the lowest private vehicle flow arises on Monday, with a recorded count of 2,566 vehicles from West to East throughout the entire week.

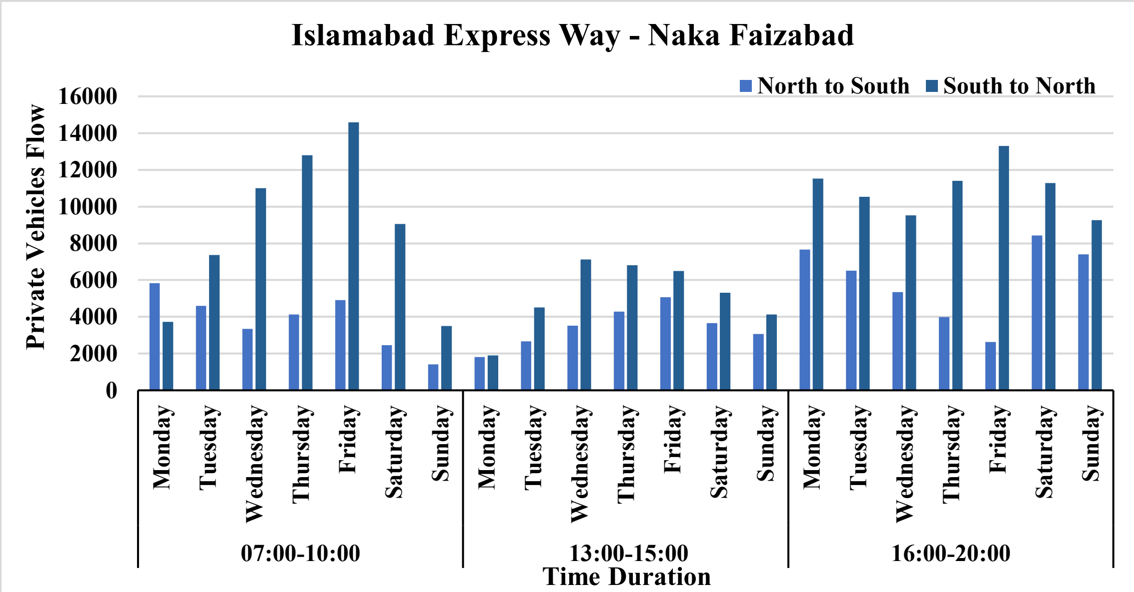


Figure 4.6 Duration-Wise Islamabad Express Way – Naka Faizabad

Figure 4.6 represents private vehicle flow at the Naka Faizabad point on Islamabad Express Way. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Friday, reaching a peak of 14,589 vehicles from the South to North direction. In contrast, the lowest private vehicle flow arises on Sunday, with a recorded count of 1,408 vehicles from North to South throughout the entire week.

During the afternoon, from 13:00 to 15:00, the private vehicle flow peaks on Wednesday, reaching 7,125 vehicles from the South to North direction. Conversely, the lowest private vehicle flow arises on Monday, with a recorded count of 1,808 vehicles from North to South throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibited its highest levels on Friday, reaching a peak of 13,239 vehicles from the South to North direction. Conversely, the lowest private vehicle flow arises on Friday, with a recorded count of 2,624 vehicles from North to South throughout the entire week.

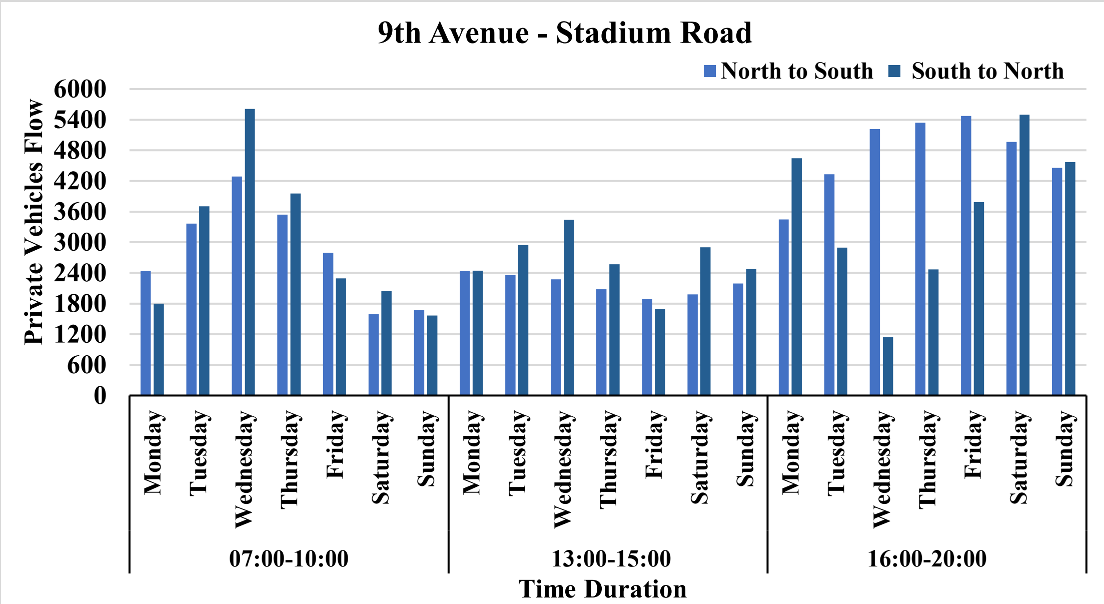


Figure 4.7 Duration-Wise 9th Avenue – Stadium Road

Figure 4.7 demonstrates the graphical representation of private vehicle flow at Stadium Road on 9th Avenue. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 5,612 vehicles from the South to North direction. Conversely, the lowest private vehicle flow arises on Sunday, with a recorded count of 1,567 vehicles from South to North throughout the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Wednesday, reaching 3,441 vehicles from the South to North direction. However, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 1,696 vehicles on Friday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Saturday, reaching a peak of 5,497 vehicles from the South to North direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 1,146 vehicles on Wednesday in the entire week.

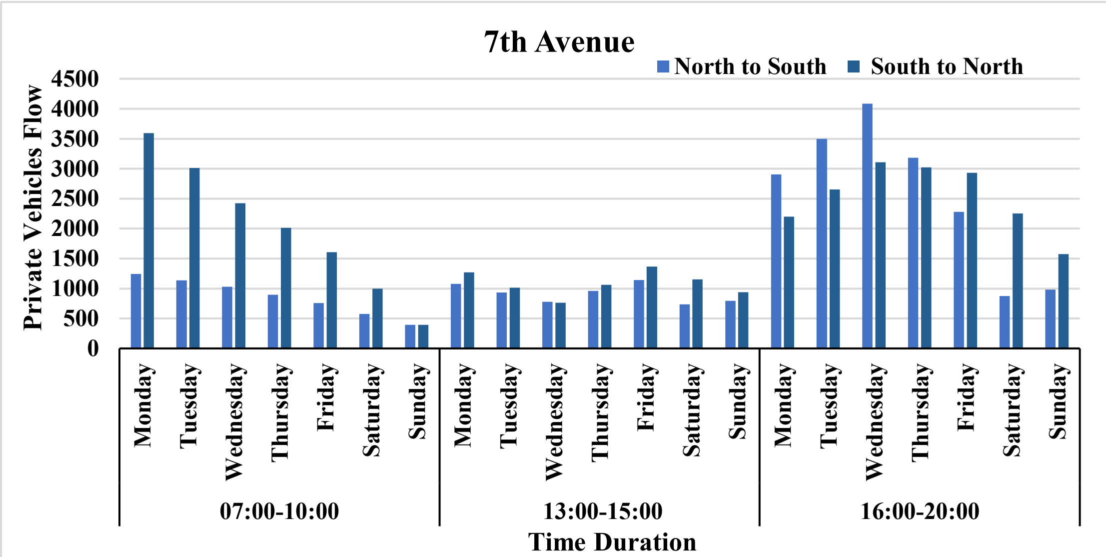


Figure 4.8 Duration-Wise 7th Avenue

Figure 4.8 depicts the graphical representation of private vehicle flow at 7th Avenue, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Monday, reaching a peak of 3,596 vehicles from the South to North direction. In contrast, both South to North and North to South exhibit the lowest private vehicle flow, with a recorded count of 393 vehicles on Sunday during the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Friday, reaching 1,366 vehicles from the South to North direction. Conversely, the North to South direction exhibits the lowest private vehicle flow, with a recorded count of 734 vehicles on Saturday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Wednesday, reaching a peak of 4,086 vehicles from the North to South direction. Conversely, the lowest private vehicle flow arises on Saturday, with a recorded count of 877 vehicles from North to South throughout the entire week.

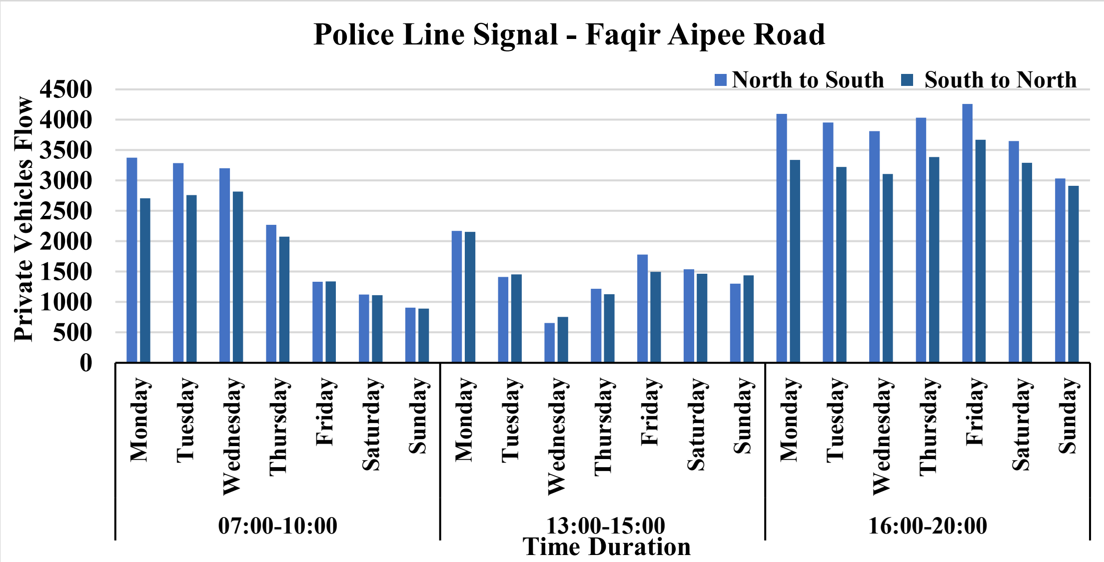


Figure 4.9. Duration-Wise Police Line Signal – Faqir Aipee Road

Figure 4.9 illustrates the graphical representation of private vehicle flow at Faqir Aipee Road from Police Line Signal, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Monday, reaching a peak of 3,376 vehicles from the North to South direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 891 vehicles on Sunday in the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Monday, reaching 2,173 vehicles from the North to South direction. Conversely, the North to South direction exhibits the lowest private vehicle flow, with a recorded count of 657 vehicles on Wednesday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Friday, reaching a peak of 4,259 vehicles from the North to South direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 2,911 vehicles on Sunday in the entire week.

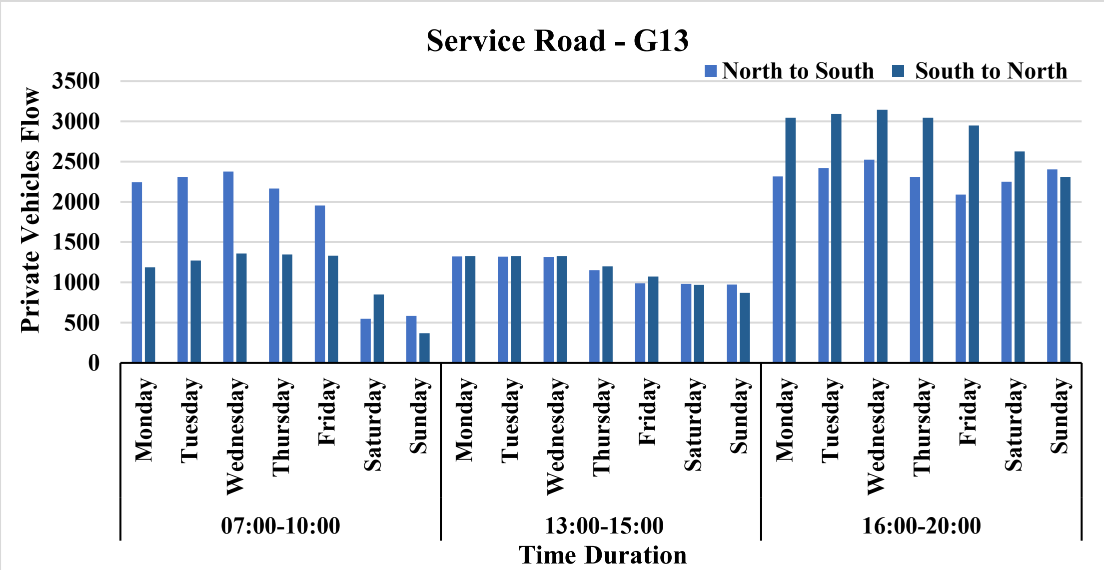


Figure 4.10. Duration-Wise Service Road – G-13

Figure 4.10 disclose the graphical representation of private vehicle flow at Service Road from G13, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 2,376 vehicles from the North to South direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 368 vehicles on Sunday in the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Monday, reaching 1,329 vehicles from the South to North direction. Conversely, the lowest private vehicle flow arises on Sunday, with a recorded count of 869 vehicles from South to North throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Wednesday, reaching a peak of 3,144 vehicles from the South to North direction. Conversely, the lowest private vehicle flow arises on Friday, with a recorded count of 2,091 vehicles from South to North throughout the entire week.

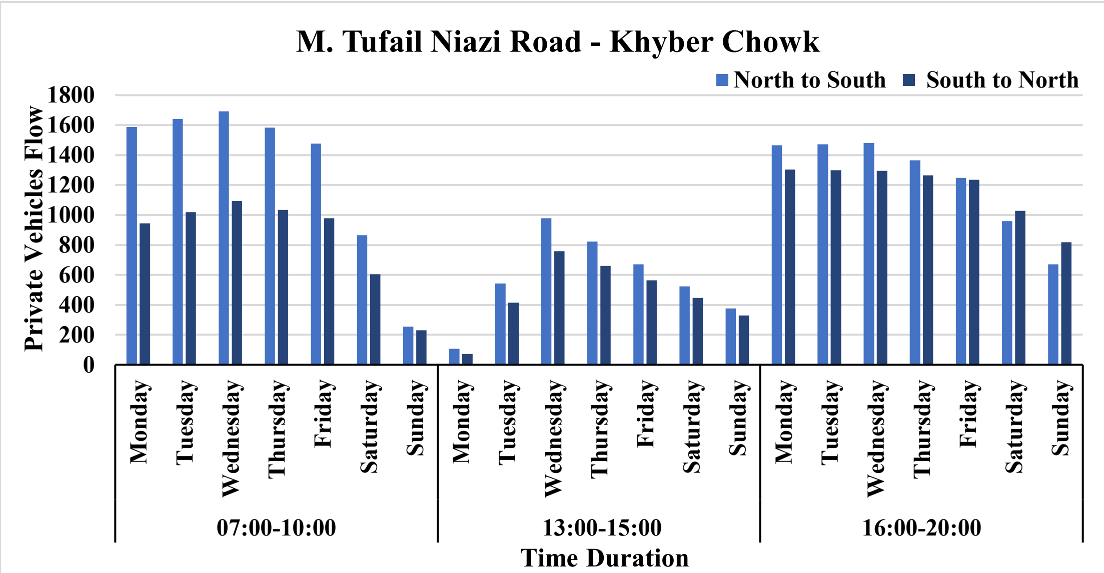


Figure 4.11. Duration-Wise M. Tufail Niazi Road – Khyber Chowk

Figure 4.11 depicts the graphical representation of private vehicle flow at M. Tufail Niazi Road from Khyber Chowk, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 1,692 vehicles from the North to South direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 230 vehicles on Sunday in the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow is again at its peak on Wednesday, reaching 1,329 vehicles from the North to South direction. Conversely, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 72 vehicles on Monday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Wednesday, reaching a peak of 1,481 vehicles from the North to South direction. Conversely, the lowest private vehicle flow arises on Sunday, with a recorded count of 670 vehicles from North to South throughout the entire week.

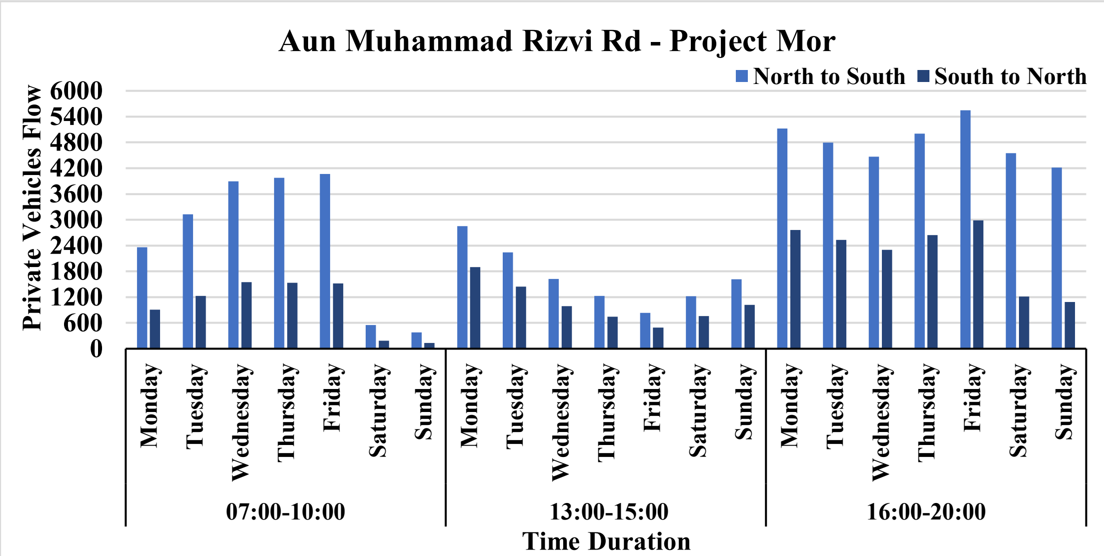


Figure 4.12. Duration-Wise Aun Muhammad Rizvi Road

Figure 4.12 shows the graphical representation of private vehicle flow at Aun Muhammad Rizvi Road from Project Morr, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Friday, reaching a peak of 4,063 vehicles from the North to South direction. Conversely, the lowest private vehicle flow arises on Sunday, with a recorded count of 133 vehicles from North to South throughout the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Monday, reaching 2,853 vehicles from the North to South direction. Conversely, the lowest private vehicle flow arises on Friday, with a recorded count of 495 vehicles from South to North throughout the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Friday, reaching a peak of 5,548 vehicles from the North to South direction. In contrast, the South to North direction exhibits the lowest private vehicle flow, with a recorded count of 1,085 vehicles on Sunday in the entire week.

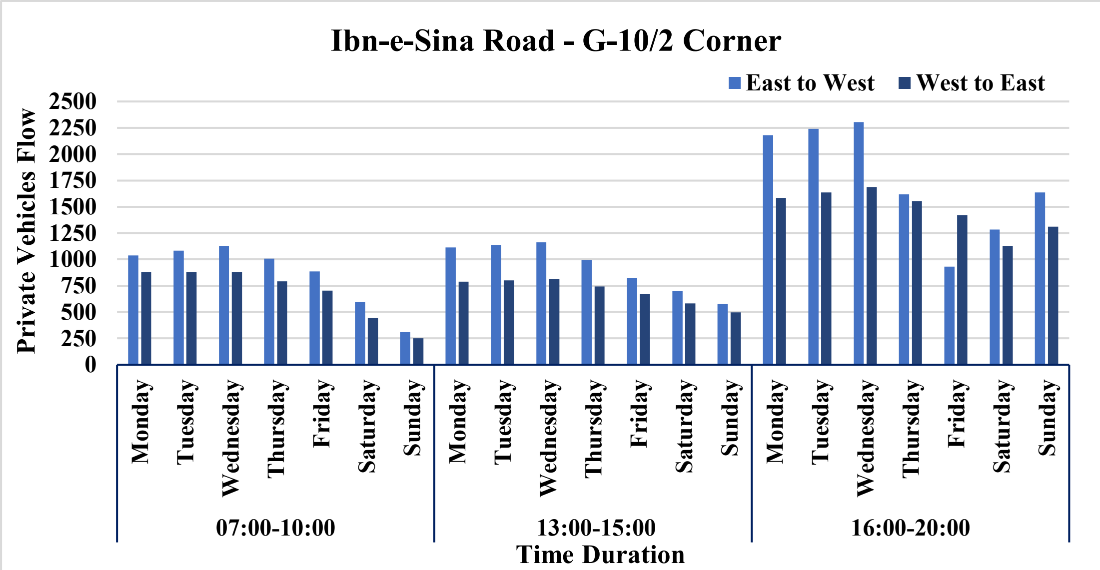


Figure 4.13. Duration-Wise Ibn-e-Sina Road – G-10/2 Corner

Figure 4.13 illustrates the graphical representation of private vehicle flow at Ibn-e-Sina Road from G-10/2, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 1,130 vehicles from the East to West direction. In contrast, the West to East direction exhibits the lowest private vehicle flow, with a recorded count of 251 vehicles on Sunday in the entire week.

During the afternoon, from 13:00 to 15:00, the private vehicle flow peaks on Wednesday, reaching 1,163 vehicles from the East to West direction. Conversely, the West to East direction exhibits the lowest private vehicle flow, with a recorded count of 496 vehicles on Sunday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Wednesday, reaching a peak of 2,303 vehicles from the West to East direction. In contrast, the East to West direction exhibits the lowest number of private vehicles, with a recorded count of 932 on Friday throughout the entire week.

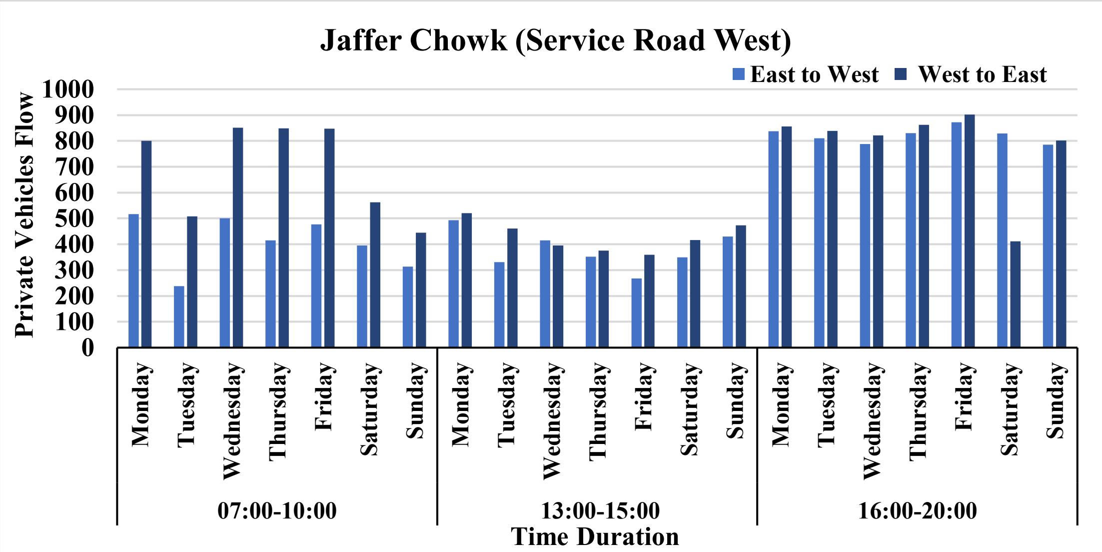


Figure 4.14. Duration-Wise Jaffer Chowk (Service Road West)

Figure 4.14 depicts the graphical representation of private vehicle flow at Service Road West from Jaffer Chowk, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Wednesday, reaching a peak of 851 vehicles from the West to East direction. In contrast, the East to West direction exhibits the lowest private vehicle flow, with a recorded count of 239 vehicles on Tuesday in the entire week.

During the afternoon time duration of 13:00 to 15:00, the private vehicle flow peaks on Monday, reaching 521 vehicles from the West to East direction. Conversely, the East to West direction exhibits the lowest private vehicle flow, with a recorded count of 268 vehicles on Friday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Friday, reaching a peak of 902 vehicles from the West to East direction. Conversely, the lowest private vehicle flow arises on Saturday, with a recorded count of 411 vehicles from West to East throughout the entire week.

