SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 224

CLIMATE CHANGE RELATED TRANSPORTATION MANAGEMENT IN PAKISTAN – GREENHOUSE GAS EMISSION REVIEW, MITIGATION STRATEGIES AND ADAPTATION MEASURES

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Purpose: Greenhouse gas emissions in Pakistan are primarily caused by the growing transportation sector, due to urbanization, population growth, and the country's heavy reliance on fossil fuels. The paper examines existing greenhouse gas emissions in Pakistan's transport sector, evaluates the present response strategies, and explores how Pakistan can adapt to climate change.
Methodology: The article uses an analytical approach, based on a literature review. The approach taken is guided by the PRISMA framework and groups results from over 115 relevant articles and official reports. This paper presents how electric vehicles, alternative fuels such as compressed natural gas (CNG), and sustainable public transport help cut emissions.
Findings: Findings show that working on all three aspects of technological development, policy changes, and infrastructure projects is necessary for reaching sustainable and resilient transportation in Pakistan.
Research limitations and implications: The study was cross-sectional and covered a selected group of respondents, which may influence the generalization of the results. In the future, it would be beneficial to expand the analysis to include data from different markets and to study the long-term effects of implementing innovations in distribution logistics.
Practical implications: The presented analysis is based on secondary materials, it outlines needed research and explains how its conclusions can be used in national policy and city management.
Social implications: The final part of the paper includes policy recommendations and outlines where future research could be focused.

Originality/Value: The article contributes to the literature on greenhouse gas emissions in Pakistan by presenting current trends and challenges.
Keywords: Greenhouse gas emissions, transportation climate change, strategies to lessen emissions, options for adapting to climate change, sustainable development.

1. Introduction

The changes in climate are mostly caused by humans burning fossil fuels, cutting down forests, using certain industrial processes, and making cities bigger (Landsberg, 1970). This has taken place much quicker than usual because of the giant rise in GHGs in the air, mainly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_x) (Solomon et al., 2009). Increased GHG emissions are responsible for global warming, unpredictable weather, and the occurrence of extreme weather situations such as heavy rains, storms, and heat waves (Walsh et al., 2016).

According to NOAA, the average temperature on Earth has increased by about 1°C over the last century, mainly due to people influence on the climate in recent decades (Wuebbles et al., 2017).

Most of the increase in global temperatures can be explained by how much CO_2 is released into the air by burning coal, oil, and natural gas for producing and transporting energy (Age & Anomaly, 2008). As the (Figure 1) demonstrates, all datasets show global temperatures rising consistently since the pre-industrial period, starting around 1880 (Hansen et al., 2010).

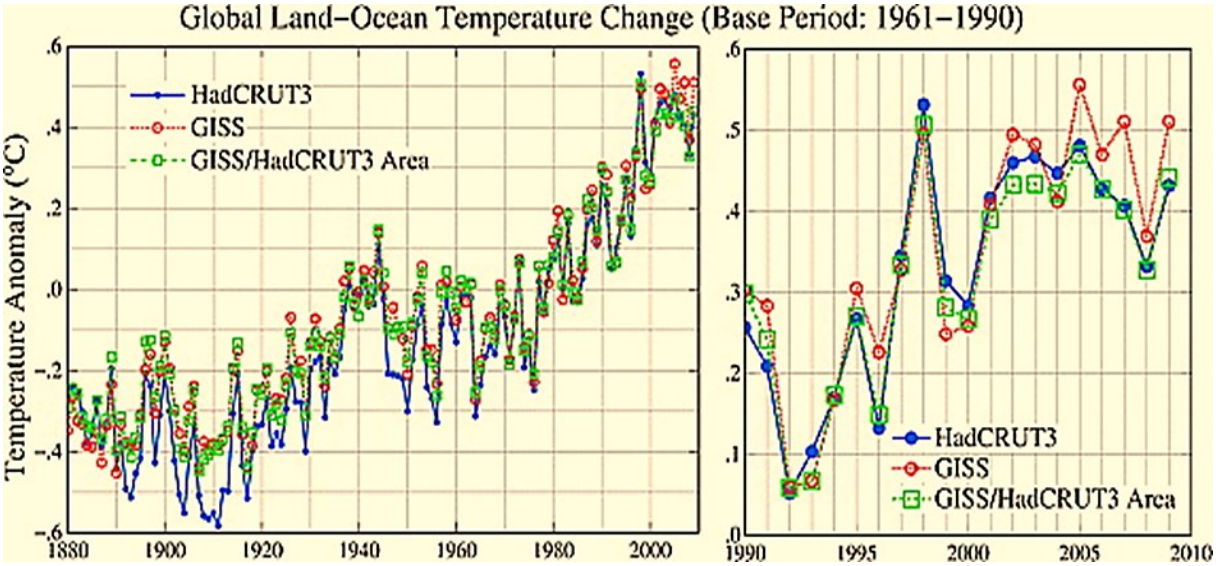

Figure 1. Global surface temperature anomalies (°C) relative to the 1961-1990 base period for three cases: HadCRUT3, GISS, and GISS anomalies limited to the HadCRUT area.

Source: (Hansen et al., 2010).

The transportation industry is responsible for 16% of worldwide greenhouse gas (GHG) emissions, as evident in (Figure 2). When it comes to transportation, no other method accounts for more emissions than road transport, with 12% of the total. After that, aviation and maritime

transport add 1% and 2% respectively (Alfredo Rivera, November 26, 2024). The reliance of the transport sector on gasoline, diesel, and jet fuel is the primary reason it significantly contributes to global climate change (Yaoxian Huang 2020). Based on (Figure 2), the transportation sector causes a lot of emissions, which contribute to global warming and worsen the global climate crisis.