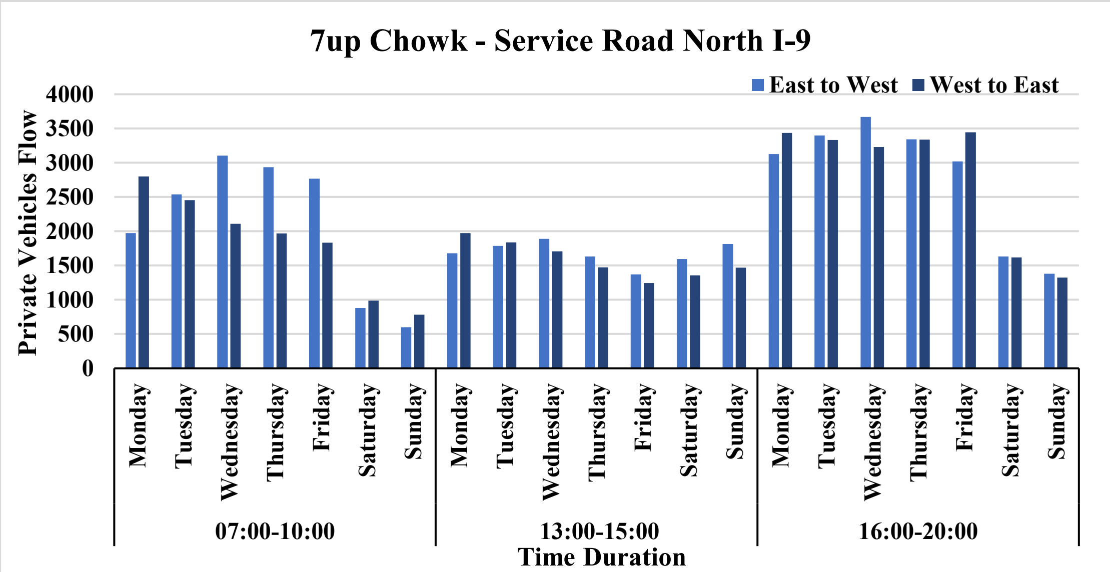


Figure 4.15 Duration-Wise. 7up Chowk – Service Road North I-9

Figure 4.15 demonstrates the graphical representation of private vehicle flow at Service Road North I-9 from 7up Chowk, Islamabad. The bar chart reveals that between 07:00 and 10:00 in the morning, the private vehicle traffic volume exhibits its highest levels on Tuesday, reaching a peak of 3,103 vehicles from the East to West direction. Conversely, the lowest private vehicle flow arises on Saturday, with a recorded count of 602 vehicles from East to West throughout the entire week.

During the afternoon, from 13:00 to 15:00, the private vehicle flow peaks on Tuesday, reaching 1,891 vehicles from the East to West direction. Conversely, the West to East direction exhibits the lowest private vehicle flow, with a recorded count of 1243 vehicles on Thursday in the entire week.

However, in the evening, from 16:00 to 20:00, the private vehicle traffic flow exhibits its highest levels on Wednesday, reaching a peak of 3,670 vehicles from the

East to West direction. In contrast, the West to East direction exhibits the lowest private vehicle flow, with a recorded count of 1,324 vehicles on Sunday in the entire week.

4.2.2.2. Data Description: Day-Wise

In the context of day-wise data description, the data is arranged into seven distinct categories based on the days in a week. In this context, bar charts visually represent the duration-based (time to time) fluctuations in the flow of private vehicles during each day.

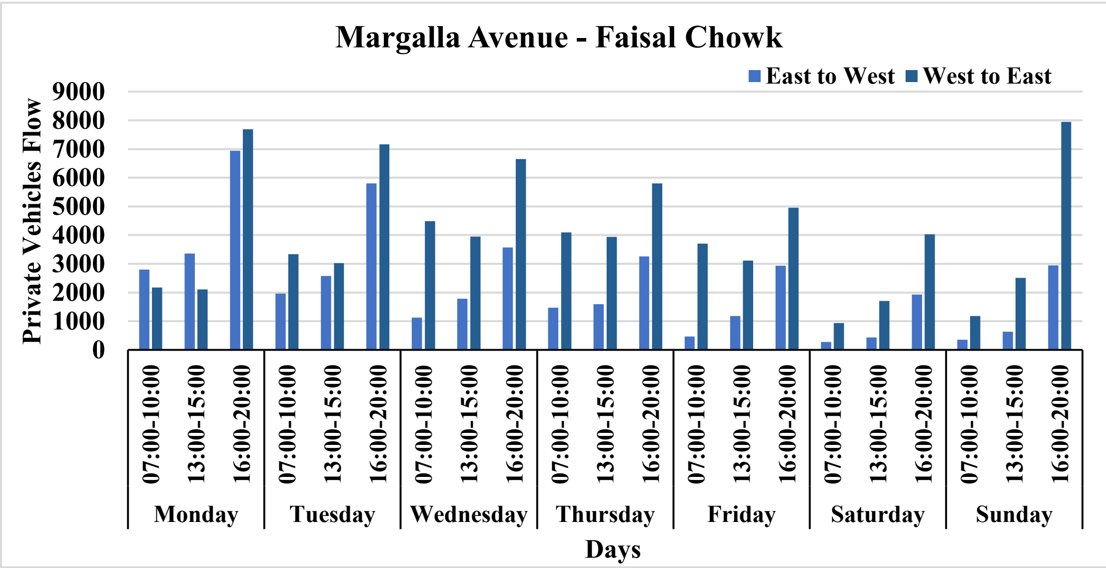


Figure 4.16. Day-Wise Margalla Avenue - Faisal Chowk

Figure 4.16 depicts the day-wise graphical representation of private vehicle flow at Faisal Chowk, situated on Margalla Avenue, Islamabad. The bar chart reveals that the period between 16:00 and 20:00 has the most substantial volume of private vehicle traffic in both the East to West and West to East directions at Faisal Chowk, Margalla Avenue throughout the entire week.

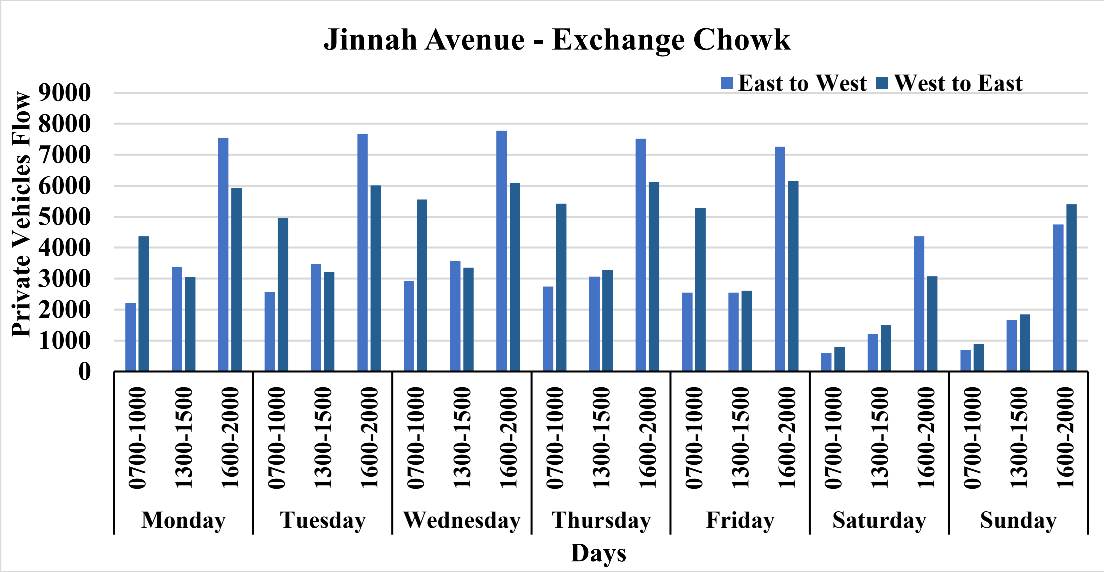


Figure 4.17 Day-Wise Jinnah Avenue – Exchange Chowk

Figure 4.17 illustrates the day-wise private vehicle flow at Exchange Chowk on Jinnah Avenue, Islamabad. The bar chart reveals that throughout the entire week, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic both from East to West and West to East direction.

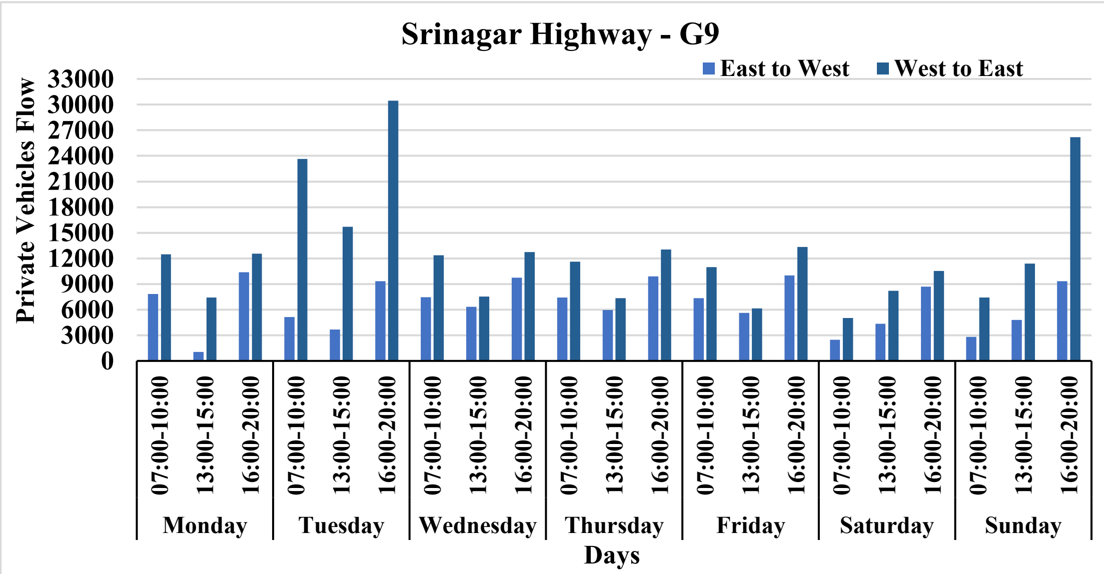


Figure 4.18 Day-Wise Srinagar Highway – G9

Figure 4.18 presents the day-wise private vehicle flow at G-9 Signal on Srinagar Highway, Islamabad. The bar chart reveals that throughout the entire week, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic both from East to West and West to East direction G-9 Signal, Srinagar Highway.

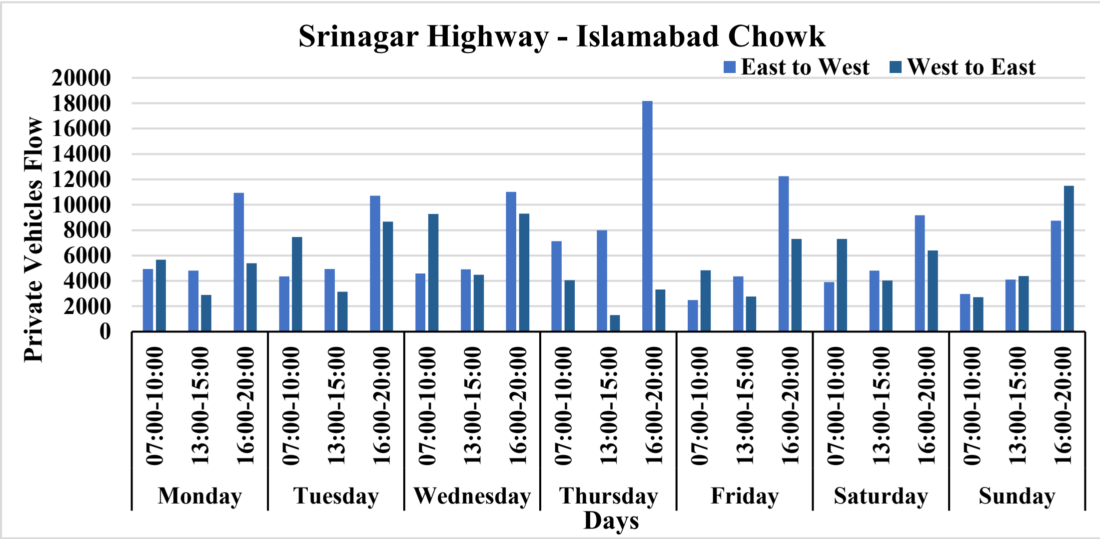


Figure 4.19 Day-Wise Srinagar - Highway

Figure 4.19 depicts the day-wise private vehicle flow at Islamabad Chowk on Srinagar Highway, Islamabad. The bar chart reveals that throughout the entire week, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic from East to West direction. However, from West to East direction, Monday, Saturday, and Thursday have the highest level of private traffic flow in the morning from 07:00 to 10:00. In contrast, Tuesday, Wednesday, Friday, and Sunday have the most substantial volume of private vehicles in the evening duration from 16:00 to 20:00. Further, the private vehicle flow is at its peak on Thursday evening.

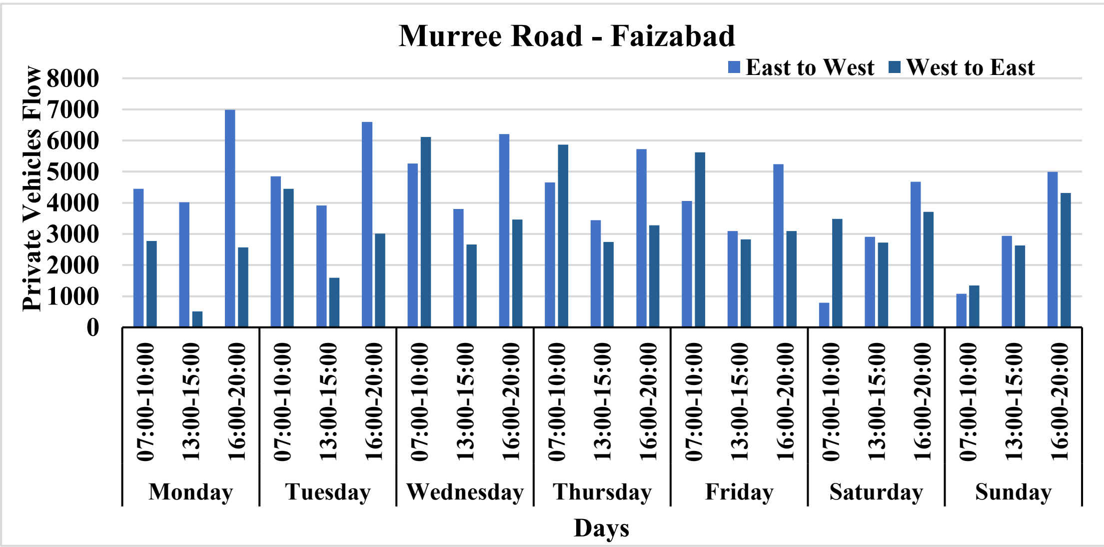


Figure 4.20 Day-Wise Murree Road - Faizabad

Figure 4.20 depicts the day-wise graphical representation of private vehicle flow at the Faizabad point on Murree Road in Islamabad. The bar chart reveals that from east to west direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week. In contrast, from west to east direction, the morning duration from 07:00 to 10:00 has the most substantial volume of private vehicle traffic on weekdays, and the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic on off days (Saturday and Sunday)

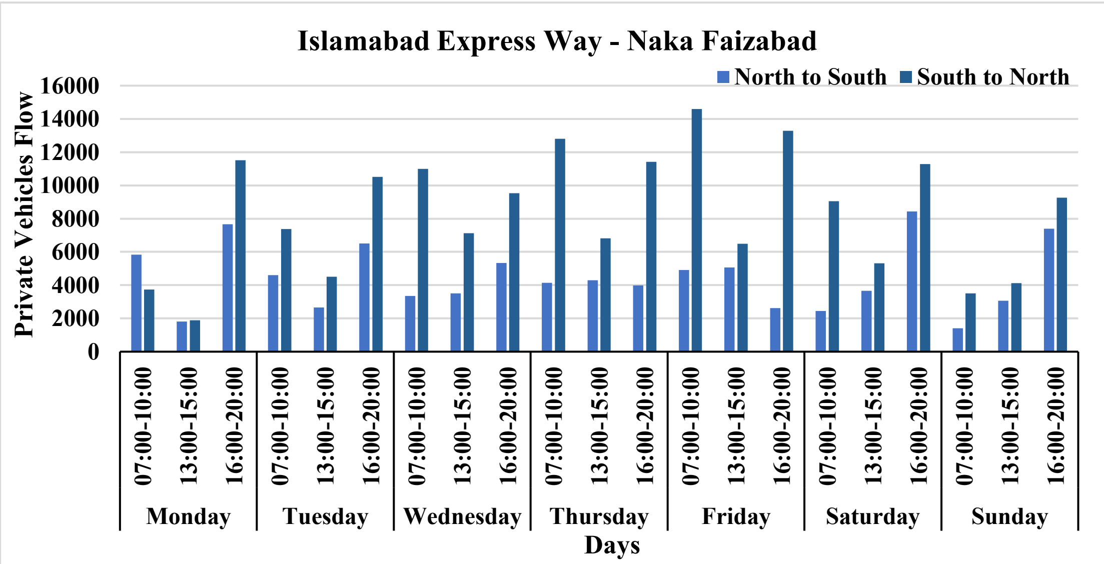


Figure 4.21 Day-Wise Islamabad Express Way – Naka Faizabad

Figure 4.21 discloses the day-wise private vehicle flow at the Naka Faizabad point on the Islamabad Express Way. The bar chart reveals that from the North to South direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic from Monday to Wednesday and Saturday to Sunday; however, on Thursday and Friday, the afternoon duration from 13:00 to 15:00 00 has the most substantial volume of private vehicle traffic. In contrast, from the South to North direction, the evening duration from 16:00 to 20:00 has the highest private vehicle traffic on Monday, Tuesday, Saturday, and Sunday; however, on Wednesday, Thursday, and Friday, the morning duration from 07:00 to 10:00 00 has the most substantial volume of private vehicle traffic.

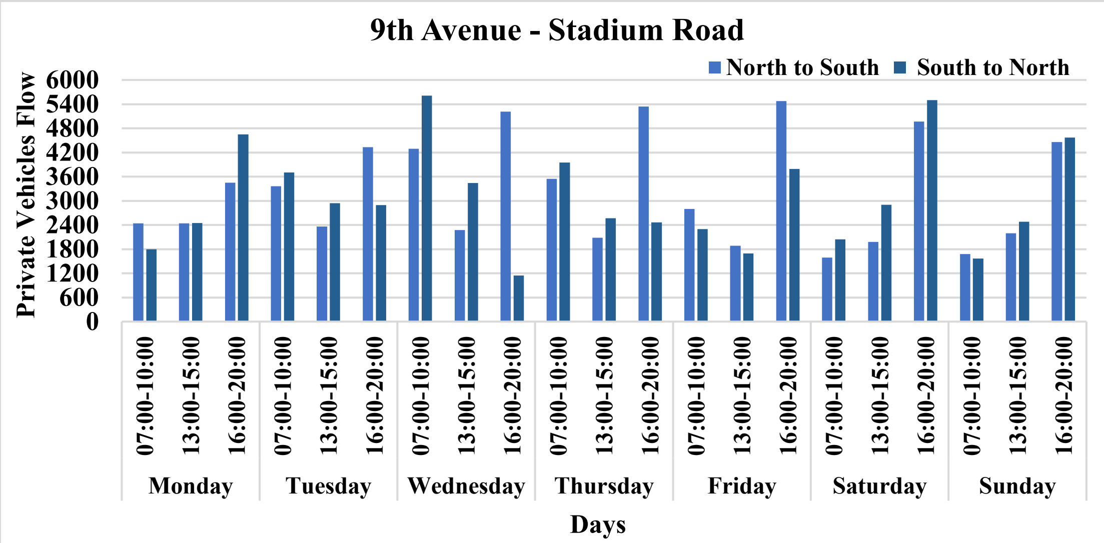


Figure 4.22 Day-Wise 9th Avenue - Stadium Road

Figure 4.22 shows the day-wise private vehicle flow at Stadium Road on 9th Avenue. The bar chart reveals that from the North to South direction, the evening duration from 16:00 to 20:00 has the highest private vehicle traffic throughout the entire week. In contrast, from the South to North direction, the evening duration from 16:00 to 20:00 has the greatest private vehicle flow on Monday, Friday, Saturday, and Sunday. From Tuesday to Thursday, the morning duration from 07:00 to 10:00 has the most substantial volume of private vehicle traffic.

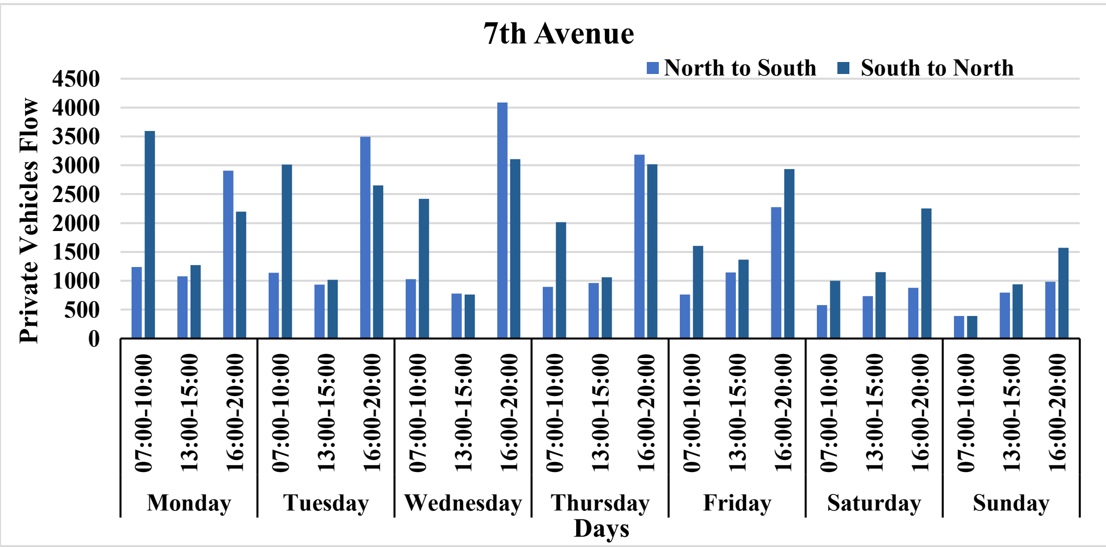


Figure 4.23 Day-Wise 7th Avenue

Figure 4.23 demonstrates the day-wise graphical representation of private vehicle flow at 7th Avenue, Islamabad. The bar chart reveals that from the North to South direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week. In contrast, from the South to North direction, the morning duration from 07:00 to 10:00 has the most substantial volume of private vehicle traffic on Monday and Tuesday; however, from Wednesday to Sunday, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic.

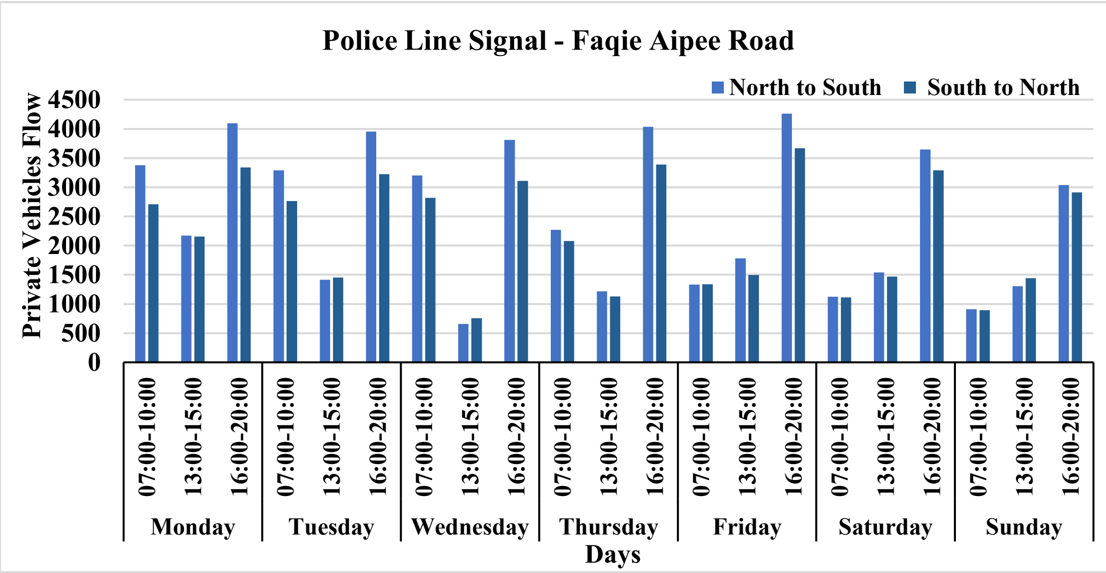


Figure 4.24 Day-Wise police Line Signal – Faqir Aipee Road

Figure 4.24 presents the day-wise graphical representation of private vehicle flow at the Faqir Aipee Road from Police Line Signal, Islamabad. The bar chart reveals that both from the North to South and North to South direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week.

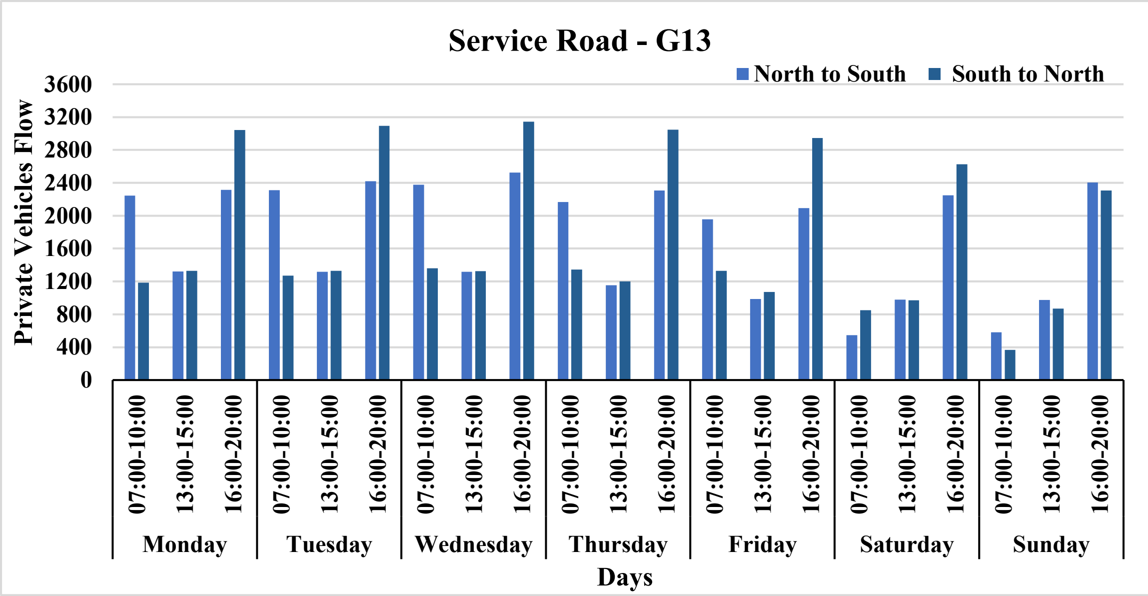


Figure 4.25 Day-Wise Service Road – G13

Figure 4.25 depicts the day-wise graphical representation of private vehicle flow at the Service Road from G13, Islamabad. The bar chart reveals that both from the North to South and North to South direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week.

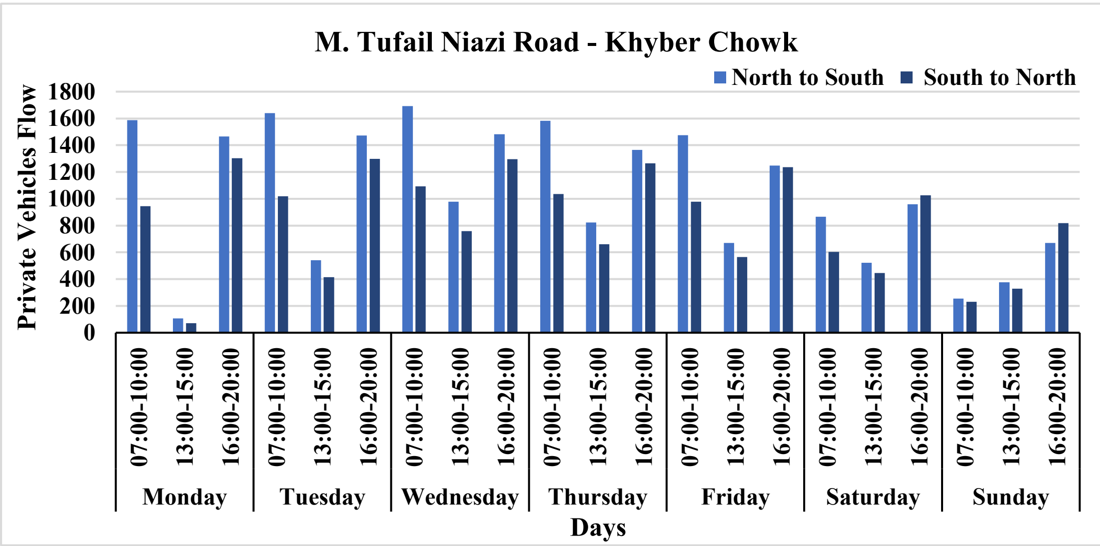


Figure 4.26 Tufail Niazi Road – Khyber Chowk

Figure 4.26 disclose the day-wise graphical representation of private vehicle flow at the M. Tufail Niazi Road from Khyber Chowk, Islamabad. The bar chart reveals that from the North to South direction, the morning duration from 07:00 to 10:00 has the most substantial volume of private vehicle traffic during the working days; however, during the off days, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic. In contrast, from the North to South direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week.

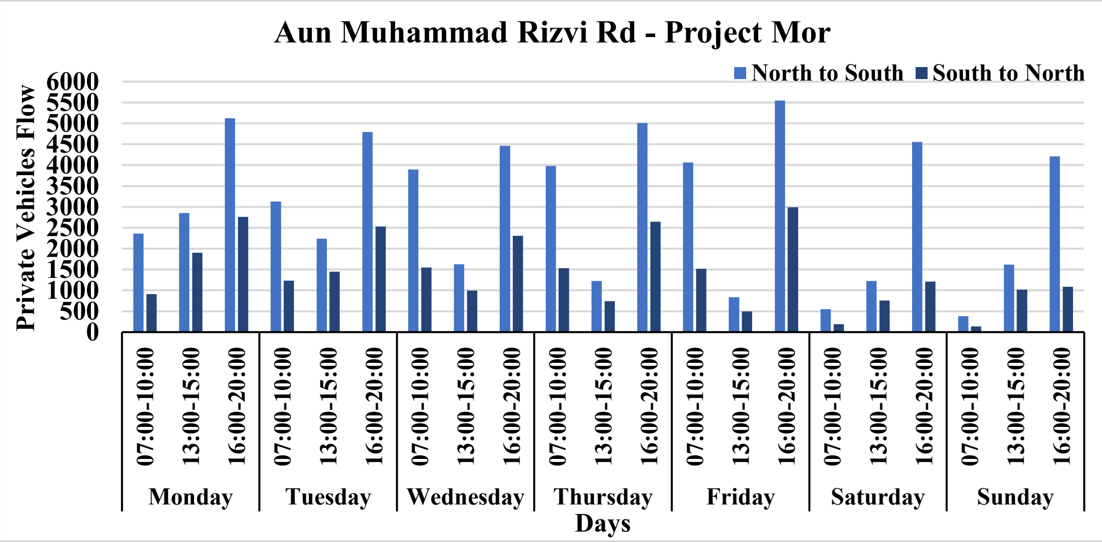


Figure 4.27 Day-Wise Aun Muhammad Rizvi Road – Project Mor

Figure 4.27 demonstrates the day-wise private vehicle flow at the Aun Muhammad Rizvi Road from Project Morr, Islamabad. The bar chart reveals that both from the North to South and North to South direction, the evening duration from 16:00 to 20:00 has the highest private vehicle traffic throughout the entire week.

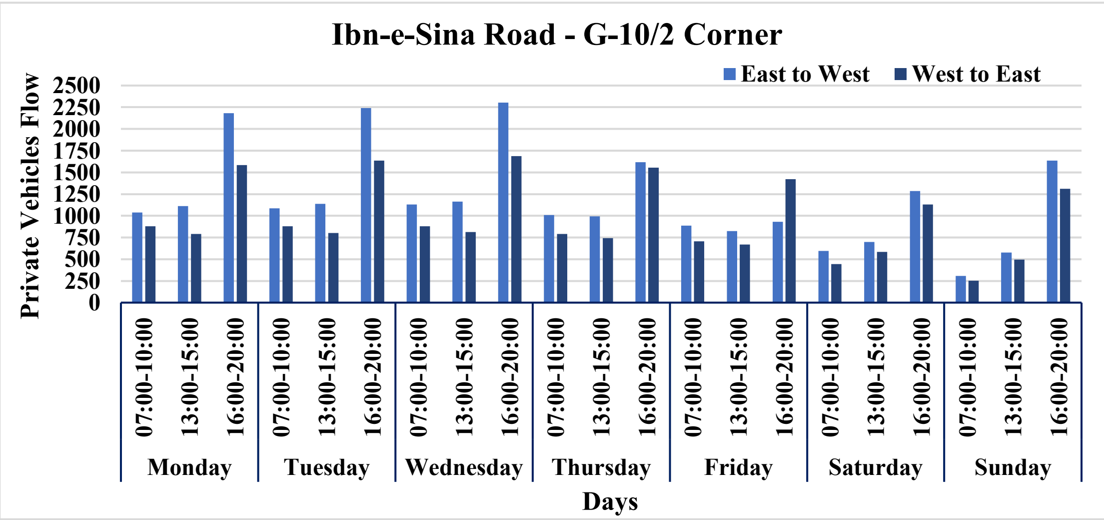


Figure 4.28 Day-Wise Ibn-e-Sina Road – G-10/2 Corner

Figure 4.28 shows the day-wise graphical representation of private vehicle flow at the at Ibn-e-Sina Road from G-10/2, Islamabad. The bar chart reveals that both from the East to West and West to East direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week.

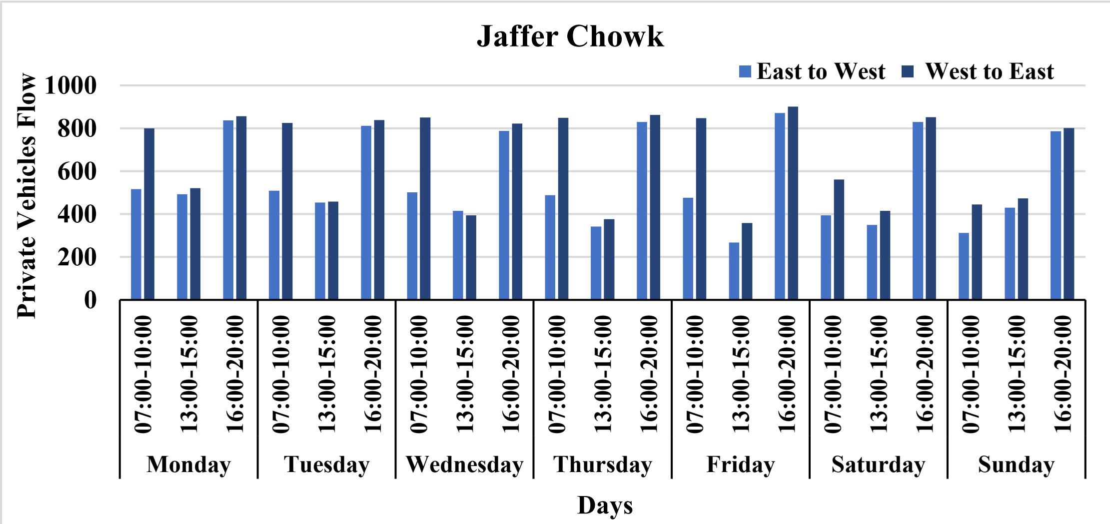


Figure 4.29 Day-Wise Jaffer Chowk

Figure 4.29 depicts the day-wise graphical representation of private vehicle flow at Service Road West from Jaffer Chowk, Islamabad. The bar chart reveals that from the East to West direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week. In contrast, from West to East direction, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week except Wednesday; however, on Wednesday, the morning duration from 07:00 to 10:00 has the most substantial volume of private vehicle traffic.

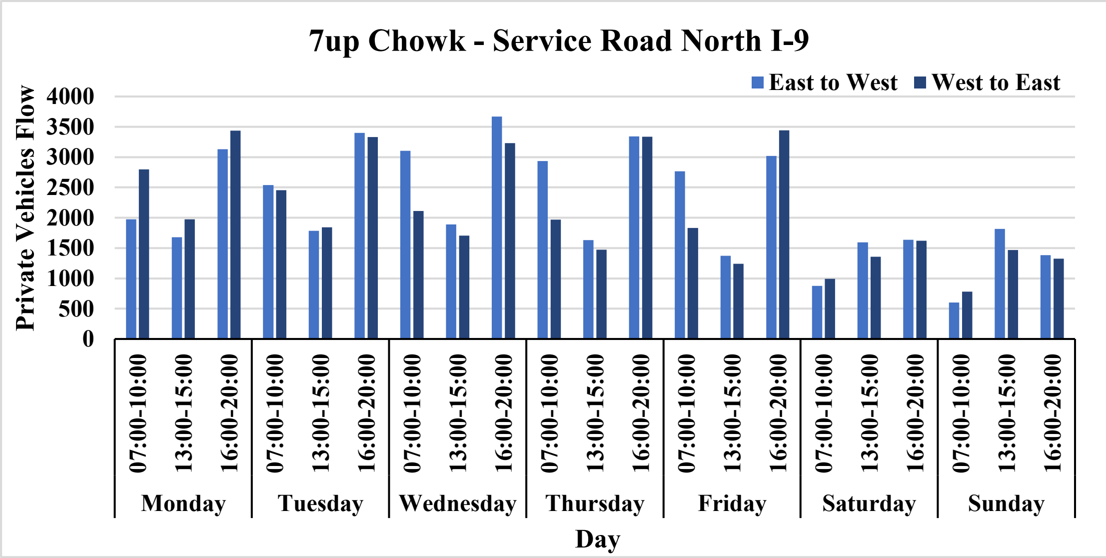


Figure 4.30 Day-Wise 7up Chowk – Service Road North I-9

Figure 4.30 presents the day-wise graphical representation of private vehicle flow at Service Road North I-9 from 7up Chowk, Islamabad. The bar chart reveals that both from East to West and West to East directions, the evening duration from 16:00 to 20:00 has the most substantial volume of private vehicle traffic throughout the entire week except Sunday. However, on Sunday, the afternoon duration from 13:00 to 15:00 has the most substantial volume of private vehicle traffic.

4.2.2.3. Data Normality Graphs

The current study data do not require normality graphs. However, they are shown to depict outliers.

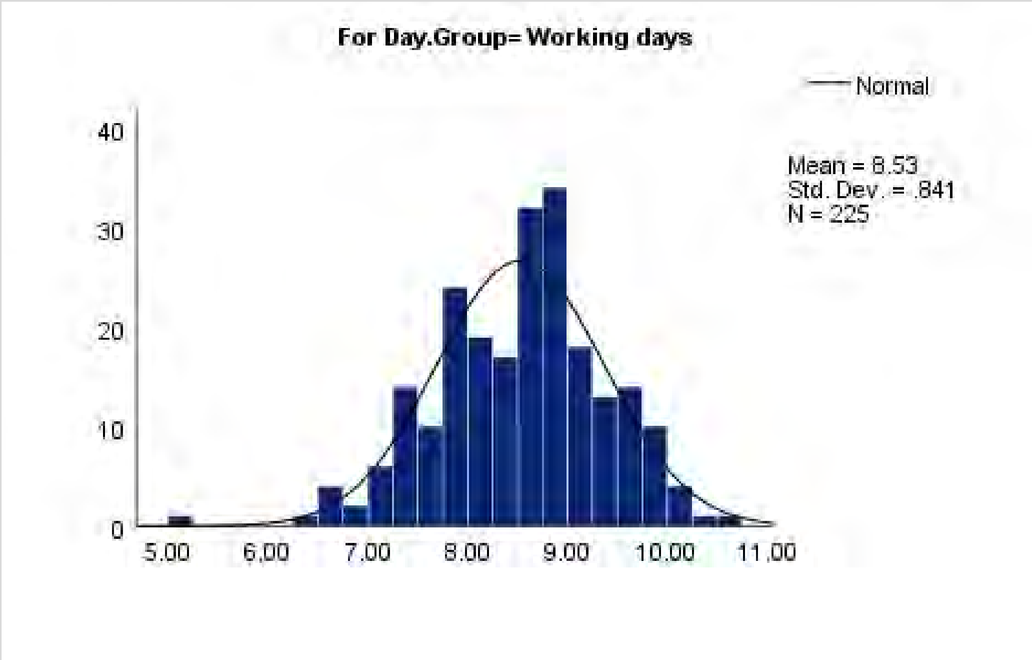


Figure 4.31 Working days normality graph for private vehicle flow

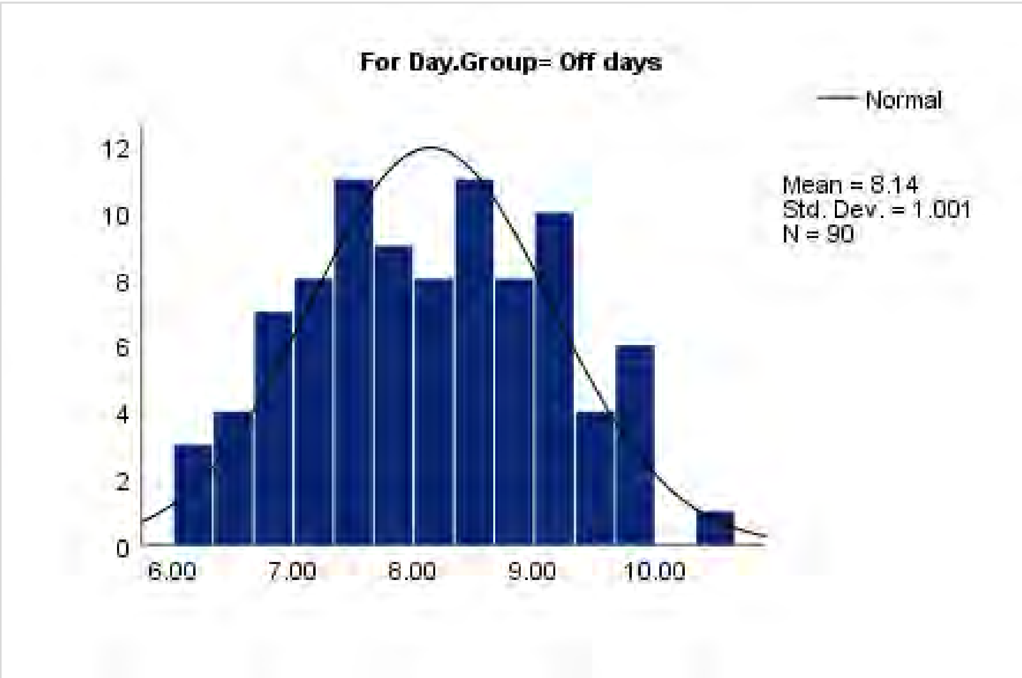


Figure 4.32 weekend normality graph for private vehicle flow

Figure 4.31 depicts the working days' normality graph, and Figure 4.32 depicts the off days' normality graph of day-wise private vehicle flow. The graphs demonstrated that day-wise private vehicle flow data is normally distributed.

4.2.2.4. Outliers in Data

To ensure data cleanliness and minimize the presence of outliers, the day-wise private vehicle flow data was computed prior to analysis.

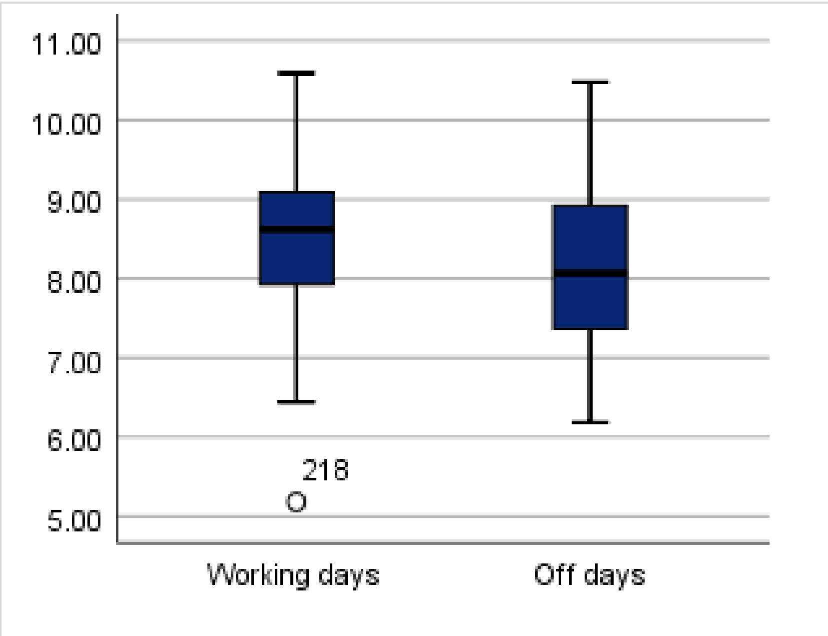


Figure 4.33 Outliers graph for working and off days

Figure 4.33 depicts that the data of day-wise private vehicle flow have one outlier. The outlier is case number 218, and it is falling in working days. The case number 218 outlier shows the Monday afternoon private vehicle flow on Muhammad Tufail Niazi Road at Khyber Chowk recorded a total count of 178 vehicles. The data indicates that during the afternoon, M. Tufail Niazi road exhibits the lowest number of private vehicle traffic compared to the overall private vehicular flow observed in the specified areas. Therefore, it is indicated as an outlier in the data. In addition, the traffic of congested roads near M. Tufail Niazi roads can be shift here to decrease the congestion. However, the presence of an outlier in the dataset is justified based on the nature of the data, thereby indicating that the current study has avoided any form of data manipulation. This observation demonstrates the dependability of the data.

4.3. Data Analysis

Data analysis results are shown in section 4.3.1 and 4.3.2.

4.3.1. Descriptive Statistics and Independent Sample T-Test Results

Table 4.3. Descriptives of private vehicle flow day-wise

PVF.DW	Working days	Off days
N	225	90
Mean	8.52	8.13
Std. dev	0.84	1.00
Maximum	10.59	6.18
Minimum	5.18	10.48

Note. PVF.DW stands for private vehicles flow day-wise. Std. dev stands for standard deviation.

Table 4.4 Independent sample t-test results

PVF.DW	Levene's test for equality of Variance			T-test Statistics	
	F	Sig.	*t*	*p*	*df*
	7.352	3.517	0.001	313	313

Note. PVF.DW stands for private vehicles flow day-wise

Table 4.3 shows the descriptive statistics of day-wise private vehicle flow, and Table 4.4 shows independent samples t-test statistic values. It was conducted to compare the private vehicle flow of working and off days. The total N for day-wise private vehicle flow is 315. First, assumptions of normality and Levene's test were checked. Both assumptions are met. The test of normality value significance is less than

0.05, which means that the data meet the normality assumption. In addition, Levene's test value is not less than the alpha value of 0.05, which shows that both groups have the same variance. There was a statistically significant difference in the flow of private vehicles for working days (M=8.52, SD=0.84) and off days [M=8.13, SD= 1.00; t(313)= 3.517,p<.05]. As the p-value is less than .05 and the difference between the two means is statistically significant, therefore the alternative hypothesis is accepted.

4.3.2. Descriptives and One-Way ANOVA Test Results

Table 4.5 Descriptives of private vehicle flow timewise

PVF.TW	T-1	T-2	T-3	Total
N	115	115	115	315
Mean	8.27	8.10	8.16	8.41
Std. dev	.917	.838	.767	.902
Maximum	10.27	9.87	10.59	10.59
Minimum	6.28	5.18	7.31	5.18

Note. T-1 = 7:00 - 10:00, T-2 = 13:00 - 15:00, T-3 = 16:00 - 20:00. PVF.TW stands for private vehicle flow timewise. Std. dev stands for standard deviation.

Table 4.6 One-way ANOVA test results

PVF.TW	SS	*df*	MS	F	Sig.
Between Groups	33.73	2	16.870	23.712	.000
Within Groups	221.9	312	0.711		
Total	255.7	314			

Note. SS stands for the sum of squares. MS stands for mean square.

Table 4.5 shows the descriptive statistics of time-wise private vehicle flow, and Table 4.6 shows one-way anova test statistic values. A one-way between-groups analysis of variance was conducted to explore the mean private vehicle flow of three different time durations. Private vehicle flows were divided into three groups according to their time duration (Group 1: T1 (7:00-10:00); Group 2: T2 (13:00-15:00); Group 3: T3 (16:00-20:00). There was a statistically significant difference as the p-value is less than the threshold α=0.05 level. So, it is concluded that the private vehicle flow for the three different time durations is different from each other.

The results of shifting scenarios are started from the next page.

4.4. Shifting Scenarios Results

The subsequent outcomes of the shifting situations are presented below, in accordance with each respective scenario.

4.4.1. Weekly Pre-Shifting Scenario

Table 4.7 Weekly Pre-Shifting Results

Locations	Passengers (T.N)	Pvt. Veh. (T.N)	Travel (T. Km)	Oil Cons. (T. L)	CO2 Emi. (T. MT)	Fuel Cost (T. Rs.)
Margalla Ave.	263740	131870	1714310	150775	360.65	40106109
Jinnah Ave.	336286	168143	1261073	110912	265.30	29502664
Isl. Chowk	526926	263463	3688482	324405	775.98	86291663
G-9 - S.H.	811422	405711	5679954	499556	1194.94	132881949
Faizabad (MR)	316986	158493	2852874	250912	600.18	66742699
Express Rd.	535686	267843	3481959	306241	732.53	81460079
9th Ave.	265216	132608	1060864	93304	223.18	24818806
7th Ave.	139220	69610	278440	24489	58.58	6514076
Fakeer AP Rd.	197957	98979	395914	34821	83.29	9262368
Golra Rd.	145107	72554	203150	17867	42.74	4752669
M. Tufail Niazi Rd.	78343	39172	215443	18948	45.32	5040273
Aun M. Rizvi Rd.	187268	93634	327719	28823	68.94	7666953
Ibn-e-Sina Rd.	89598	44799	335993	29551	70.69	7860511
Jaffer Rd.	49205	24603	110711	9737	23.29	2590078
7up Chowk	179712	89856	404352	35563	85.07	9459774
Total	4122672	2061336	22011237	1935905	4630.68	514950670

Note. (T.N) stands for the total number. Pvt. Veh. Stands for Private Vehicles. (T. KM) stands for total kilometers. Oil Cons. stands for Oil Consumption. (T. L) stands for total liters. Co2 Emis. stands for Carbon dioxide Emissions. (T. MT) stands for total metric tons. (T. Rs) stands for total rupees.

Table 4.7 depicts the weekly pre-shifting scenario of private vehicle flow across the 15 most important locations in Islamabad, including the number of private vehicles on these roads, the average travel distance in kilometers covered by these vehicles, the oil consumption consumed by these vehicles in liters, the CO_2 emissions in metric tons emitted by these vehicles based on their average consumption, and the average fuel consumption cost in rupees of these vehicles. The cumulative number of private vehicles at each location throughout the week is shown. Nonetheless, the aggregate private vehicle flow encompasses the cumulative private vehicle flow during the designated peak hours, which are 7:00 to 10:00, 13:00 to 15:00, and 16:00 to 20:00. The measurements of travel distance, oil consumption, CO_2 emissions, and fuel cost are determined based on the number of vehicles on each road and the average length of stated roads.

During the peak hours of the week, a substantial number of private vehicle commuters, approximately 4,122,670 individuals, utilized 2,061,336 private vehicles for their trips on these roadways. The total distance traveled by all these vehicles is 22,011,237 kilometers. The overall oil consumption, specifically petroleum, by these vehicles amounts to an average of 1,935,905 liters. However, the total carbon dioxide (CO_2) emissions released by these vehicles is 4,631 metric tons. Furthermore, the average expenditure on fuel for these vehicles amounts to a sum of 514,950,670 rupees. The computation of all pre-shifting values is performed according to the methodology outlined in Section 3.4.7 of Chapter 3.

4.4.2. Scenario 1: Shifting of all Private Vehicles to Public Transport

The shifting of all private vehicles to public transport and its impact on related factors are presented in the first scenario.

Table 4.8 Weekly 100 % post-shifting results

Locations	Passengers (T.N)	Pub.Trans. (T.N)	Travel (T. Km)	Oil Cons. (T. L)	CO2 Emis. (T. MT)	Fuel Cost (T. Rs.)
Margalla Ave.	263740	5733	74535	18634	49.19	4760937
Jinnah Ave.	336286	7311	54829	13707	36.19	3502218
Isl. Chowk	526926	11455	160369	40092	105.84	10243556
G-9 - S.H.	811422	17640	246955	61739	162.99	15774220
Faizabad (MR)	316986	6891	124038	31010	81.87	7922927
Express Rd.	535686	11645	151390	37847	99.92	9670006
9th Ave.	265216	5766	46125	11531	30.44	2946204
7th Ave.	139220	3027	12106	3027	7.99	773276
Fakeer AP Rd.	197957	4303	17214	4303	11.36	1099522
Golra Rd.	145107	3155	8833	2208	5.83	564182
M. Tufail N. Rd.	78343	1703	9367	2342	6.18	598323
Aun M. Rizvi Rd.	187268	4071	14249	3562	9.40	910133
Ibn-e-Sina Rd.	89598	1948	14608	3652	9.64	933110
Jaffer Rd.	49205	1070	4814	1203	3.18	307464
7up Chowk	179712	3907	17581	4395	11.60	1122956
Total	4122672	89623	957010	239253	49.19	61129034

Note. Note. (T.N) stands for the total number. Pub. Trans. Stands for Public Transport. (T. KM) stands for total kilometers. Oil Cons. stands for Oil Consumption. (T. L) stands for total liters. Co2 Emis. stands for Carbon dioxide Emissions. (T. MT) stands for total metric tons. (T. Rs) stands for total rupees.

Table 4.8 depicts the weekly 100 percent post-shifting scenario of private vehicle flow across the 15 most important locations in Islamabad, including the post-shifting number of vehicles on these roads, the post-shifting average travel distance in kilometers covered by these vehicles, the post-shifting oil consumption consumed by these vehicles in liters, the post-shifting CO2 emissions in metric tons emitted by these vehicles based on their average consumption, and the post-shifting average fuel consumption cost in rupees. In simple terms, the private vehicles at each location throughout the week were shifted to public transport, and their impact on various factors has shown in Figure 4.8. Nonetheless, the aggregate private vehicle flow encompassed the cumulative private vehicle flow during the designated peak hours, which are 7:00 to 10:00, 13:00 to 15:00, and 16:00 to 20:00, and they were shifted to public transport similarly. In addition, measurements of travel distance, oil consumption, CO2 emissions, and fuel cost were determined based on the post-shifting number of vehicles on each road and the average length of stated roads.

The shift from private vehicles to public transport has a significant impact on various factors, including the number of vehicles, the travel distance due to decreased trip frequency, the consumption of oil, the emission of carbon dioxide, and the cost of fuel. Such as, by shifting the same passengers 4,122,672 from private vehicles to public transport, the total number of vehicles experienced a reduction to 89,623. The total distance traveled experienced a reduction to 9,57,010 kilometers. The oil consumption shifted from petrol to diesel and decreased to 2,39,253 liters. The quantity of carbon emissions released by vehicles experienced a reduction to 632 metric tons. The expenditure on fuel experienced a reduction, amounting to a total of 61,129,034 rupees. However, the computation of all post-shifting values is performed according to the formulas given in Section 3.4.8 and methodology outlined in Section 3.4.11 of Chapter 3.

4.4.2.1. Weekly Pre-and Post-Shifting Graphs – 100 Percent Shifting

The weekly pre-shifting and 100 percent post-shifting graphs illustrate the disparities across numerous factors, such as the number of vehicles, trip distance, oil consumption, CO2 emissions, and fuel expenditure, before and after the shifting process. The disparity shown in the bar lines of the graphs signifies the extent to which the corresponding factor has experienced a decline as a result of shifting from private to public transport. A large gap signifies a more significant decrease, while a small gap signifies a lesser decrease in the associated factor. However, a factor is reduced by the same percentage in each location.

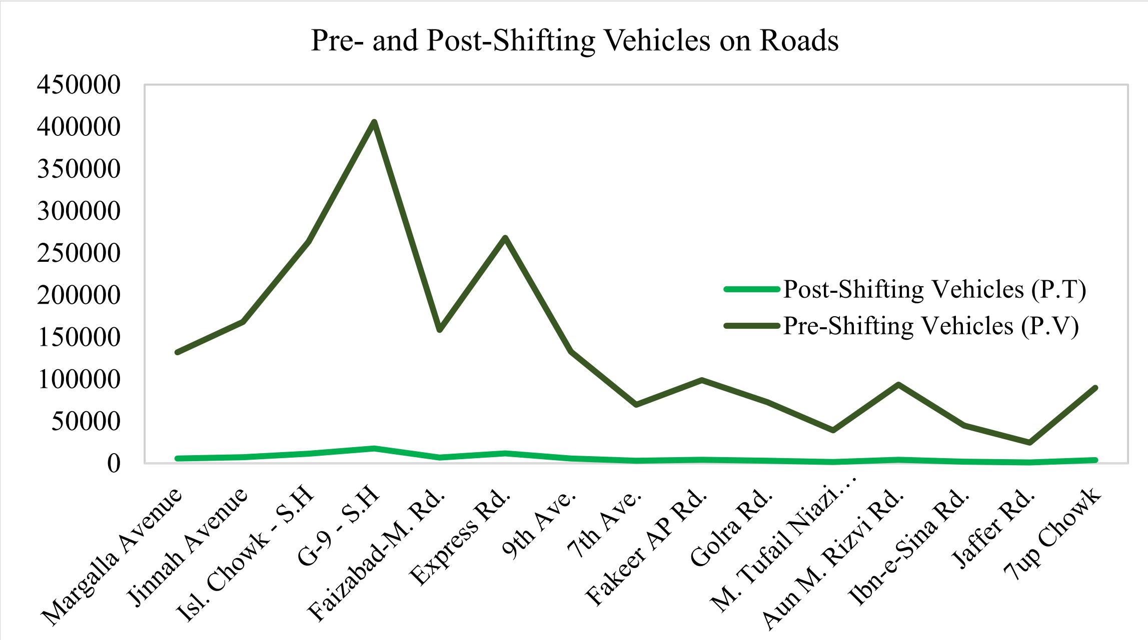


Figure 4.34 100% pre-and post-shifting vehicles on roads

Figure 4.34 depicts the weekly peak hours of pre-shifting and 100 percent post-shifting vehicles on roads. The observed difference in the distance between the line bars of pre-shifting and post-shifting vehicles indicates an apparent decrease in the number of vehicles after the shifting.

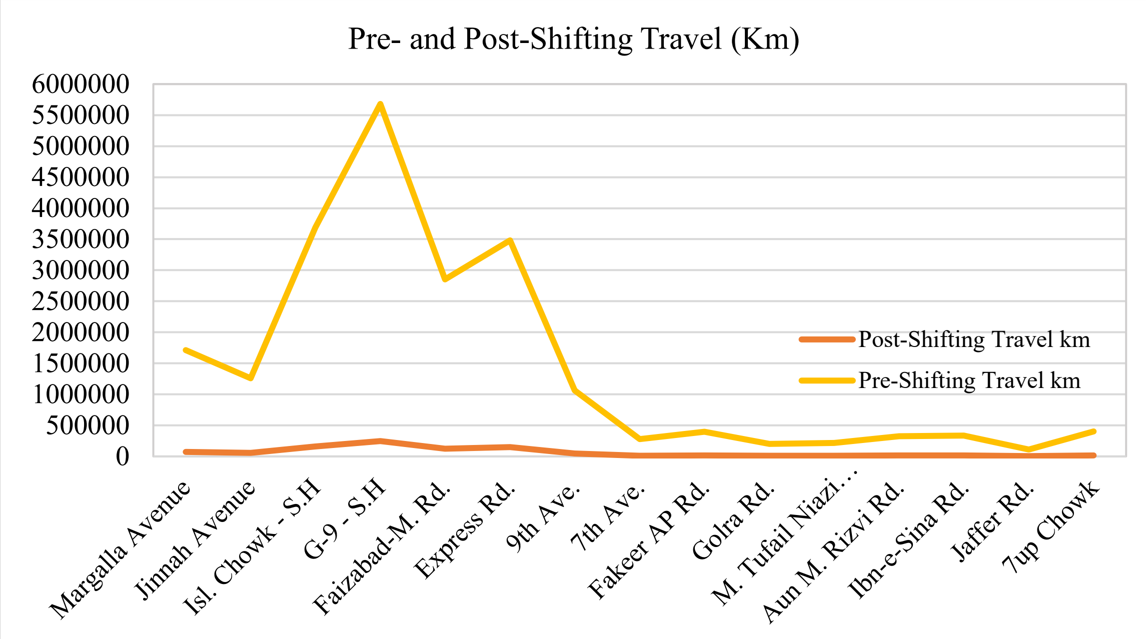


Figure 4.35 100% pre- and post-shifting travel in kilometers

Figure 4.35 depicts the weekly peak hours pre-shifting and post-shifting travel distance in kilometers. The observed difference in the gap between the line bars of pre-shifting and post-shifting travel km indicates an apparent decrease in the kilometers travel distance after the shifting.

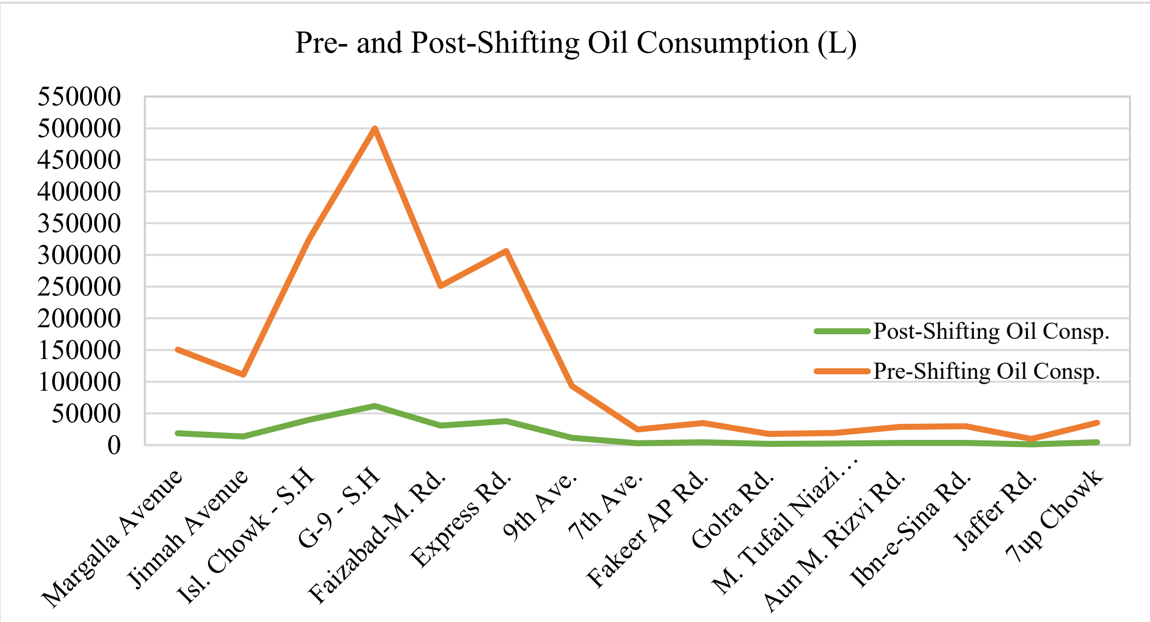


Figure 4.36 100% pre-and post-shifting oil consumption in liters

Figure 4.36 depicts the weekly peak hours of pre-shifting and post-shifting oil consumption in liters. The observed difference in the distance between the line bars of pre-shifting and post-shifting oil consumption indicates an apparent decrease in oil consumption after the shifting.

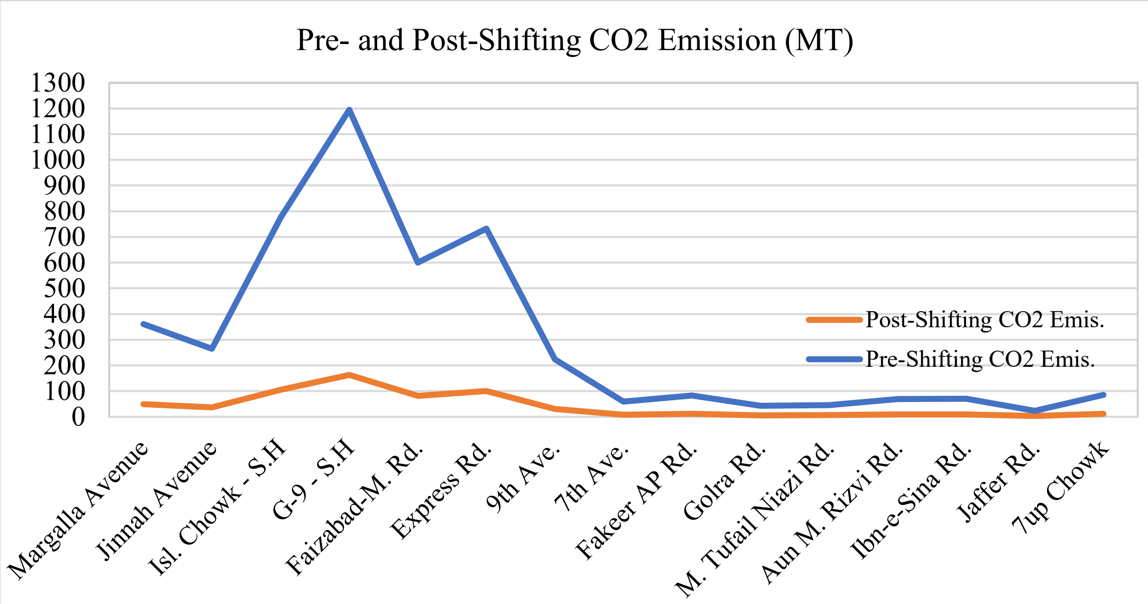


Figure 4.37 100% pre-and post-shifting CO2 emissions in metric tons

Figure 4.37 depicts the weekly peak hours of pre-shifting and post-shifting CO_2 emissions in metric tons from private vehicles and public transport. The observed difference in the distance between the line bars of pre-shifting and post-shifting CO_2 emissions indicates an apparent reduction in the CO_2 emissions in metric tons after the shifting.

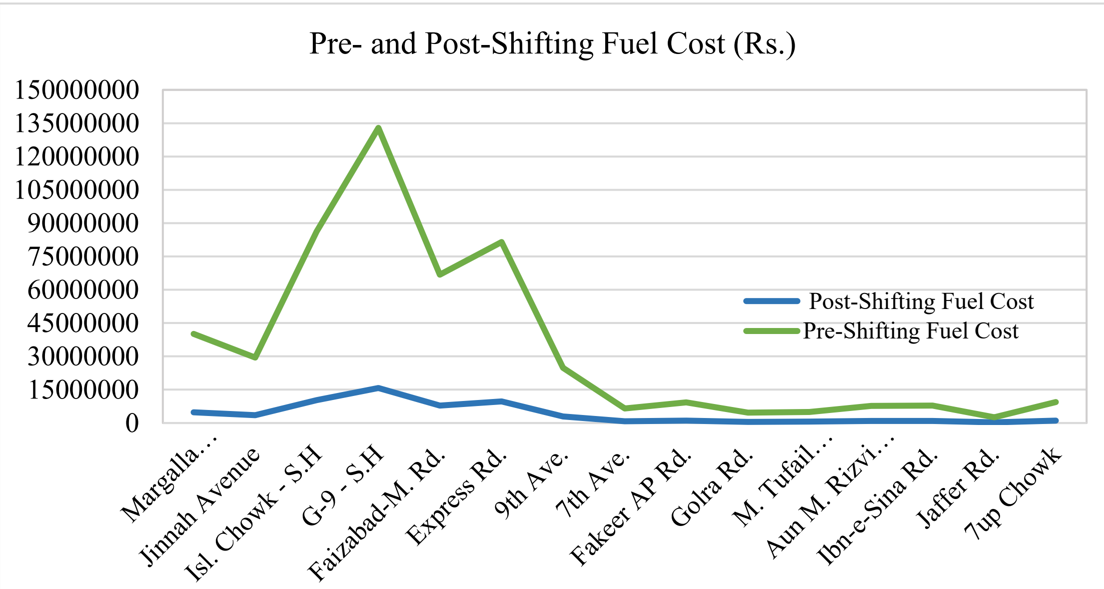


Figure 4.38 100% pre-and post-shifting fuel cost in rupees

Figure 4.38 depicts the weekly peak hours of pre-shifting and post-shifting fuel cost of vehicles in rupees. The observed difference in the distance between the line bars of pre-shifting and post-shifting fuel cost indicates an apparent decrease in fuel cost or expenditure after the shifting.

Figures 4.34, 4.35, 4.36, 4.37, and 4.38 also demonstrate that G-9, Srinagar Highway, has the highest number of vehicles, travel distance in kilometers, oil consumption, CO2 emissions, and fuel cost in pre- and post-shifting across all 15 locations.

4.4.2.2. Weekly impact of 100 Percent Shifting

Table 4.9 Weekly pre-post difference scenario of 100% shifting

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	89623	1971713	95.7%
Travel (Km)	22011237	957010	21054227	95.7%
Oil Consumption (L)	1935905	239253	1696652	87.6%
Fuel Cost (Rs.)	514950670	61129034	453821636	88.1%
CO2 Emissions (MT)	4630.68	631.63	3999.06	86.4%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (Rs.) stands for rupees. (MT) stands for metric tons.

Table 4.9 depicts the weekly pre-post difference scenario of 100 percent shifting. The 100 percent shift from private vehicles to public transport resulted in a significant reduction in vehicles, specifically by 95.7 percent, corresponding to a total decrease of 1,971,713 vehicles per week. It demonstrates that if all private vehicles shift to public transport, traffic congestion can decrease by 95.7 percent of its current level due to fewer vehicles on the road. The distance traveled, measured in kilometers, also decreased by 95.7 percent, resulting in a total reduction of 21,054,227 kilometers per week in a 100 percent shifting scenario. Consequently, it can decrease fuel consumption, CO_2 emissions, and fuel costs proportional to the drop in kilometers traveled. Oil consumption decreased by 87.6 percent, amounting to a total reduction of 1,696,652 liters per week. It demonstrates that 87.6 percent of the current oil consumed in private vehicles can be saved by shifting 100 percent of private vehicles to public transport, which can also help to reduce the country's oil imports and oil import bills, as Pakistan imports its major portion of the oil from other countries to fulfill its needs (GOP, 2022). The fuel cost decreased by 88.1 percent, resulting in savings of 453,821,636 rupees per week. It demonstrates that 88.1 percent of the current fuel expenditure in private vehicles and millions of rupees can be saved by shifting all private vehicles to public transport. CO_2 emissions decreased by 86.4 percent, resulting in a decrease of 3,999 metric tons weekly. It demonstrates that shifting all private vehicles to public transport can reduce 86.4 percent of CO_2 emissions and mitigate the release of thousands of metric tons of CO_2 into the environment.

4.4.2.3. Daily Impact of 100 Percent Shifting

Table 4.10 Daily pre-post difference scenario of 100% shifting

	Pre-Shift	Post-Shift	DIV/Day	% Change
No. of Passengers	588953	588953	0	0.0%
No. of Vehicles	294477	12803	281673	95.7%
Travel (Km)	3144462	136716	3007747	95.7%
Oil Consumption (L)	276558	34179	242379	87.6%
Fuel Cost (M Rs.)	73.6	8.7	64.8	88.1%
CO_2 Emissions (MT)	661.53	90.23	571.29	86.4%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.10 depicts the daily pre-post difference scenario of 100 percent shifting. The 100 percent shift from private vehicles to public transport resulted in a significant daily reduction in all factors. Such as, the daily number of vehicles decreased by 2,81,673, travel distance decreased by 3,007,747 km per day, oil consumption decreased by 242,379 liters per day, fuel cost decreased by 64.8 million rupees per day, and CO2 emissions from vehicles reduced by 571 metric tons daily. Nonetheless, the calculation of daily impacts involves dividing the impacts observed during a week by the total number of days in a week, which is seven.

4.4.2.4. Annual Impact of 100 Percent Shifting

Table 4.11 Annual pre-post difference scenario of 100% shifting

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	214967897	214967897	0	0.0%
No. of Vehicles	107483949	4673215	102810733	95.7%
Travel (Km)	1147728802	49901252	1097827550	95.7%
Oil Consumption (L)	100943606	12475313	88468293	87.6%
Fuel Cost (M Rs.)	26851.0	3187.4	23663.6	88.1%
CO2 Emissions (MT)	241457.11	32934.83	208522.28	86.4%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.11 depicts the annual pre-post difference scenario of 100 percent shifting. It shows the number of vehicles decreased by 102,810,733 annually, travel distance decreased by 1,097,827,550 km per annum, oil consumption decreased by annually 88,468,293 liters, fuel cost decreased by 23,663.6 million rupees annually and CO2 emissions from vehicles reduced by 208,522 metric tons per annum as a result of 100 percent shifting. However, in order to determine the yearly effects, the daily impacts are multiplied by the total number of days in a calendar year, which are 365.

4.4.3. Scenario 2: 90 Percent Shifting to Public Transport

The pilot study reveals that most of the respondents, specifically 90 percent, are inclined to shift toward public transport if they are provided with efficient public transport. Therefore, the current scenario highlights the contrasting effects of 90 percent post-shifting influences on associated factors. Hence, based on the assumption that 90 percent of private vehicles shift to public transport, resulting outcomes are as follow:

Table 4.12 Weekly 90% post-shifting results

Locations	Passengers (T.N)	Pub.Trans. (T.N)	Travel (T. Km)	Oil Cons. (T. L)	CO2 Emis. (T. MT)	Fuel Cost (T. Rs.)
Margalla Ave.	263740	18347	238513	31848	80.34	8295454
Jinnah Ave.	336286	23394	175454	23428	59.10	6102262
Isl. Chowk	526926	36656	513180	68523	172.86	17848367
G-9 - S.H.	811422	56447	790254	105520	266.18	27484993
Faizabad (MR)	316986	22051	396922	53000	133.70	13804904
Express Rd.	535686	37265	484446	64687	163.18	16849013
9th Ave.	265216	18450	147598	19708	49.72	5133464
7th Ave.	139220	9685	38739	5173	13.05	1347356
Fakeer AP Rd.	197957	13771	55084	7355	18.55	1915807
Golra Rd.	145107	10094	28264	3774	9.52	983031
M. Tufail N. Rd.	78343	5450	29975	4002	10.10	1042518
Aun M. Rizvi Rd.	187268	13027	45596	6088	15.36	1585815
Ibn-e-Sina Rd.	89598	6233	46747	6242	15.75	1625850
Jaffer Rd.	49205	3423	15403	2057	5.19	535726
7up Chowk	179712	12502	56258	7512	18.95	1956638
Total	4122672	286795	3062433	408918	1031.53	106511198

Note. Note. (T.N) stands for the total number. Pub. Trans. Stands for Public Transport. (T. KM) stands for total kilometers. Oil Cons. stands for Oil Consumption. (T. L) stands for total liters. Co2 Emis. stands for Carbon dioxide Emissions. (T. MT) stands for total metric tons. (T. Rs) stands for total rupees.

Table 4.12 depicts the weekly 90 percent post-shifting scenario of private vehicle flow across the 15 most important locations in Islamabad, including the post-shifting number of vehicles on these roads, the post-shifting average travel distance in kilometers covered by these vehicles, the post-shifting oil consumption consumed by these vehicles in liters, the post-shifting CO2 emissions in metric tons emitted by these vehicles based on their average consumption, and the post-shifting average fuel consumption cost in rupees. In simple terms, 90 percent of private vehicles at each location throughout the week have shifted to public transport, while the remaining 10 percent of private vehicles continue to be in use. And the impact of this 90 percent shift on associated factors is shown in Figure.12. Nonetheless, the aggregate private vehicle flow encompassed the cumulative private vehicle flow during the designated peak hours, which are 7:00 to 10:00, 13:00 to 15:00, and 16:00 to 20:00, and they were shifted to public transport similarly. In addition, measurements of travel distance, oil consumption, CO2 emissions, and fuel cost have been determined based on the post-shifting total number of vehicles on each road and the average length of stated roads.

The 90 percent shift from private vehicles to public transport also has a significant impact on associated factors. Such as, by shifting 90 percent of private vehicles to public transport and considering 10 percent of private vehicles in use, the total number of vehicles experienced a reduction to 286,795 vehicles from 2,061,336 vehicles. The total distance traveled experienced a reduction to 3,062,433 kilometers from 22,011,237 kilometers. The oil consumption (a mixture of 10 percent petrol and 90 percent diesel due to 90 percent shifting) decreased to 408,918 liters from 1,935,905 liters. The quantity of carbon emissions released by vehicles experienced a reduction to 1031.53 metric tons from 4631 metric tons. The expenditure on fuel experienced a reduction, amounting to a total of 106,511,198 rupees from 514,950,670 rupees.

However, the computation of all post-shifting values is performed according to the formulas given in Section 3.4.8 and the methodology outlined in Section 3.4.12 of Chapter 3.

4.4.3.1. Weekly Pre-and Post-Shifting Graphs – 90 Percent Shifting

The weekly pre-shifting and 90 percent post-shifting graphs illustrate the disparities across numerous factors, such as the number of vehicles, trip distance, oil consumption, CO2 emissions, and fuel expenditure, before and after the shifting process. In addition, 90 percent of public transport with associated impacts and 10 percent of private vehicles with associated impacts are included in the 90 percent shifting graphs.

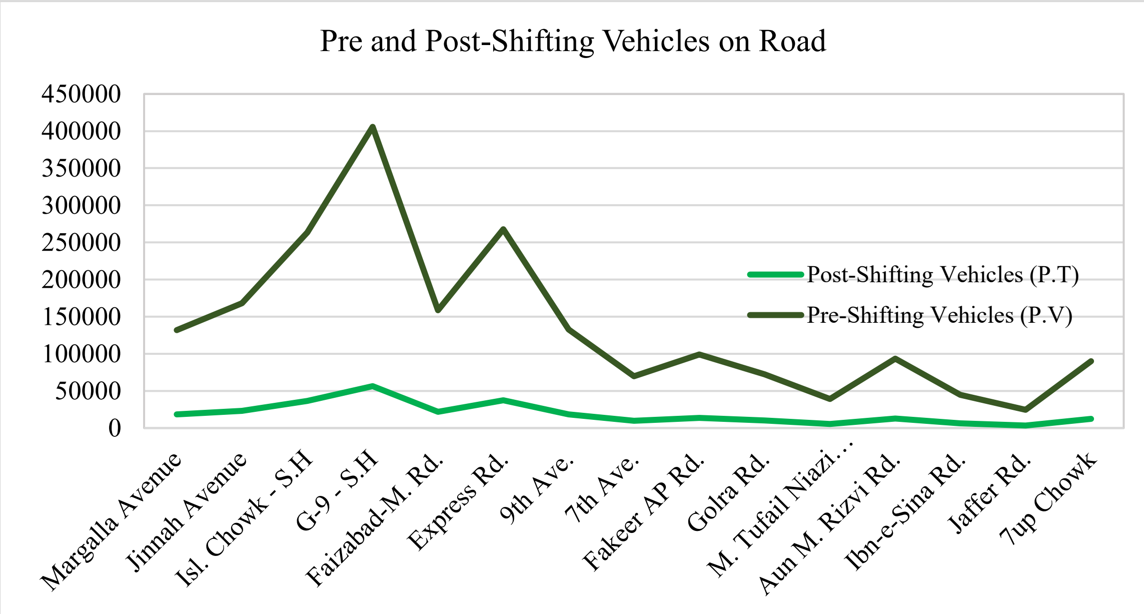


Figure 4.39 90% pre-and post-shifting vehicles on road

Figure 4.39 depicts the weekly peak hours of pre-shifting and 90 percent of post-shifting vehicles on roads. The observed difference in the distance between the line bars of pre-shifting and post-shifting vehicles indicates an apparent decrease in the number of vehicles after the shifting.

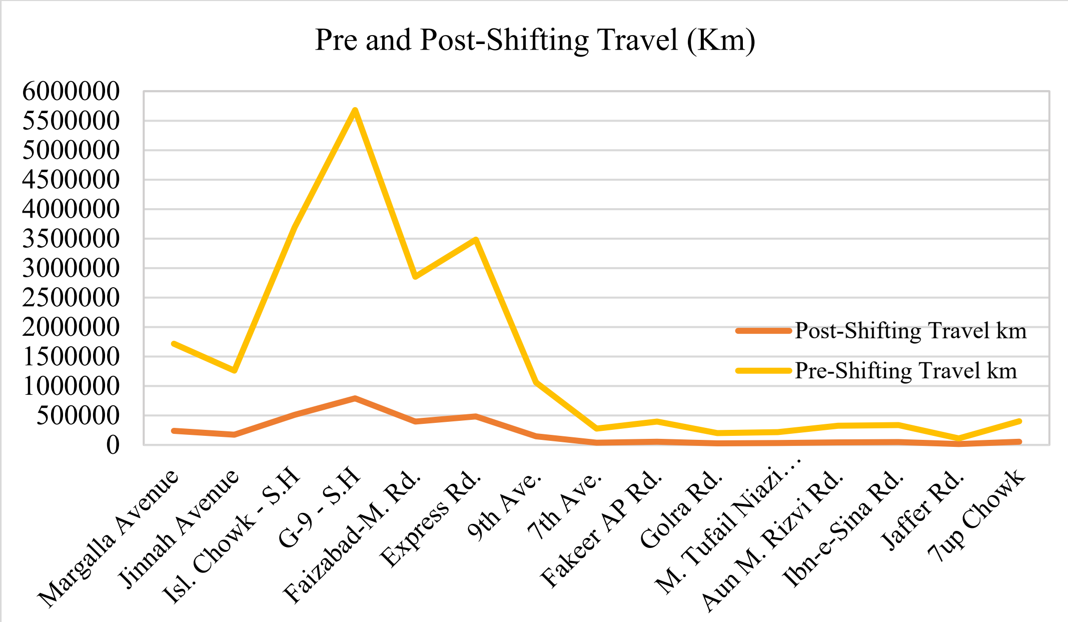


Figure 4.40 90% pre-and post-shifting travel

Figure 4.40 depicts the weekly peak hours of pre-shifting and 90 percent of post-shifting travel distance in kilometers. The observed difference in the gap between the line bars of pre-shifting and post-shifting travel km indicates an apparent decrease in the number of vehicles after the shifting.

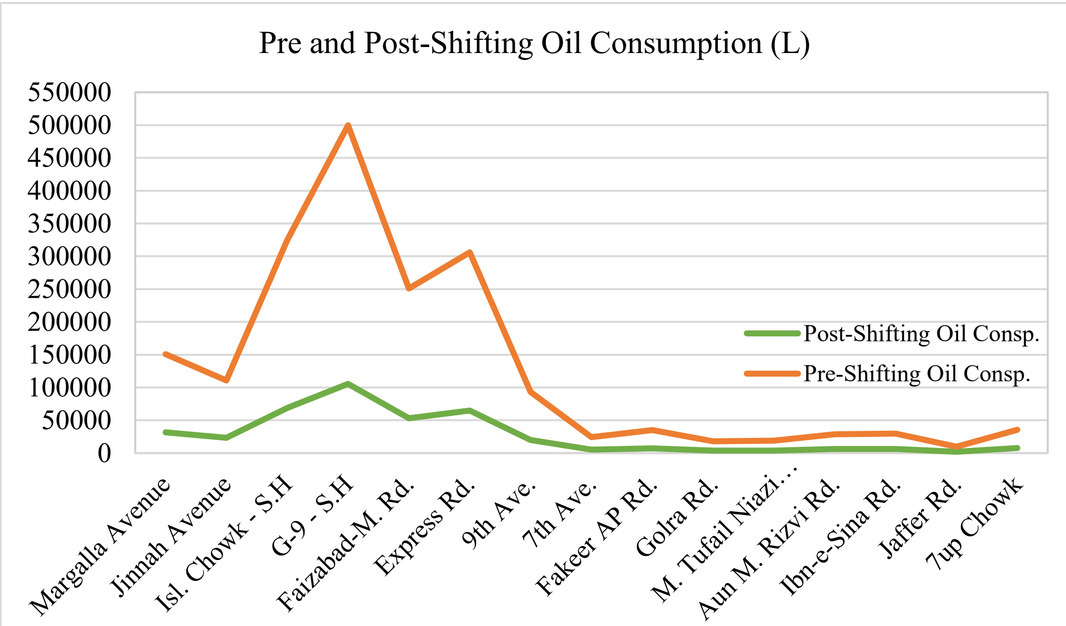


Figure 4.41 90% pre-and post-shifting oil consumption

Figure 4.41 depicts the weekly peak hours of pre-shifting and 90 percent post-shifting oil consumption in vehicles. The observed difference in the distance between the line bars of pre-shifting and post-shifting oil consumption indicates an apparent decrease in the consumption of oil after the shifting.

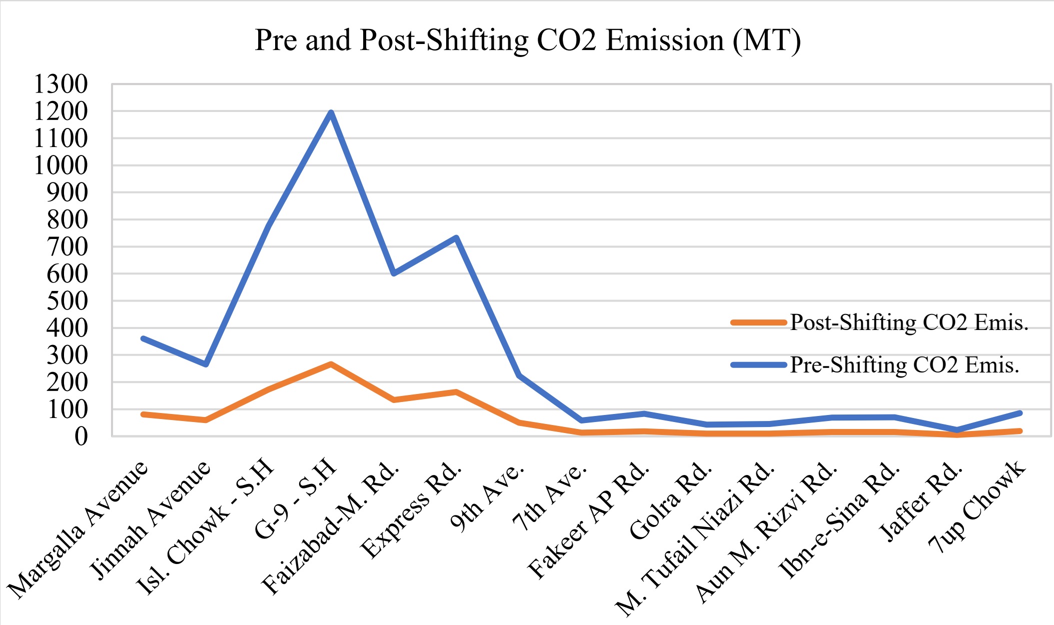


Figure 4.42 90% pre-and post-shifting CO_2 emissions

Figure 4.42 depicts the weekly peak hours of pre-shifting and 90 percent post-shifting carbon dioxide emissions from oil consumption in public transport and private vehicles. The observed difference in the gap between the line bars of pre-shifting and post-shifting carbon dioxide emissions indicates an apparent decrease in the metric tons of carbon dioxide emissions after the shifting.

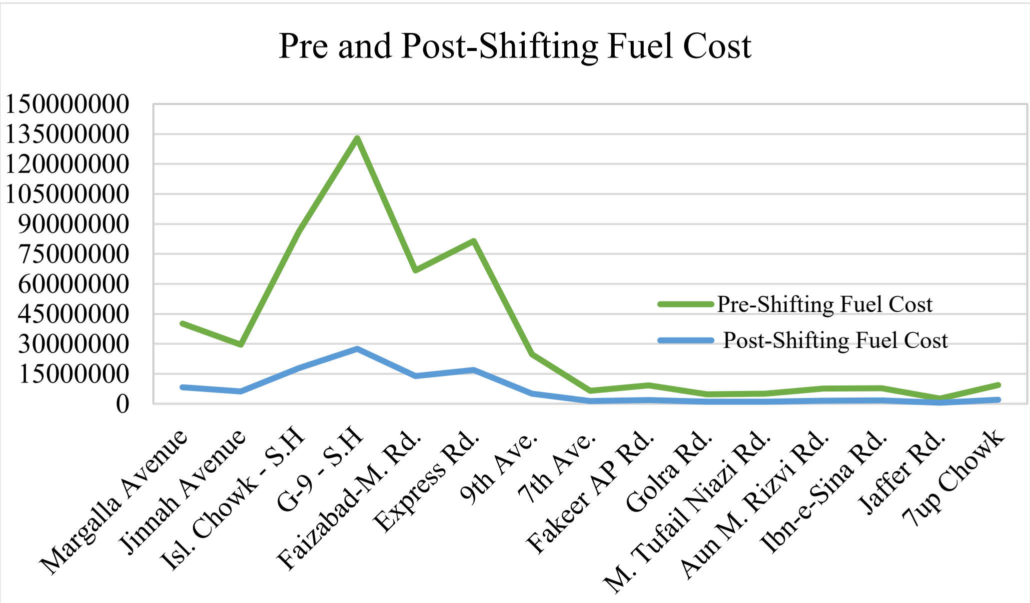


Figure 4.43 90% pre-and post-shifting fuel cost

Figure 4.43 depicts the weekly peak hours of pre-shifting and 90 percent post-shifting fuel cost of vehicles in rupees. The observed difference in the distance between the line bars of pre-shifting and post-shifting fuel cost indicates an apparent decrease in fuel cost or expenditure after the shifting.

4.4.3.2. Weekly impact of 90 Percent Shifting

Table 4.13 Weekly pre-post difference scenario of 90% shifting

	Pre-Shift	Post-Shift	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	286795	1774541	86.1%
Travel (Km)	22011237	3062433	18948804	86.1%
Oil Consumption (L)	1935905	408918	1526987	78.9%
Fuel Cost (Rs.)	514950670	106511198	408439473	79.3%
CO2 Emissions (MT)	4630.68	1031.53	3599.15	77.7%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (Rs.) stands for rupees. (MT) stands for metric tons.

Table 4.13 depicts the weekly pre-post difference of 90 percent shifting. The post-shifting values of all linked variables in Figure 4.13 represent the combination of 90 percent public transport and 10 percent private vehicles. The 90 percent shift from private vehicles to public transport resulted in a significant reduction in vehicles, specifically by 86.1 percent, corresponding to a total decrease of 1,774,541 vehicles per week. It demonstrates that if 90 percent of private vehicles shift to public transport, traffic congestion can decrease by 86.1 percent of its current level due to fewer vehicles on the road. The distance traveled, measured in kilometers, also decreased by 86.1 percent, resulting in a total reduction of 18,948,804 kilometers per week in a 90 percent shifting scenario. Consequently, it can decrease fuel consumption, CO2 emissions, and fuel costs proportional to the drop in kilometers traveled. Oil consumption decreased by 78.9 percent, amounting to a total reduction of 1,526,987 liters per week. It demonstrates that 87.6 percent of the current oil consumed in private vehicles can be saved by shifting 90 percent of private vehicles to public transport, which can also help to reduce the country's oil imports and oil import bills, as Pakistan imports its major portion of the oil from other countries to fulfill its needs (GOP, 2022). The fuel cost decreased by 79.3 percent, resulting in savings of 408,439,473 rupees per week. It demonstrates that 79.3 percent of the current fuel expenditure in private vehicles and millions of rupees can be saved by shifting 90 percent of private vehicles to public transport. CO2 emissions decreased by 77.7 percent, resulting in a decrease of 3,599 metric tons weekly. It demonstrates that shifting 90 percent of private vehicles to public transport can reduce 77.7 percent of CO2 emissions and mitigate the release of thousands of metric tons of CO2 into the environment.

4.4.3.3. Daily Impact of 90 Percent Shifting

Table 4.14 Daily pre-post difference scenario of 90% shifting

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	588953	588953	0	0.00%
No. of Vehicles	294477	40971	253506	86.10%
Travel (Km)	3144462	437490	2706972	86.10%
Oil Consumption (L)	276558	58417	218141	78.90%
Fuel Cost (Rs.)	73564381	15215885	58348496	79.30%
CO2 Emissions (MT)	661.57	147.43	514.14	77.70%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (Rs.) stands for rupees. (MT) stands for metric tons.

Table 4.14 depicts the daily pre-post difference scenario of 90 percent shifting. The post-shifting values of all linked variables in Figure 4.14 represent the combination of 90 percent public transport and 10 percent private vehicles. The 90 percent shift from private vehicles to public transport resulted in a significant daily reduction in all associated factors. Such as, the daily number of vehicles decreased by 253,506, travel distance decreased by 2,706,972 km per day, oil consumption decreased by 218,141 liters per day, fuel cost decreased by 58,348,496 rupees per day, and CO2 emissions from vehicles reduced by 514.14 metric tons daily.

4.4.3.4. Annual Impact of 90 Percent Shifting

Table 4.15 Annual pre-post difference scenario of 90% shifting

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	214967897.1	214967897	0	0.0%
No. of Vehicles	107483949	14954311	92529638	86.1%
Travel (Km)	1147728786	159684006	988044780	86.1%
Oil Consumption (L)	100943618	21322153	79621465	78.9%
Fuel Cost (Rs.)	26850999221	5553798181	21297201040	79.3%
CO2 Emissions (MT)	241473.57	53811.43	187662.14	77.7%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.15 depicts the annual pre-post difference scenario of 90 percent shifting. The post-shifting values of all linked variables in Figure 4.15 represent the combination of 90 percent public transport and 10 percent private vehicles. The 90 percent shift from private vehicles to public transport resulted in a significant annual reduction in all factors. Such as the number of vehicles decreased by 92,529,638 annually, travel distance decreased by 988,044,780 km per annum, oil consumption decreased by annually 79,621,465 liters, fuel cost decreased by 212,97,201,040 rupees annually and CO2 emissions from vehicles reduced by 187,662.14 metric tons per annum.

4.4.4. Scenario 3: Weekdays (Working Days) Shifting to Public Transport

According to the findings of the pilot study, people prefer to use private vehicles on weekends or off days in order to spend personal time with their family without inconvenience. Therefore, in the third scenario, the flow of private vehicles during peak hours on all five working days (Monday to Friday) in each of the 15 locations is shifted to public transport. Nevertheless, private vehicles continue to be utilized during non-working days or weekends (Saturday and Sunday). Hence, based on the assumption that private vehicles shift to public transport during weekdays, the resulting outcomes or impacts are as follows:

Table 4.16 Weekly working days post-shifting results

Locations	Passengers (T.N)	Pub.Trans. (T.N)	Travel (T. Km)	Oil Cons. (T. L)	CO2 Emis. (T. MT)	Fuel Cost (T. Rs.)
Margalla Ave.	263740	29524	383813	43557	107.94	11427390
Jinnah Ave.	336286	54000	405002	41926	102.7	11050161
Isl. Chowk	526926	78429	1098001	115651	283.94	30454122
G-9 - S.H.	811422	114432	1602047	170939	420.38	44983104
Faizabad (MR)	316986	40936	736857	80393	198.26	21132168
Express Rd.	535686	77584	1008594	106925	262.74	28146951
9th Ave.	265216	40128	321021	33684	82.66	8871573
7th Ave.	139220	14186	56745	6624	16.47	1735464
Fakeer AP Rd.	197957	25994	103974	11295	27.84	2969632
Golra Rd.	145107	18196	50948	5602	13.83	1471981
M. Tufail N. Road	78343	8496	46730	5353	13.28	1403672
Aun M. Rizvi Rd.	187268	20272	70951	8131	20.17	2132341
Ibn-e-Sina Rd.	89598	10859	81441	9038	22.34	2373670
Jaffer Rd.	49205	7011	31548	3358	8.25	883719
7up Chowk	179712	18678	84053	9752	24.23	2555754
Total	4122672	558725	6081724	652227	1605.02	171591701

Note. P. Trans. Stands for public transport. (T.N) stands for the total number. (T. Km) stands for total kilometers. (T. L) stands for total liters. (T. MT) stands for total metric tons. (T. Rs) stands for total rupees. P. Veh = Private Vehicles, Oil Cons. = Oil Consumption, Co2 Emis. = Carbon dioxide Emissions

Table 416. depicts the week (working) days post-shifting scenario of private vehicle flow across the 15 most important locations in Islamabad, including the post-shifting number of vehicles on these roads, the post-shifting average travel distance in kilometers covered by these vehicles, the post-shifting oil consumption consumed by these vehicles in liters, the post-shifting CO2 emissions in metric tons emitted by these vehicles based on their average consumption, and the post-shifting average fuel consumption cost in rupees. In simple terms, the working days' flow of private vehicles at each location throughout the week has shifted to public transport, while the weekend (off days) flow of private vehicles continues to be in use. And the impact of this working days shift on associated factors is shown in Figure 4.16. Nonetheless, the aggregate private vehicle flow encompassed the cumulative private vehicle flow during the designated peak hours, which are 7:00 to 10:00, 13:00 to 15:00, and 16:00 to 20:00, and they were shifted to public transport similarly. In addition, measurements of travel distance, oil consumption, CO2 emissions, and fuel cost have been determined based on the post-shifting total number of vehicles on each road and the average length of stated roads.

The working days shift from private vehicles to public transport also has a significant impact on associated factors. Such as, by shifting working days private vehicles flow to public transport and considering off days private vehicles in use, the total number of vehicles experienced a reduction to 558,725 vehicles from 2,061,336 vehicles. The total distance traveled experienced a reduction to 6,081,724 kilometers from 22,011,237 kilometers. The oil consumption (a mixture of working days diesel consumption and off days petrol consumption as private vehicles consume petrol and public vehicles (buses) consume diesel) decreased to 652,227 liters from 1,935,905 liters. The quantity of carbon emissions released by vehicles experienced a reduction to

1605.02 metric tons from 4631 metric tons. The expenditure on fuel experienced a reduction, amounting to a total of 171,591,701 rupees from 514,950,670 rupees. However, the computation of all working days post-shifting values is performed according to the formulas given in Section 3.4.8 and the methodology outlined in Section 3.4.13 of Chapter 3.

Similar to the previous two scenarios of total shifting and 90 percent shifting, the present scenario exhibits diverse rates of reduction in the impact on associated variables at various locations. As a consequence, Tables 4.17, 4.18, 4.19, 4.20, and 4.21 are created to illustrate the percentage change of each variable at each location.

4.4.4.1. Working Days Shifting Impacts on Vehicles

Table 4.17 Working days pre-and post-shifting vehicles

Locations	Pre-Shift Vehicles (T.N – P.V)	Post-Shift Vehicles (T.N – P.T)	DIV (T.N.V)	Change (-) Percentage
Margalla Ave.	131870	29524	102346	77.6%
Jinnah Ave.	168143	54000	114143	67.9%
Isl. Chowk	263463	78429	185034	70.2%
G-9 - S.H.	405711	114432	291279	71.8%
Faizabad (MR)	158493	40936	117557	74.2%
Express Rd.	267843	77584	190259	71.0%
9th Ave.	132608	40128	92480	69.7%
7th Ave.	69610	14186	55424	79.6%
Fakeer AP Rd.	98979	25994	72985	73.7%
Golra Rd.	72554	18196	54358	74.9%
M. Tufail N. Rd.	39172	8496	30675	78.3%
Aun M. Rizvi Rd.	93634	20272	73362	78.4%
Ibn-e-Sina Rd.	44799	10859	33940	75.8%
Jaffer Rd.	24603	7011	17592	71.5%
7up Chowk	89856	18678	71178	79.2%
Total	2061336	558725	1502611	72.9%

Note. DIV stands for difference in values. (-) stands for decrease. (TN-PV) stands for the total number of private vehicles. (T.N-P.T) stands for the total number of public transports. (T.N.V) stands for the total number of vehicles.

Table 4.17 displays the working days' pre- and post-shift vehicles. It demonstrates the difference in pre-shift and post-shift vehicle counts, as well as the percentage change or reduction in vehicle counts following working days shifting at all locations.

The results indicate that the impact of shifting on vehicles across all locations ranges from 67.9 percent to 79.6 percent, depending on the flow of private vehicles on weekdays at each location. However, the cumulative working days private vehicles shifting impact on the number of vehicles is 72.9 percent. It indicates that 72.9 percent of vehicles or congestion can be reduced if private vehicles are replaced with public transport on weekdays.

In addition, the graphical representation is presented to clearly show the differences between the working days' pre-shifting and post-shifting number of vehicles, as shown in Figure 4.44.

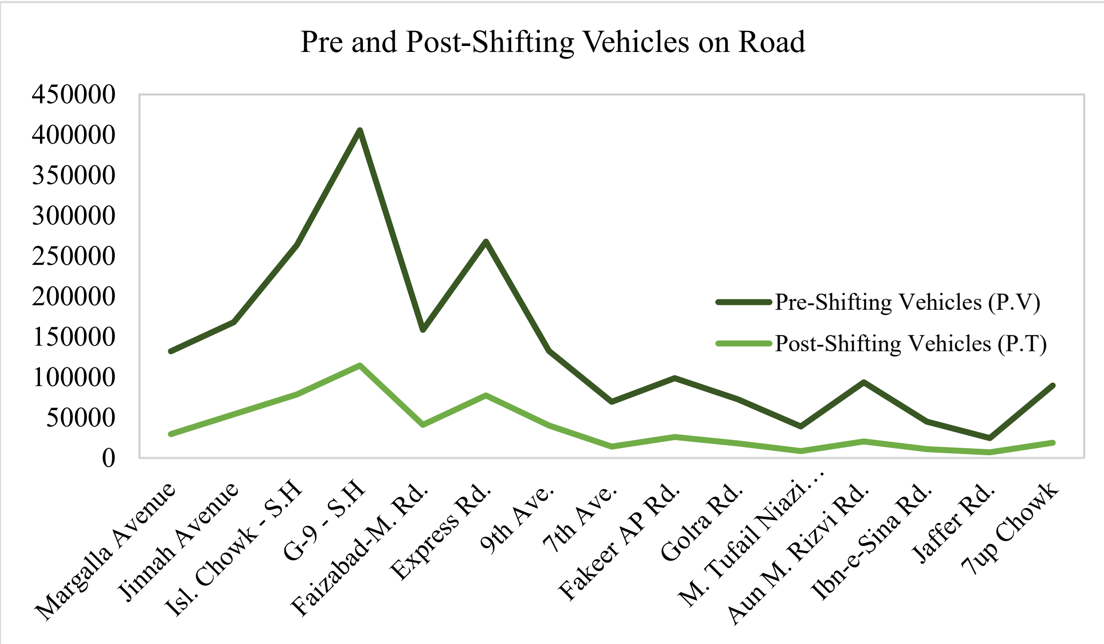


Figure 4.44 Working days pre-and post-shifting vehicles

Figure 4.44 depicts the weekly peak hours of pre-shifting and weekdays (working days) post-shifting vehicles on roads. The observed difference in the distance between the line bars of pre-shifting and post-shifting vehicles indicates an apparent decrease in the number of vehicles after the shifting.

4.4.4.2.Working Days Shifting Impacts on Travel

Table 4.18 Working days pre-and post-shifting travel

Locations	Pre-Shift Travel (T. Km)	Post-Shift Travel (T. Km)	DIV (T. Km)	Change (-) Percentage
Margalla Ave.	1714310	383813	1330497	77.6%
Jinnah Ave.	1261073	405002	856070	67.9%
Isl. Chowk	3688482	1098001	2590481	70.2%
G-9 - S.H.	5679954	1602047	4077907	71.8%
Faizabad (MR)	2852874	736857	2116017	74.2%
Express Rd.	3481959	1008594	2473365	71.0%
9th Ave.	1060864	321021	739843	69.7%
7th Ave.	278440	56745	221695	79.6%
Fakeer AP Rd.	395914	103974	291940	73.7%
Golra Rd.	203150	50948	152202	74.9%
M. Tufail N. Rd.	215443	46730	168713	78.3%
Aun M. Rizvi Rd.	327719	70951	256768	78.4%
Ibn-e-Sina Rd.	335993	81441	254552	75.8%
Jaffer Rd.	110711	31548	79163	71.5%
7up Chowk	404352	84053	320299	79.2%
Total	22011237	6081724	15929513	72.4%

Note. DIV stands for difference in values. (-) stands for decrease. (T. Km) stands for the total kilometers.

Table 4.18 displays the working days' pre- and post-shift travel distance. It demonstrates the difference in pre-shift and post-shift travel distance in kilometers, as well as the percentage change or reduction in travel kilometers following working days shifting at all locations.

The results indicate that the impact of shifting on travel kilometers across all locations ranges from 67.9 percent to 79.6 percent, depending on the flow of private vehicles on weekdays at each location. However, the cumulative working days private vehicles shifting impact on the travel kilometers is 72.4 percent. It indicates that 72.4 percent of travel kilometers and associated costs can be reduced if private vehicles are replaced with public transport on weekdays.

In addition, the graphical representation is presented to clearly show the differences between the working days' pre-shifting and post-shifting travel kilometers, as shown in Figure 4.45

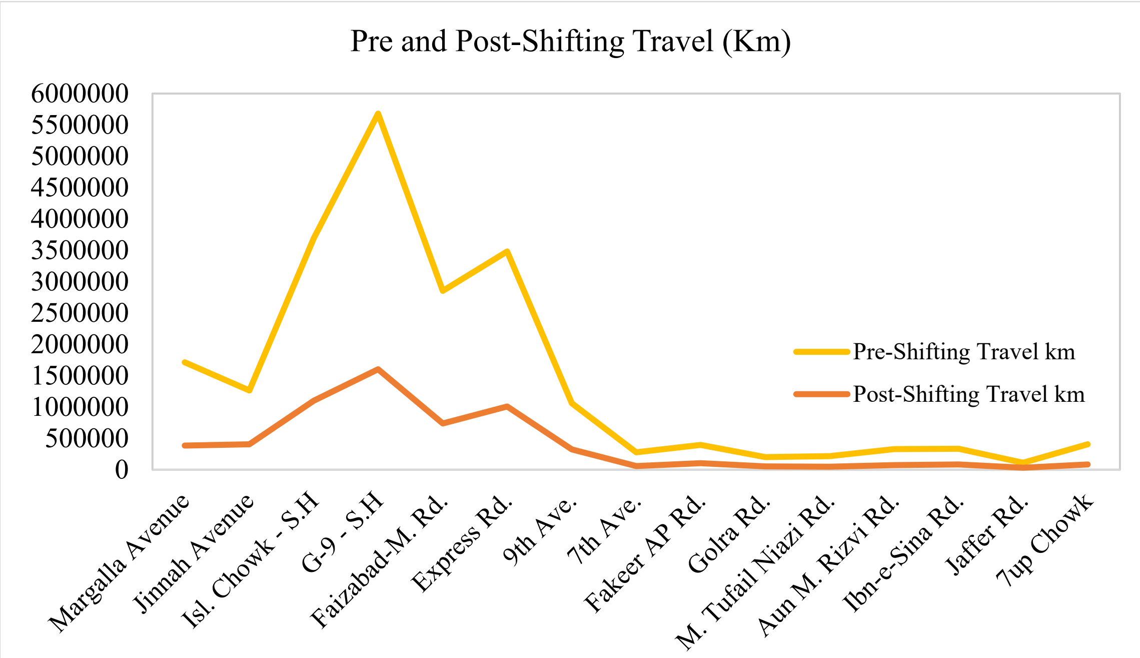


Figure 4.45 Working days pre-and post-shifting travel

Figure 4.45 depicts the weekly peak hours pre-shifting and weekdays (working days) post-shifting travel distance in kilometers. The observed difference in the gap between the line bars of pre-shifting and post-shifting travel km indicates an apparent decrease in the kilometers travel distance after the shifting.

4.4.4.3. Working Days Shifting Impacts on Oil Consumption

Table 4.19 Working days pre-and post-shifting oil consumption

Locations	Pre-Shift Oil Cons. (T. L)	Post-Shift Oil Cons. (T. L)	DIV (T. L)	Change (-) Percentage
Margalla Ave.	150775	43557	107218	71.1%
Jinnah Ave.	110912	41926	68986	62.2%
Isl. Chowk	324405	115651	208754	64.3%
G-9 - S.H.	499556	170939	328618	65.8%
Faizabad (MR)	250912	80393	170519	68.0%
Express Rd.	306241	106925	199316	65.1%
9th Ave.	93304	33684	59620	63.9%
7th Ave.	24489	6624	17865	73.0%
Fakeer AP Rd.	34821	11295	23526	67.6%
Golra Rd.	17867	5602	12265	68.6%
M. Tufail N. Rd.	18948	5353	13596	71.8%
Aun M. Rizvi Rd.	28823	8131	20692	71.8%
Ibn-e-Sina Rd.	29551	9038	20513	69.4%
Jaffer Rd.	9737	3358	6379	65.5%
7up Chowk	35563	9752	25811	72.6%
Total	1935905	652227	1283678	66.3%

Note. Cons. stands for consumption. DIV stands for difference in values. (-) stands for decrease. (T. L) stands for the total liters.

Table 4.19 displays the working days' pre- and post-shift oil consumption. It demonstrates the difference in pre-shift and post-shift oil consumption in liters, as well as the percentage change or reduction in oil consumption following working days shifting at all locations.

The results indicate that the impact of shifting on oil consumption consumption across all locations ranges from 62.2 percent to 73 percent, depending on the flow of private vehicles on weekdays at each location. However, the cumulative working days private vehicles shifting impact on oil consumption is 66.3 percent. It indicates that 66.3 percent of oil consumption can be reduced if private vehicles are replaced with public transport on weekdays.

In addition, the graphical representation is presented to clearly show the differences between the working days' pre-shifting and post-shifting oil consumption in liters, as shown in Figure 4.46.

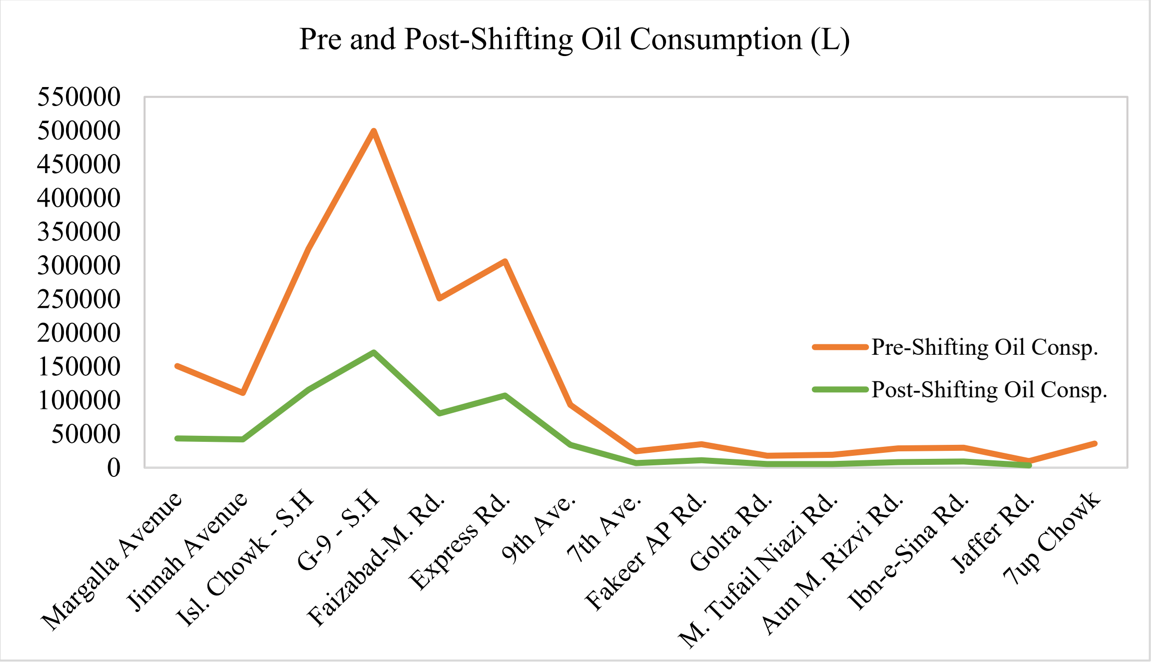


Figure 4.46 Working days pre-and post-shifting oil consumption

Figure 4.46 depicts the weekly peak hours of pre-shifting and weekdays (working days) post-shifting oil consumption in vehicles. The observed difference in the distance between the line bars of pre-shifting and post-shifting oil consumption indicates an apparent decrease in the consumption of oil after the shifting.

4.4.4.4. Working Days Shifting Impacts on CO2 Emissions

Table 4.20 Working days pre- and post-shifting CO2 emissions

Locations	Pre-Shift CO2 Emis. (T. MT)	Post-Shift CO2 Emis. (T. MT)	DIV (T. MT)	Change (-) Percentage
Margalla Ave.	360.65	107.94	252.72	70.1%
Jinnah Ave.	265.30	102.70	162.60	61.3%
Isl. Chowk	775.98	283.94	492.04	63.4%
G-9 - S.H.	1194.94	420.38	774.56	64.8%
Faizabad (MR)	600.18	198.26	401.92	67.0%
Express Rd.	732.53	262.74	469.79	64.1%
9th Ave.	223.18	82.66	140.53	63.0%
7th Ave.	58.58	16.47	42.11	71.9%
Fakeer AP Rd.	83.29	27.84	55.45	66.6%
Golra Rd.	42.74	13.83	28.91	67.6%
M. Tufail N. Rd.	45.32	13.28	32.05	70.7%
Aun M. Rizvi Rd.	68.94	20.17	48.77	70.7%
Ibn-e-Sina Rd.	70.69	22.34	48.35	68.4%
Jaffer Rd.	23.29	8.25	15.04	64.6%
7up Chowk	85.07	24.23	60.84	71.5%
Total	4630.68	1605.02	3025.66	65.3%

Note. CO2 Emis. stands for carbon dioxide emissions. DIV stands for difference in values. (-) stands for decrease. (T. MT) stands for the total metric tons.

Table 4.20 displays the working days' pre- and post-shift CO2 emissions. It demonstrates the difference in pre-shift and post-shift CO2 emissions in metric tons, as well as the percentage change or reduction in CO2 emission following working days shifting at all locations.

The results indicate that the impact of shifting on CO2 emissions across all locations ranges from 61.3 percent to 71.9 percent, depending on the flow of private vehicles on weekdays at each location. However, the cumulative working days private vehicles shifting impact on CO2 emission is 65.3 percent. It indicates that 65.3 percent of CO2 emissions can be reduced if private vehicles are replaced with public transport on weekdays.

In addition, the graphical representation is presented to clearly show the differences between the working days' pre-shifting and post-shifting CO2 emissions in metric tons, as shown in Figure 4.47.

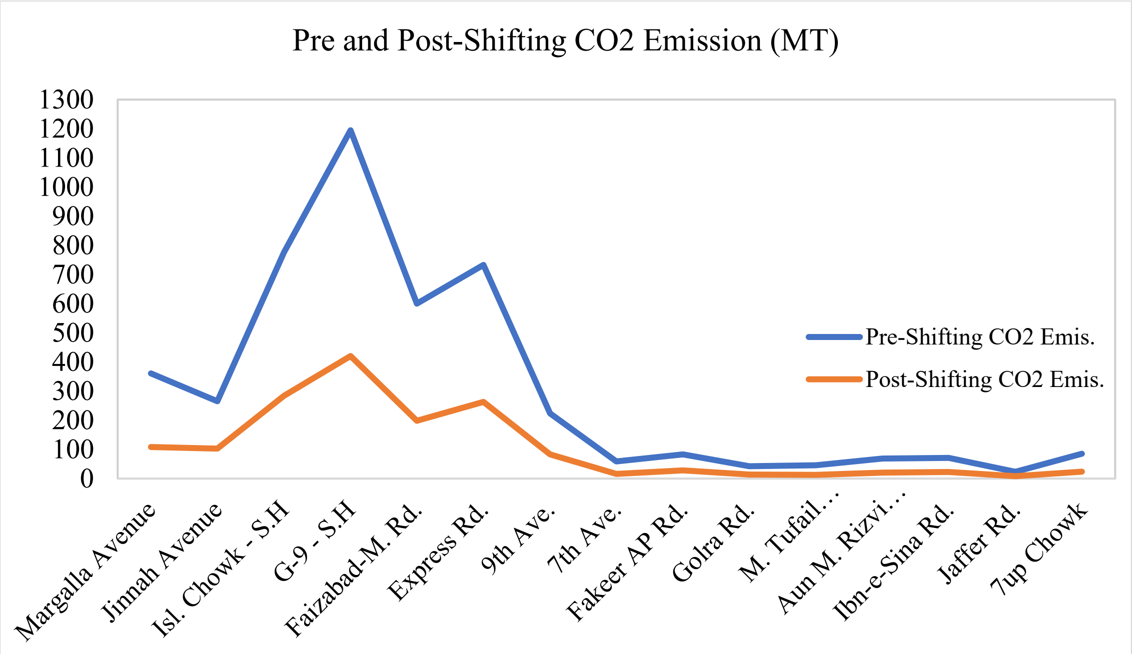


Figure 4.47 Working days pre- and post-shifting CO2 emissions

Figure 4.47 depicts the weekly peak hours of pre-shifting and weekdays (working days) post-shifting carbon dioxide emissions from oil consumption in public transport and private vehicles. The observed difference in the gap between the line bars of pre-shifting and post-shifting carbon dioxide emissions indicates an apparent decrease in the metric tons of carbon dioxide emissions after the shifting.

4.4.4.5. Working Days Shifting Impacts on Fuel Cost

Table 4.21 working days' pre- and post-shifting fuel cost

Locations	Pre-Shift Fuel Cost (T. Rs.)	Post-Shift Fuel Cost (T. Rs.)	DIV (T. Rs.)	Change (-) Percentage
Margalla Ave.	40106109	11427390	28678719	71.5%
Jinnah Ave.	29502664	11050161	18452503	62.5%
Isl. Chowk	86291663	30454122	55837541	64.7%
G-9 - S.H.	132881949	44983104	87898846	66.1%
Faizabad (MR)	66742699	21132168	45610531	68.3%
Express Rd.	81460079	28146951	53313128	65.4%
9th Ave.	24818806	8871573	15947233	64.3%
7th Ave.	6514076	1735464	4778611	73.4%
Fakeer AP Rd.	9262368	2969632	6292736	67.9%
Golra Rd.	4752669	1471981	3280688	69.0%
M. Tufail N. Rd.	5040273	1403672	3636601	72.2%
Aun M. Rizvi Rd.	7666953	2132341	5534612	72.2%
Ibn-e-Sina Rd.	7860511	2373670	5486841	69.8%
Jaffer Rd.	2590078	883719	1706359	65.9%
7up Chowk	9459774	2555754	6904020	73.0%
Total	514950670	171591701	343358969	66.7%

Note. DIV stands for difference in values. (-) stands for decrease. (T. Rs.) stands for the total rupees.

Table 4.21 displays the working days' pre- and post-shift fuel costs. It demonstrates the difference in pre-shift and post-shift fuel costs in rupees, as well as the percentage change or reduction in fuel cost following working days shifting at all locations.

The results indicate that the impact of shifting on fuel cost across all locations ranges from 62.5 percent to 73.4 percent, depending on the flow of private vehicles on weekdays at each location. However, the cumulative working days private vehicles shifting impact on fuel cost is 66.7 percent. It indicates that 66.7 percent of fuel costs can be reduced if private vehicles are replaced with public transport on weekdays.

In addition, the graphical representation is presented to clearly show the differences between the working days' pre-shifting and post-shifting fuel cost in rupees, as shown in Figure 4.48.

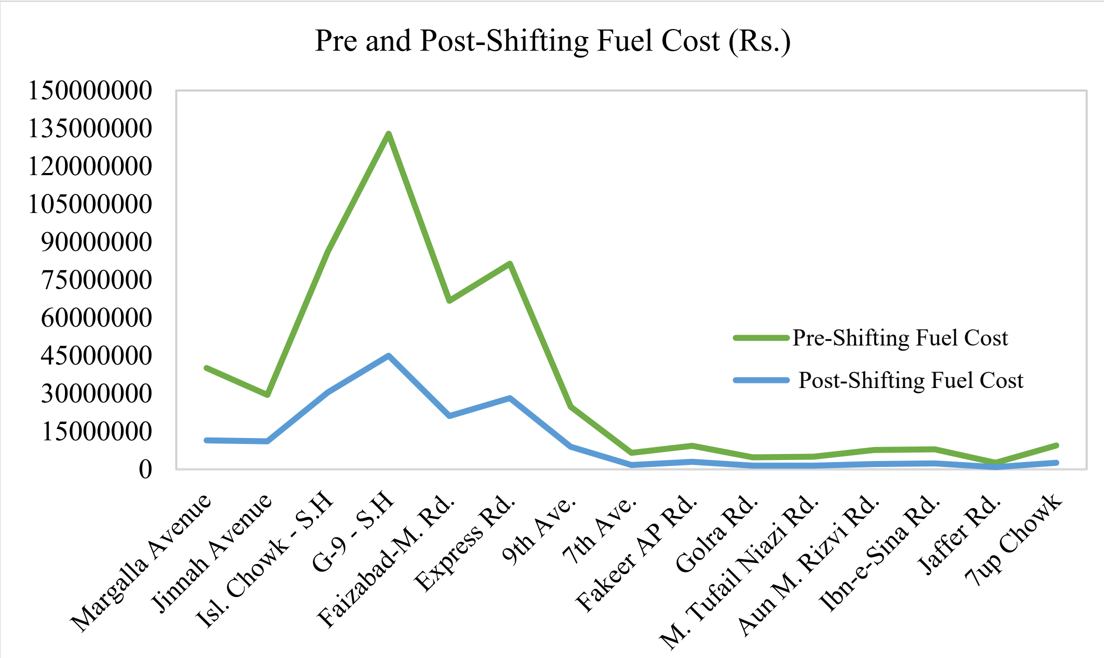


Figure 4.48 Working days' pre- and post-shifting fuel cost

Figure 4.48 depicts the weekly peak hours of pre-shifting and weekdays (working days) post-shifting fuel cost of vehicles in rupees. The observed difference in the distance between the line bars of pre-shifting and post-shifting fuel cost indicates an apparent decrease in fuel cost or expenditure after the shifting.

4.4.5. Other Percentages Shifting Scenarios

Following are the overview pf some other scenarios of shifting private vehicles to public transport. The results of all shifting scenarios in current section are calculated according of pre-shifting formulas, post-shifting formulas, difference in values formulas, percentage differences formulas, and other scenarios calculations described in Section 3.4.7, 3.4.8, 3.4.9, 3.4.10, and 3.4.14 of Chapter 3.

4.4.5.1. 80 Percent Shifting to Public Transport

In the present scenario, shifting 80 percent of private vehicles to public transport and its impacts are added to the impacts of 20 percent of private vehicles, and an 80 percent post-shift scenario is created. Hence, based on the assumption that 80 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follows

Table 4.22 Weekly 80% pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	483966	1577370	76.5%
Travel (Km)	22011237	5167856	16843382	76.5%
Oil Consumption (L)	1935905	578583	1357322	70.1%
Fuel Cost (Rs.)	514950670	151893361	363057309	70.5%
CO2 Emissions (MT)	4631	1431	3199	69.1%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.22 depicts the weekly pre-post difference of 80 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.22 show the combination of 80 percent public transport and 20 percent private vehicles. The 80 percent shift from private vehicles to public transport has also resulted in a substantial reduction in vehicles, specifically by 76.5 percent, which corresponds to a weekly decrease of 1,577,370 vehicles. The distance traveled, measured in kilometers, also decreased by 76.5 percent, resulting in a total reduction of 16,843,382 kilometers per week in an 80 percent shift scenario. Oil consumption decreased by 70.1 percent, amounting to a total reduction of 1,357,322 liters per week. The fuel cost decreased by 70.5 percent, resulting in savings of 363,057,309 rupees per week. In addition, CO2 emissions decreased by 69.1 percent, resulting in a decrease of 3,199 metric tons of CO2 emissions weekly in an 80 percent shifting scenario.

4.4.5.2. 70 Percent Shifting to Public Transport

In the present scenario, shifting 70 percent of private vehicles to public transport and its impacts are added to the impacts of 30 percent of private vehicles, and a 70 percent post-shift scenario is created. Hence, based on the assumption that 70 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follows:

Table 4.23 Weekly 70 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	681137	1380199	67.0%
Travel (Km)	22011237	7273278	14737959	67.0%
Oil Consumption (L)	1935905	748248	1187657	61.3%
Fuel Cost (Rs.)	514950670	197275525	317675145	61.7%
CO2 Emissions (MT)	4631	1831	2799	60.5%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.23 demonstrates the weekly pre-post difference of 70 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.23 represent the combination of 70 percent public transport and 30 percent private vehicles. The 70 percent shift from private vehicles to public transport has also resulted in a substantial reduction in vehicles, specifically by 67.0 percent, which corresponds to a weekly decrease of 1,380,199 vehicles. The distance traveled, measured in kilometers, also decreased by 67.0 percent, resulting in a total reduction of 14,737,959 kilometers per week in a 70 percent shift scenario. Oil consumption decreased by 61.3 percent, amounting to a total reduction of 1,187,657 liters per week. The fuel cost decreased by 61.7 percent, resulting in savings of 317,675,145 rupees per week. In addition, CO2 emissions decreased by 60.5 percent, resulting in a decrease of 2,799 metric tons of CO2 emissions weekly in a 70 percent shifting scenario.

4.4.5.3. 60 Percent Shifting to Public Transport

In the present scenario, shifting 60 percent of private vehicles to public transport and its impact on number of vehicles, travel, oil consumption, fuel cost, and CO2 emissions are added to the impacts of 40 percent of private vehicles, and a 60 percent post-shift scenario is created. Hence, based on the assumption that 60 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are shown in Table 4.24.

Table 4.24 Weekly 60 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	878308	1183028	57.4%
Travel (Km)	22011237	9378701	12632536	57.4%
Oil Consumption (L)	1935905	917913	1017991	52.6%
Fuel Cost (Rs.)	514950670	242657689	272292982	52.9%
Co2 Emissions (MT)	4631	2231	2399	51.8%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.24 depicts the weekly pre-post difference of 60 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.24 demonstrate the combination of 60 percent public transport and 40 percent private vehicles. The 60 percent shift from private vehicles to public transport has resulted in a significant reduction in vehicles, specifically by 57.4 percent, which corresponds to a weekly decrease of 1,183,028 vehicles. The distance traveled, measured in kilometers, also decreased by 57.4 percent, resulting in a total reduction of 12,632,536 kilometers per week in a 60 percent shift scenario. Oil consumption decreased by 52.6 percent, amounting to a total reduction of 1,017,991 liters per week. The fuel cost decreased by 52.9 percent, resulting in savings of 272,292,982 rupees per week. In addition, CO2 emissions decreased by 51.8 percent, resulting in a decrease of 2,399 metric tons of CO2 emissions weekly in a 60 percent shifting scenario.

4.4.5.4. 50 Percent Shifting to Public Transport

In the present scenario, shifting 50 percent of private vehicles to public transport and its impact on number of vehicles, travel, oil consumption, fuel cost, and CO2 emissions are added to the impacts of 50 percent of private vehicles, and a 50 percent post-shift scenario is created. Hence, based on the assumption that 50 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follow:

Table 4.25 Weekly 50 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	1075480	985856	47.8%
Travel (Km)	22011237	11484124	10527113	47.8%
Oil Consumption (L)	1935905	1087579	848326	43.8%
Fuel Cost (Rs.)	514950670	288039852	226910818	44.1%
Co2 Emissions (MT)	4631	2631	2000	43.2%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.25 depicts the weekly pre-post difference of 50 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.25 show the combination of 50 percent public transport and 50 percent private vehicles. The 50 percent shift from private vehicles to public transport has also resulted in a significant reduction in vehicles, specifically by 47.8 percent, which corresponds to a weekly decrease of 985,856 vehicles. The distance traveled, measured in kilometers, also decreased by 47.8 percent, resulting in a total reduction of 10,527,113 kilometers per week in a 50 percent shift scenario. Oil consumption decreased by 43.8 percent, amounting to a total reduction of 848,326 liters per week. The fuel cost decreased by 44.1 percent, resulting in savings of 226,910,818 rupees per week. In addition, CO2 emissions decreased by 43.2 percent, resulting in a decrease of 2,000 metric tons of CO2 emissions weekly in a 50 percent shifting scenario.

4.4.5.5. 40 Percent Shifting to Public Transport

In the present scenario, shifting 40 percent of private vehicles to public transport and its impacts are added to the impacts of 60 percent of private vehicles, and a 40 percent post-shift scenario is created. Hence, based on the assumption that 40 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follow:

Table 4.26 Weekly 40 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	1272651	788685	38.3%
Travel (Km)	22011237	13589547	8421691	38.3%
Oil Consumption (L)	1935905	1257244	678661	35.1%
Fuel Cost (Rs.)	514950670	333422016	181528655	35.3%
Co2 Emissions (MT)	4631	3031	1600	34.5%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.26 depicts the weekly pre-post difference of 40 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.26 represent the combination of 40 percent public transport and 60 percent private vehicles. The 40 percent shift from private vehicles to public transport has resulted in a reduction of 38.3 percent number of vehicles, which corresponds to a weekly decrease of 788,685 vehicles on the road. The distance traveled, measured in kilometers, also decreased by 38.3 percent, resulting in a total reduction of 8,421,691 kilometers per week in a 40 percent shift scenario. Oil consumption decreased by 35.1 percent, amounting to a total reduction of 678,661 liters per week. The fuel cost decreased by 35.3 percent, resulting in savings of 181,528,655 rupees per week. In addition, CO_2 emissions decreased by 34.5 percent, resulting in a decrease of 1,600 metric tons of CO_2 emissions weekly in a 40 percent shifting scenario.

4.4.5.6. 30 Percent Shifting to Public Transport

In the present scenario, shifting 30 percent of private vehicles to public transport and its impacts are added to the impacts of 70 percent of private vehicles, and a 30 percent post-shift scenario is created. Hence, based on the assumption that 30 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follows:

Table 4.27 Weekly 30 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	1469822	591514	28.7%
Travel (Km)	22011237	15694969	6316268	28.7%
Oil Consumption (L)	1935905	1426909	508996	26.3%
Fuel Cost (Rs.)	514950670	378804179	136146491	26.4%
Co2 Emissions (MT)	4631	3431	1200	25.9%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.27 depicts the weekly pre-post difference of 30 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO_2 emissions in Figure 4.27 represent the combination of 30 percent public transport and 70 percent private vehicles. The 30 percent shift from private vehicles to public transport has resulted in a reduction of 28.7 percent number of vehicles, which corresponds to a weekly decrease of 591,514 vehicles on the road. The distance traveled, measured in kilometers, also decreased by 28.7 percent, resulting in a total reduction of 6,316,268 kilometers per week in a 30 percent shift scenario. Oil consumption decreased by 26.3 percent, amounting to a total reduction of 508,996 liters per week. The fuel cost decreased by 26.4 percent, resulting in savings of 136,146,491 rupees per week. In addition, CO_2 emissions decreased by 25.9 percent, resulting in a decrease of 1,200 metric tons of CO_2 emissions weekly in a 30 percent shifting scenario.

4.4.5.7. 20 Percent Shifting to Public Transport

In the present scenario, shifting 20 percent of private vehicles to public transport and its impacts are added to the impacts of 80 percent of private vehicles, and a 20 percent post-shift scenario is created. Hence, based on the assumption that 20 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are shown in Table 4.28.

Table 4.28 Weekly 20 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	1666993	394343	19.1%
Travel (Km)	22011237	17800392	4210845	19.1%
Oil Consumption (L)	1935905	1596574	339330	17.5%
Fuel Cost (Rs.)	514950670	424186343	90764327	17.6%
Co2 Emissions (MT)	4631	3831	800	17.3%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.28 depicts the weekly pre-post difference of 20 percent shifting. The post-shifting values of passengers, vehicles, travel, oil consumption, fuel cost, and CO_2 emissions in Figure 4.28 represent the combination of 20 percent public transport and

80 percent private vehicles. The 20 percent shift from private vehicles to public transport has resulted in a reduction of 19.1 percent number of vehicles, which corresponds to a weekly decrease of 394,343 vehicles on the road. The distance traveled, measured in kilometers, also decreased by 19.1 percent, resulting in a total reduction of 4,210,845 kilometers per week in a 20 percent shift scenario. Oil consumption decreased by 17.5 percent, amounting to a total reduction of 3,39,330 liters per week. The fuel cost decreased by 17.6 percent, resulting in savings of 90,764,327 rupees per week. In addition, CO2 emissions decreased by 17.3 percent, resulting in a decrease of 800 metric tons of CO2 emissions weekly in a 20 percent shifting scenario.

4.4.5.8. 10 Percent Shifting to Public Transport

In the present scenario, shifting 10 percent of private vehicles to public transport and its impacts are added to the impacts of 90 percent of private vehicles, and a 10 percent post-shift scenario is created. Hence, based on the assumption that 10 percent of private vehicles shift to public transport, the overall weekly resulting outcomes or impacts are as follows:

Table 4.29 Weekly 10 percent pre- and post-shifting difference

	Pre-Shifting	Post-Shifting	DIV	% Change
No. of Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	1864165	197171	9.6%
Travel (Km)	22011237	19905815	2105423	9.6%
Oil Consumption (L)	1935905	1766240	169665	8.8%
Fuel Cost (Rs.)	514950670	469568507	45382164	8.8%
Co2 Emissions (MT)	4631	4231	400	8.6%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.29 depicts the weekly pre-post difference of 10 percent shifting. The post-shifting values passengers, vehicles, travel, oil consumption, fuel cost, and CO2 emissions in Figure 4.29 represent the combination of 10 percent public transport and 90 percent private vehicles. The 10 percent shift from private vehicles to public transport has resulted in a reduction of 9.6 percent number of vehicles, which corresponds to a weekly decrease of 197,171 vehicles on the road. The distance traveled, measured in kilometers, also decreased by 9.6 percent, resulting in a total reduction of 2,105,423 kilometers per week in a 10 percent shift scenario. Oil consumption decreased by 8.8 percent, amounting to a total reduction of 169,665 liters per week. The fuel cost decreased by 8.8 percent, resulting in savings of 45,382,164 rupees per week. In addition, CO2 emissions decreased by 8.6 percent, resulting in a decrease of 400 metric tons of CO2 emissions weekly in a 10 percent shifting scenario.

4.4.6. Summary of Percentage Shifting Key Results

Table 4.30 shows the key results of percentage shifting in the form of percentage change or reduction in number of vehicles, travel, oil consumption, fuel cost and CO2 emissions.

Table 4.30 Summary of all percentage shifting results

Shifting	Vehicles	Travel	Oil Cons.	Fuel Cost	CO2 Emi.
0%	0%	0%	0%	0%	0%
10%	9.57%	9.57%	8.76%	8.81%	8.64%
20%	19.1%	19.1%	17.5%	17.6%	17.3%
30%	28.7%	28.7%	26.3%	26.4%	25.9%
40%	38.3%	38.3%	35.1%	35.3%	34.5%
50%	47.8%	47.8%	43.8%	44.1%	43.2%
60%	57.4%	57.4%	52.6%	52.9%	51.8%
70%	67.0%	67.0%	61.3%	61.7%	60.5%
80%	76.5%	76.5%	70.1%	70.5%	69.1%
90%	86.1%	86.1%	78.9%	79.3%	77.7%
100%	95.7%	95.7%	87.6%	88.1%	86.4%

Note. Oil Cons. Stands for oil consumption. CO2 Emis. Stands for carbon dioxide emission.

However, Figure 4.49 shows the visual depiction of percentage change across all percentage shifting scenarios.

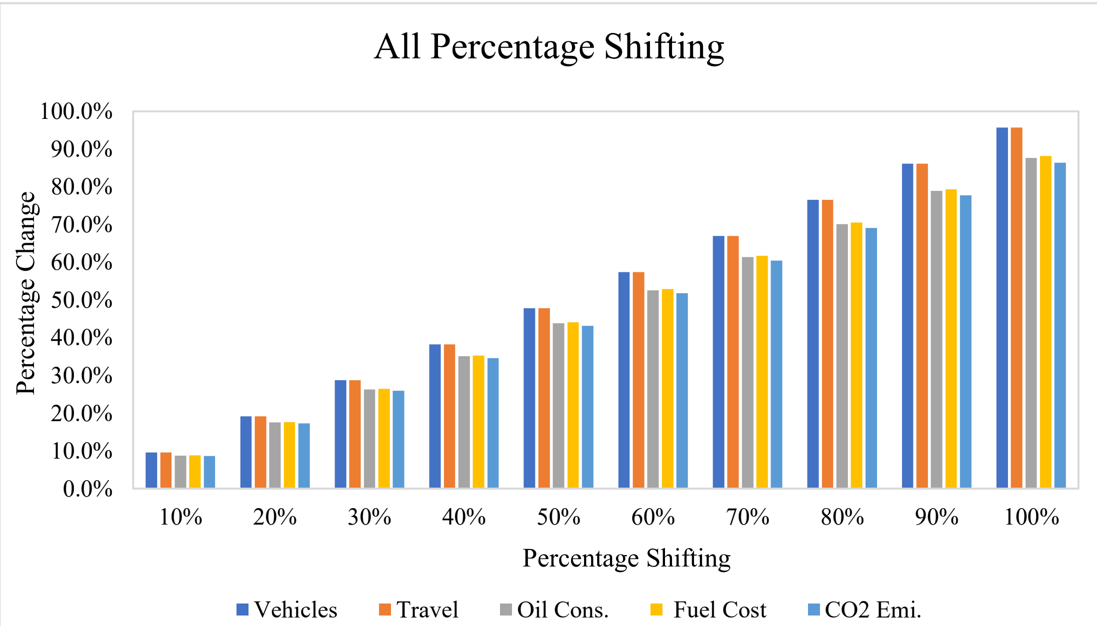


Figure 4.49 All percentage shifting chart

The summary of all percentage shifting values results of number of vehicles, travel, oil consumption, fuel cost, and CO2 emissions are given in Table 4.31.

Table 4.31 Summary of all percentage shifting results in values

Shifting	Vehicles (C)	Travel (Km)	Oil Cons. (L)	Fuel Cost (M. Rs.)	CO2 Emi. (MT)
0%	2061336	22011237	1935905	514.95	4630.68
10%	1864165	19905815	1766240	469.57	4230.78
20%	1666993	17800392	1596574	424.19	3830.87
30%	1469822	15694969	1426909	378.80	3430.97
40%	1272651	13589547	1257244	333.42	3031.06
50%	1075480	11484124	1087579	288.04	2631.16
60%	878308	9378701	917913	242.66	2231.25
70%	681137	7273278	748248	197.28	1831.34
80%	483966	5167856	578583	151.89	1431.44
90%	286795	3062433	408918	106.51	1031.53
100%	89623	957010	239253	61.13	631.63

Note. Cons. stands for consumption. CO2 Emi. Stands for carbon dioxide emission. (C) stands for the count. (Km) stands for kilometer. (L) stands for liter. (M. Rs.) stands for a million rupees. (MT) stands for metric ton.

Table 4.31 depicts the summary of all percentage shifting results in the form of changes in values. However, the 0% stands for pre-shifting impacts. Furthermore, Figure 4.50, 4.51, 4.52, 4.53, and 4.54 depicts the pictoral representation of all percentage shifting impacts on number of vehicles, travel, oil consumption, fuel cost, and CO2 emissions.

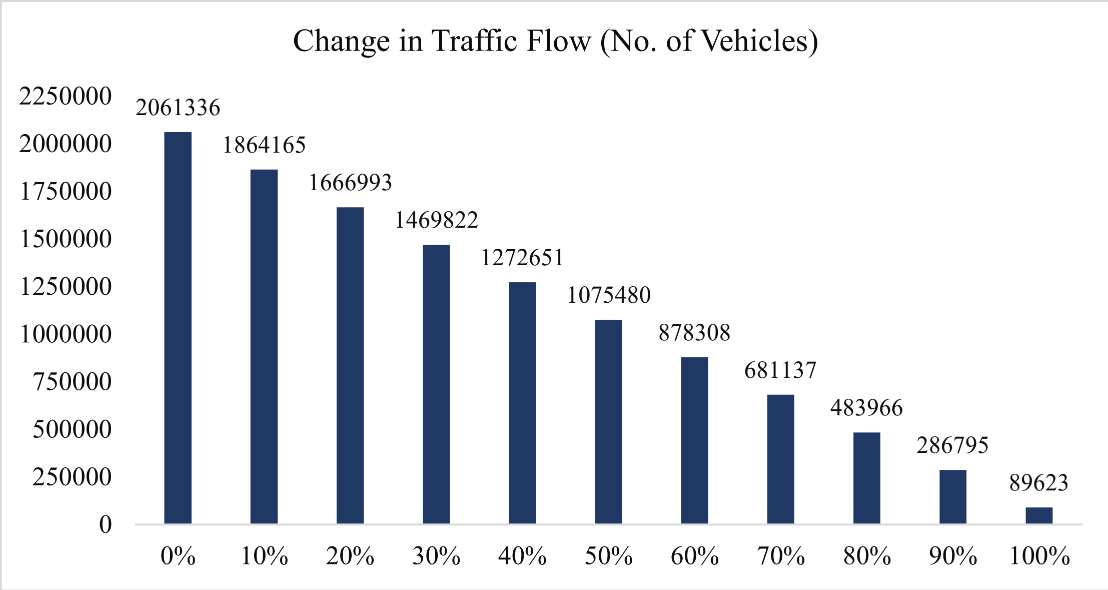


Figure 4.50 All percentage shifting impact on vehicles

Figure 4.50 demonstrates the visual representation of all percentage shifting impacts on vehicles in the form of change in values. The downward trend of the curve depicts the reduction in number of vehicles caused by each 10 percent shift from private vehicles to public transport

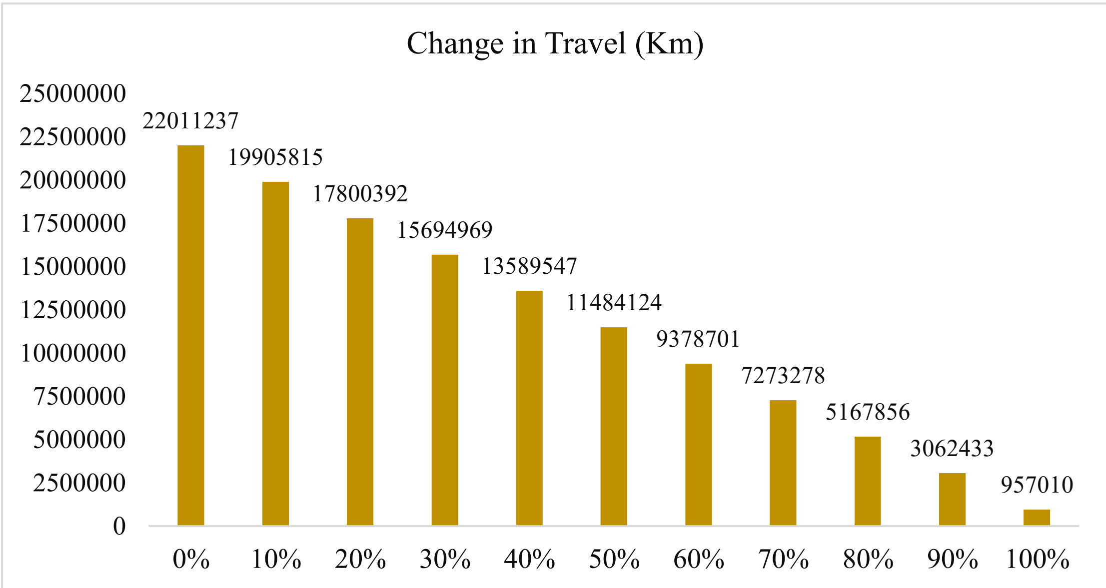


Figure 4.51 All percentage shifting impact on travel

Figure 4.51 depicts the visual representation of all percentage shifting impacts on travel kilometers in the form of change in values. The downward trend of the curve depicts the reduction in travel caused by each 10 percent shift from private vehicles to public transport

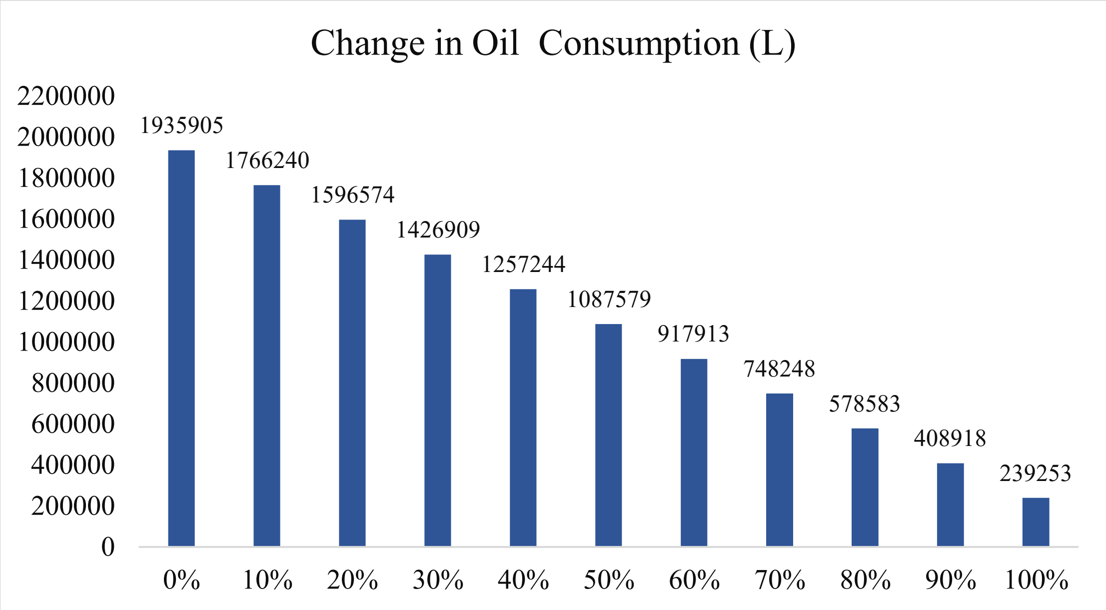


Figure 4.52 All percentage shifting impact on oil consumption

Figure 4.52 is the graphical representation of the different percentage shifting impacts on oil consumption, as represented by numbers. The downward trend of the curve depicts the reduction in oil consumption caused by each 10% shift from private vehicle to public transport.

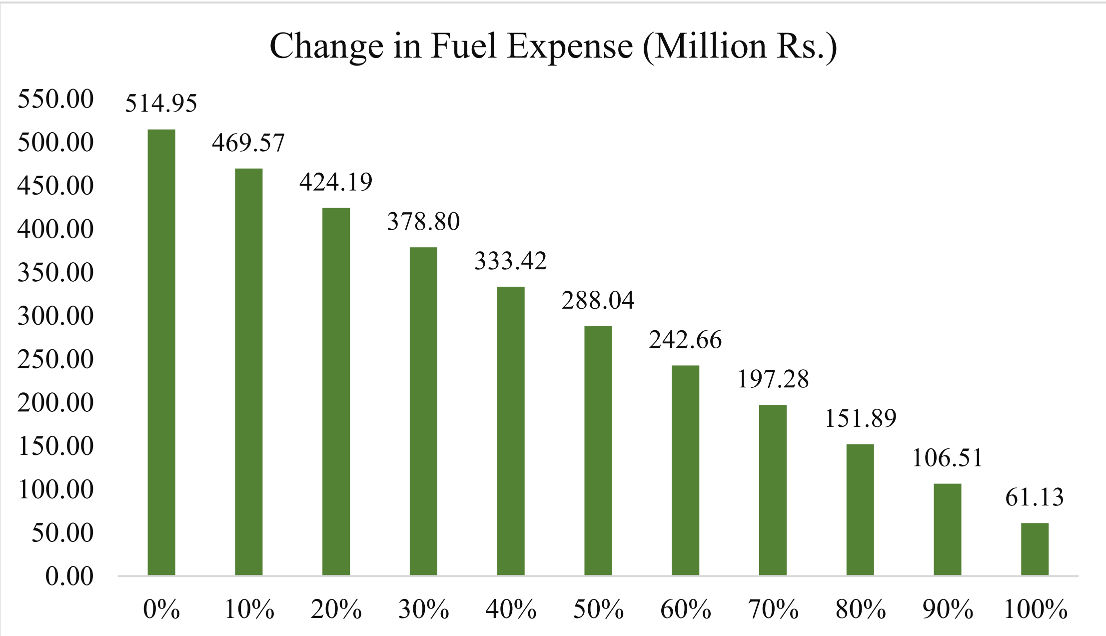


Figure 4.53 All percentage shifting impact on fuel cost

Figure 4.53 shows the numerical visual representation of all percentage shifting impacts on fuel prices. The downward trend of the curve depicts the reduction in fuel cost caused by each 10 percent shift from private vehicles to public transport.

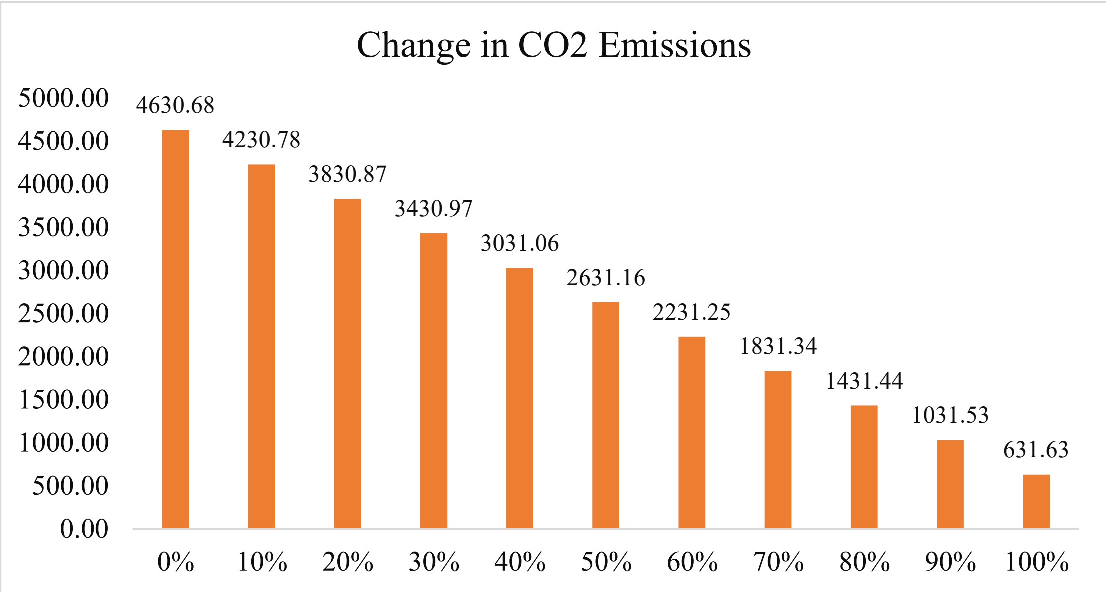


Figure 4.54 All percentage shifting impact on CO2 emissions

Figure 4.54 is a graphical representation of the different percentage shifting impacts on CO2 emissions, as represented by numbers. The downward trend of the curve depicts the reduction in CO2 emissions caused by each 10% shift from private vehicle to public transport.

4.4.7. Key Summary Results of Weekdays Shifting

Table 4.32 Key Summary Results of Weekdays Shifting

	Pre-shift	Post-Shift	DIV	% Change
Passengers	4122672	4122672	0	0.0%
No. of Vehicles	2061336	558724.5217	1502611	72.9%
Travel km	22011237	6081724.274	15929513	72.4%
Oil Consumption	1935905	652227	1283678	66.3%
Fuel Cost	514950670	171591701.5	343358969	66.7%
Co2 Emissions	4631	1605.019248	3025.66	65.3%

Note. The shifting process is based on the number of passengers, resulting in an equivalence between the pre-shifting and post-shifting passenger counts. DIV stands for difference in values. (Km) stands for kilometers. (L) stands for liters. (M Rs.) stands for a million rupees. (MT) stands for metric tons.

Table 4.32 demonstrates the key summary results of weekdays' shifting.

4.5. Discussions

As per the results of the data description, the evening hours between 16:00 and 20:00 experience the highest volume of traffic. In addition, the G9-Srinagar Highway has the highest flow of private vehicles among all 15 locations. The findings revealed that the weekly total number of private vehicle flows amounted to 2,061,336 vehicles across 15 locations. This substantial presence of private vehicles has resulted in various issues, including traffic congestion, heightened oil consumption, increased burden of fuel costs, and deterioration in environmental quality. However, the findings reveal that the aforementioned impacts can be mitigated through the shifting of private vehicles to public transport systems.

The observed results indicate that one public transport can replace twenty-six private vehicles on the road. If all private vehicles are shifted to public transport, the number of vehicles on the road can be diminished by 95.7 percent, resulting in a significant decrease in traffic congestion. Additionally, oil consumption, fuel costs, and CO2 emissions can be reduced by 87.6 percent, 88.16 percent, and 86.76 percent, respectively. Similarly, if 90 percent of private vehicles are shifted to public transport, the number of vehicles can be decreased by 86.1 percent oil consumption can be reduced by 78.9 percent, fuel costs can be lessened by 79.3 percent, and CO2 emissions can be mitigated by 77.7 percent. However, for every 10 percent shift from private vehicles to public transport, the number of vehicles on the road can be minimized by 9.57 percent, oil consumption can be decreased by 8.76 percent, fuel costs can be declined by 8.81 percent, and CO2 emissions can be mitigated by 8.67 percent. Moreover, if working-day private vehicles are shifted to public transport, the number of vehicles can be reduced by 72.9 percent, oil consumption can be decreased by 66.3 percent, fuel costs can be lessened by 65.3 percent, and CO2 emissions can be declined by 66.73 percent. However, in each case, travel kilometers decreased by the same proportion as the number of vehicles. The results of the current study show that shifting private vehicles to public transport has a significant impact on the number of vehicles, travel, oil consumption, fuel cost, and CO2 emissions.

According to Haroon et al. (2023), private vehicles in the country own a greater proportion than public transport. Hence, it may be inferred that personal vehicles make a substantial contribution to the issue of traffic congestion. Therefore, a reduction in the quantity of privately owned vehicles has the potential to alleviate traffic congestion on roads. According to the findings of the present study, if all private vehicles are shifted to public transport, it has the potential to result in a substantial reduction in the number of vehicles, estimated at 97.5 percent. This reduction holds promise for alleviating road congestion. Nevertheless, in the event that the shifting of all private vehicles to public transport is unfeasible, an alternative option of a 90 percent shifting or weekday shifting scenario could be considered as the outcomes of the pilot study support this decision and the findings of the study demonstrate that it has a significant impact on reducing the number of vehicles and easing traffic congestion. However still, if it is not conceivable to achieve a 90 percent shift, alternative scenarios could be considered, as they also contribute to the decrease in vehicles on the road. The results further indicated that the decrease in the number of vehicles on roads also leads to a proportional reduction in travel kilometers.

As per the results, if all private vehicles are shifted to public transport, oil consumption could be reduced by 87.6 percent. This reduction in oil consumption could lead to a decrease in oil import bills, as the transport sector currently accounts for over 75 percent of the country's overall oil consumption (GOP, 2023) and the country fulfills 85 percent of its oil needs through imports (Raza & Boqiang, 2021). If scenarios based on the findings of the pilot study are selected, they can also drastically reduce oil consumption. For instance, the scenario involving a 90 percent shift can result in a reduction of oil consumption by 78.9 percent, while the scenario including a shift in working days can lead to a reduction of oil consumption by 66.3 percent.

Additionally, the study revealed that the decrease in oil consumption has the potential to yield substantial savings in fuel costs, amounting to millions of rupees. By shifting all private vehicles to public transport, the overall number of vehicles can potentially be decreased, thereby leading to a reduction in oil consumption within the transport sector. This is mainly due to the decreased number of vehicles in use. Reducing oil consumption and increasing the use of public transport can result in a fuel cost reduction of more than 80 percent. In recent times, the Pakistani government has undertaken several increases in fuel prices as a strategy to comply with the stipulations established by the International Monetary Fund (IMF) and manage the budget deficit (Shahzad & Peshimam, 2023) and as per the findings of the pilot study, the escalating costs of fuel have imposed financial burdens on individuals who utilize private vehicles, particularly those who largely depend on them for daily commuting or business-related activities. Therefore, the shifting of private vehicles to public transport can significantly decrease the financial burden of private vehicle users.

Moreover, the decrease in oil consumption reduces CO2 emissions by 86.4% and could mitigate the metric tons of CO2 emitted by the transport sector if all private vehicles are replaced by public transport. Kaffashi et al. (2016) also demonstrated that the shift of commuters from private vehicles to public transport can serve as a crucial tactic in mitigating energy usage and consequent carbon dioxide emissions. If shifting all private vehicles is unfeasible, 90 percent shifting or working days shifting can be considered as they all have a significant impact on the mitigation of CO2 emissions.

The reduction in CO_2 emissions can save the environment from harmful impacts and climate change (Unar et al., 2022).

Traffic congestion mostly occurs during peak hours, typically spanning from 8 a.m. to 10 a.m., when individuals commute to their workplaces and students travel to educational institutions. Additionally, congestion is prevalent throughout the period from 4 p.m. to 8 p.m. when people return home (Ali et al., 2021). If private vehicles of these peak hours are shifted to public transport, a significant reduction in congestion, oil consumption, fuel cost, and CO_2 emissions can be achieved. Although, effective public transport is needed for this shift. The existing intracity public transport is either local public transport that has low service quality (CDA, 2017) or BRT (metro buses) which does not provide comprehensive coverage of the entire city (Zameen, 2022). However, the current study is not against the BRT as it is a viable option as public transport but in the developing economy of Pakistan, it imposes a financial burden on the government. For instance, such projects are prohibitively expensive for Pakistan's developing economy because they require separate infrastructure, involve high passenger and operational expenses, and necessitate daily subsidies (Abid, 2020). In addition, previous studies in Pakistan concentrated on the adoption of electric vehicles to reduce oil consumption and carbon dioxide emissions (Asim et al., 2022; Shakeel, 2022; Unar et al., 2022 Butt & Singh, 2023). However, the adoption of electric vehicles in Pakistan faces a number of obstacles, including a shortage of electricity, high capital expenditures for charging stations, exemptions on EV purchases, and a lack of a pricing policy for EVs. (Asghar et al., 2021). Hence, it is imperative to establish a public transport system in Pakistan that is both feasible for its developing economy and capable of meeting the demands of private vehicle users, thereby facilitating their shift to utilizing public transport.

4.6. Summary of the Chapter

The current chapter of the dissertation elaborates the description of registered private vehicles in Islamabad. Further, day-wise and duration-wise descriptions of private vehicles flow in 15 intracity points of Islamabad. In addition, the current chapter illustrates the results of independent sample t-test, one-way ANOVA, pre-shifting scenario, and eleven different post-shifting scenarios of private vehicles. Furthermore, this chapter depicts the pictorial representation of the post-shifting results.

CHAPTER 5

IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSION

5.1. Introduction

The current section (section 5.1) illustrates the introduction of the chapter and structure of the remaining chapter. Section 5.2 illustrates the conclusion of the study. Section 5.3 elaborates the implications. Section 5.4 shows recommendations of the study. Section 5.5 demonstrates the research limitations and future roadmap of the study. Section 5.6 describes the summary of the chapter.

5.2. Conclusion

The description of the data reveals that private vehicles have the highest traffic flow in the morning and evening timing. The results further illustrate that the G9-Srinagar Highway has the greatest vehicle flow across all the locations examined during the study. Therefore, oil consumption, fuel cost, CO2 emissions, and congestion are also highest in this location, particularly in the evening timings.

The shifting results reveal that if all private vehicles are shifted to public transport, the number of vehicles decreases by 95.7 percent, which decreases oil consumption by 87.6 percent. The decrease in oil consumption reduces fuel costs by 88.1 percent and mitigates CO2 emissions by 86.4 percent.

However, it may appear too c. Therefore, this study suggests and analyzes a phase-wise shifting of private vehicles to public transport that may appear more practicable. Nevertheless, the respective shifting produces favorable results in terms of oil consumption, CO2 emissions, fuel cost, and congestion. For instance, if only 10 percent of private vehicles are converted to public transport, the number of vehicles will decline by 9.57 percent. As a result, oil consumption will decrease by 8.76 percent,

CO_2 emissions will mitigate by 8.64 percent, and fuel costs will decline by 8.81 percent.

5.3. Implications

The present study proposes that governmental authorities and policymakers should contemplate the shifting from private vehicles to public transport as an effective way to alleviate traffic congestion and diminish national oil consumption, thereby reducing oil imports and associated bills, promoting fuel cost savings, and mitigating the adverse environmental effects of carbon dioxide emissions. If the shift of all private vehicles to public transport proves challenging, the study proposes 10 more scenarios. In addition, governmental authorities and policymakers have the flexibility to choose any of these scenarios based on their suitability for shifting and subsequently reduce the respective impacts. Furthermore, government officials and policymakers have the option to assess the validity of the findings by initially applying a specific scenario in a single place before extending it to the entire city.

Furthermore, the study proposes to implement formal public transport on weekdays and will be permitted to suspend operations on weekends. This implication should aim to provide convenience to private vehicle users during the week while allowing them to use their vehicles for recreational purposes with their families on weekends.

5.4. Recommendations

After examining the impact of shifting private vehicles to public transport on oil consumption, CO_2 emissions, and congestion, as well as the findings from the pilot study, the following recommendations are proposed for government authorities and policymakers to decrease the use of private vehicles by improving public transport.

The governmental authorities and policymakers should take steps towards the improvement of public transport, as it is the best time to take the initiative because private vehicle users show the willingness to shift to public transport due to fuel price hikes. However, instead of contemplating the Bus Rapid Transit (BRT), it is advisable to implement an effective and efficient public transport system that leverages the preexisting infrastructure and necessitates reduced subsidies. Public-private partnerships (PPPs) can be a viable option for authorities to address this issue. This partnership should aim to improve user experience, transparency, and efficiency by promoting the adoption of technology solutions like real-time tracking, passenger mobile apps, and digital payment systems so private vehicle users prefer public transport due to its efficiency.

The government should identify areas with insufficient access to public transport and encourage private bus companies to increase their services in order to fill these gaps. The collaborations between the government and private bus companies can be helpful for this purpose. For instance, by enhancing accessible public transport through strategic public-private partnerships (PPPs), governments can work together with private companies to significantly improve the availability, quality, and inclusivity of public transport services for all members of society, including people with disabilities. In addition, by offering incentives or subsidies, the government can persuade companies to take less profitable routes.

The study suggests optimizing public transport routes to connect densely populated residential areas with major employment centers and educational institutions. Collaboration with employers and educational institutions is also recommended to promote public transport usage through employer-sponsored programs or student passes. Additionally, improving last-mile connectivity options can increase accessibility to public transport stations or stops. These possibilities include walking, cycling, and micro-mobility services. Data analytics should be utilized to monitor and analyze commuting patterns, guiding service adjustments, route optimizations, and resource allocation. The study proposes starting implementation in selected urban corridors or areas with high commuting demands and gradually expanding coverage based on demand, resource availability, and positive outcomes.

The authorities must establish regulations and standards for public transport to ensure the compliance of private bus companies with these parameters and formulate regulations regarding the fare structure. The implementation of fare regulations across public transport should be imperative, with the aim of ensuring uniformity in fare pricing.

The policymakers should implement a comprehensive regulatory framework that includes operational standards, safety protocols, service quality benchmarks, and guidelines for environmental sustainability for private bus companies providing public transport services. Nonetheless, to ensure adherence to safety, maintenance, and service quality standards, the regulatory framework includes provisions for routine inspections and audits of the operations of private bus companies. If there is noncompliance, there should be penalties or business closures.

Marketing and public awareness strategies should be implemented to highlight the advantages of public transport over private vehicles. The positive environmental effects, financial benefits, reduced traffic congestion, and improved convenience provided by public transport should be emphasized in these strategies to change perceptions and attitudes. In addition, incentives and rewards should be provided to encourage the consistent use of public transport. For example, loyalty programs, discounts, and other incentives can encourage private vehicle users to shift and continue the use of public transport. Furthermore, incorporate user input into the planning and design phases of improvements in public transport. Collect feedback through a variety of methods, such as surveys, focus groups, and public consultations, to ensure that the system is in accordance with user preferences and effectively resolves their issues.

5.5. Research Limitations and Future Roadmap of the Study

The current study has some limitations that are needed for further analysis to combat the insufficiency. First, due to time limitations, the present study uses only the data of one city to analyze the impact of shifting private vehicles to public transport. Therefore, the present study recommends that in order to generalize the findings, future studies should include data from multiple cities. This will provide a more comprehensive understanding of the impact of shifting private vehicles to public transport across different urban contexts. Researchers should employ the same methodology to ensure consistency in the analysis. Secondly, this study does not include motorbikes as a private vehicle for analysis. Therefore, to capture a complete picture of private vehicle usage, future studies should incorporate motorbikes as a category of private vehicles. This will allow for a more thorough analysis of the potential shift towards public transport and its impacts. Thirdly, the current study uses one-week peak-hours data of private vehicles. Therefore, to improve the reliability of the results, future research should collect data for a longer duration. Instead of relying on one-week peak-hour data, researchers should consider using 24-hour data for multiple weeks. This will provide a more accurate representation of private vehicle usage patterns and allow for more robust conclusions. Fourthly, the present study focuses on analyzing the willingness of private vehicle users to shift towards public transport in a pilot study. However, to obtain more accurate results, future studies should consider using a larger sample size. Additionally, it is recommended that future studies should also analyze the effective and efficient public transport according to the developing economy of Pakistan through different analysis methods, such as cost and benefits analysis.

5.6. Summary of the Chapter

This chapter illustrates the implications of the study and recommendations for the public transport system. Further, discuss the limitations and future roadmap of the study. Furthermore, the current chapter illuminates the conclusion of the study.

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Appendix

Appendix-A

Pilot Study

A pilot study is a preliminary investigation conducted to assess the feasibility of the methods intended for a subsequent, more comprehensive, or conclusive research project (Arain et al., 2010). The pilot study is a crucial phase in research work, pinpointing potential issues and inadequacies in the research instruments and protocol before implementation in the whole study (Hassan et al., 2006).

A pilot study was undertaken to examine individuals' perspectives regarding the utilization of private vehicles, the average monthly consumption and associated expenses of oil, the average utilization of public transport, their opinions concerning the existing public transport system, and their inclination to shift from private vehicles to public transport based on their income level. In addition, their recommendations for the public transport system to which they are willing to shift.

Methodology

The pilot study was conducted through semi-structured interviews comprised of nine questions. The individuals residing in Islamabad were selected for semi-structured interviews based on their voluntary participation. The primary locations for conducting the interviews were parks, office parking, university parking, and shopping mall parking areas during weekends, as individuals' weekday schedules are occupied with work-related obligations. A total of hundred participants were interviewed in order to gain valuable insights on the current topic.

Findings of Pilot Study

The majority of interviewees were government employees, while a few were businessmen. The salaries of these government employees were falling between one lac and two lac rupees. However, the earnings of businessmen exceeded two lacs. As per findings, the average monthly private vehicle oil cost for intracity trips ranges from 15,000 to 20,000 rupees. However, for some individuals, it is between 60,000 and 70,000 rupees. People further stated that the rise in oil prices resulted in a twofold increase in oil costs over the preceding months, resulting in an additional financial burden. In addition, the majority of private vehicle users do not commonly use public transport and have not utilized public transport in the past 30 days.

Purpose of using private vehicle

The majority of residents in Islamabad mostly rely on private vehicles for various purposes such as commuting to work, engaging in shopping activities, spending leisure time with their family, going on weekend outings with family, working trips, and pursuing education.

Reasons for using private vehicles.

Most of the people living in Islamabad use private vehicles, primarily due to concerns regarding personal safety, the security of one's family, timely arrival at intended locations, ease of access, efficiency in time management, situations involving single-parent households, and comfortability.

Current Public Transport System

As per findings, private vehicle users in Islamabad have a negative perception of public transport. According to them, the current public transport system is inadequate and has significant safety issues. People claimed to feel insecure traveling with their families on public transport. In addition, they experience congestion on public transport and believe that the current public transport system wastes time. They also stated that public transport in Islamabad is inaccessible to them and does not serve their office route, so they must depend on private vehicles. People also mentioned that the bad behavior of drivers is also irresistible. Single parents, specifically single mothers concerned about their daughter's safety, and they believe that the current public transport system is not secure for women, so they prefer to use private vehicles. Further, People also stated that the metro bus is a reliable mode of public transport, but they claimed that it does not serve their routes or meet their commuting requirements.

Willingness to Shift Toward Public Transport

Ninety percent (90) of the participants exhibited a willingness to shift to public transport if public transport satisfied their needs and expectations. However, ten percent of participants exhibited reluctance to shift to public transport because they perceive private vehicles as a status symbol and they prefer personalized travel because it provides them with a sense of freedom and independence, allowing them to travel wherever they want without being constrained by public transport schedules or routes. In addition, people exhibited a preference to travel in private vehicles on weekends with families.

Suggestions regarding Public Transport

Individuals suggested implementing regulated fares and improved convenience in the public transport system is essential. Moreover, it is essential to ensure public transport systems' safety, security, and better service quality. Also, some people suggested providing gender-segregated public transport.

People recommended improving the existing public transport systems and creating a government-sanctioned transport application to facilitate public grievances about public transport matters.

In addition, individuals also suggested the attainment of door-to-door accessibility or an emphasis on minimizing the distance between public transport stops and desired destinations. In addition, some individuals stated that the Varan bus service was exemplary, and they would be willing to shift if provided with the same quality of public transport.

Numerous people suggested that private intercity bus services, such as Faisal Movers and Daewoo, are commendable modes of public transport. And they are willing to shift if comparable intracity transport services are provided.

People expressed that they are willing to switch to public transport if these amenities are provided. Although it is difficult for them to use private transport due to rising oil prices, they are oppressed to do so due to inefficient public transport.

Appendix-B

Letter of Recommendation For Data Collection

Quaid-i-Azam School of Management Sciences
Quaid-i-Azam University, Islamabad
Ph#-05190644305

No. QAU/QASMS/2023- **Dated:**
31.05.2023

Dr. Syed Mustafa Tanveer,
SSP Traffic Police ICT
ISLAMABAD

Subject: - **LETTER OF RECOMMENDATION FOR DATA COLLECTION AND RESEARCH WORK**

It is to request you that Miss Zainish Riaz is the current MPhil research student of Quaid-I-Azam University Islamabad, Department of Management Sciences. She is working on analyzing the impact of shifting private vehicles to public transportation on oil consumption. She will come to you for the data permission. Since the research work she is doing holds valuable importance to the university and government. You are kindly requested to allow her the information she needs. She needs data related to the current usage of private vehicles in intra-city Islamabad. After her work, you are welcome to preview this research any time you want. I assure you that she will be no misuse of this information and the source of this information will be kept concealed if you want. We will be responsible for any misuse of this information.

I hope that you will allow her to have this information in the light of the above-mentioned events. I shall be thankful to you for this kind favor.

Thanks in advance

Your sincerely,

Dr. Burhan Ali Shah
Assistant Professor
QASMS, QAU,
Islamabad

Appendix-C1

Some Glimpse During Data Collection from Safe City

Appendix-C2

Glimpse of Data Collection from Excise Office, Islamabad and Different Roads of Islamabad