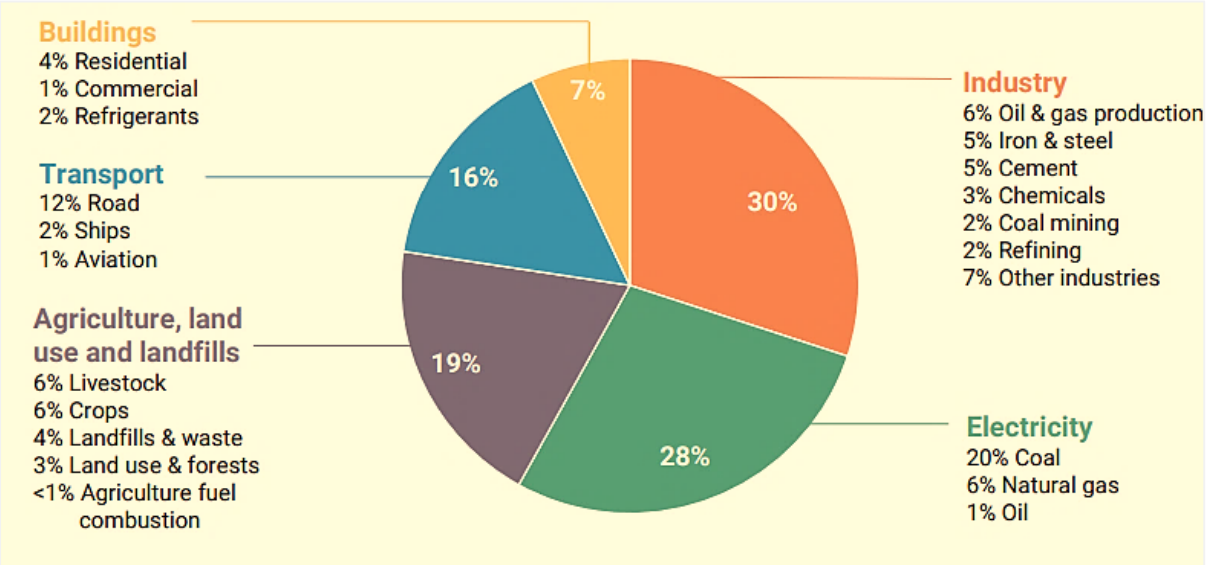

Figure 2. Global Emissions of GHG by Sector.

Source: (Alfredo Rivera, November 26, 2024).

Since transportation causes a lot of emissions, reducing them is crucial to achieving the global climate targets agreed by countries, such as in the Paris Agreement, which aims to limit global warming to well below 2°C above pre-industrial levels (OECD/ITF, 2018; UNFCCC, 2015). While North America, Europe, and East Asia have advanced by using cleaner technologies and making laws to reduce emissions from transport, many underdeveloped countries, including Pakistan, experience difficulties with this challenge. Because of swifter city growth, more factories, poor infrastructure, and a rise in personal cars, transportation is having a bigger negative effect on the environment in developing areas (Partnership, 2021; Transport, 2023).

As people in Pakistan and other countries continue to live in the city, pollutants from road vehicles are likely to rise sharply unless action is taken (Partnership, 2021). As cities are growing fast and new vehicles keep being produced, road transport is becoming responsible for an increasing amount of greenhouse gas emissions (change, 2022; IEA, 2023). The rising use of road vehicles, as illustrated in (Figure 2), makes it important to implement useful methods for reducing emissions (Sims, 2014). While energy production accounts for one-fourth of worldwide CO_2 emissions, it is clear that road transport plays the biggest role (Creutzig, 2015; IEA, 2023).

In cities, mainly in growing countries, busy highways and poor public transport lead to higher emissions and can harm both nature and health (Anenberg et al., 2017; WHO, 2018). If EVs, alternative fuels, and green public transport are not widely used, the harmful emissions from vehicles will keep increasing, leading to more global climate change (IEA, 2023). Therefore, decreasing emissions from road traffic is necessary to contribute to worldwide climate action and to address conditions caused by climate change (Change, 2022).

Climate change is affecting people all around the world and is causing many challenges in economic and social areas (Change, 2022; Stern, 2008). Regions near the coast are being affected by higher sea levels, and dry regions are experiencing longer problems with droughts (Dai, 2013; Nicholls et al., 1999). When rainfall patterns are unstable, many crops fail to grow as much as expected, leading to less food for people (Lobell et al., 2011; Wheeler, Von Braun, 2013). Moreover, heatwaves, large storms, and floods are happening more often, endangering people, buildings, and businesses (Emanuel, 2017). As shown in (Figure 3), various climate change effects, notably extreme weather and unstable precipitation, directly endanger the global food security and nutrition systems (Farooq et al., 2022).

Such disruptions often lead to reduced harvests, problems with getting food to markets, and an increase in malnutrition among people in South Asia. Therefore, it is very important to cut emissions from energy, agriculture, and transportation to deal with climate change and support the stability and sustainability of global systems (FAO, 2018).

Compared to other sectors, the transportation sector in Pakistan is responsible for releasing the most greenhouse gases. Rapid growth in urbanization, industry, and population has caused the sector's share of $C0_2$ emissions in the country to go up year by year. According to reports from UNFCCC and the World Bank, more than 20% of all greenhouse gas emissions in Pakistan come from the transport industry (Imran, 2010; Observatory, 2023).

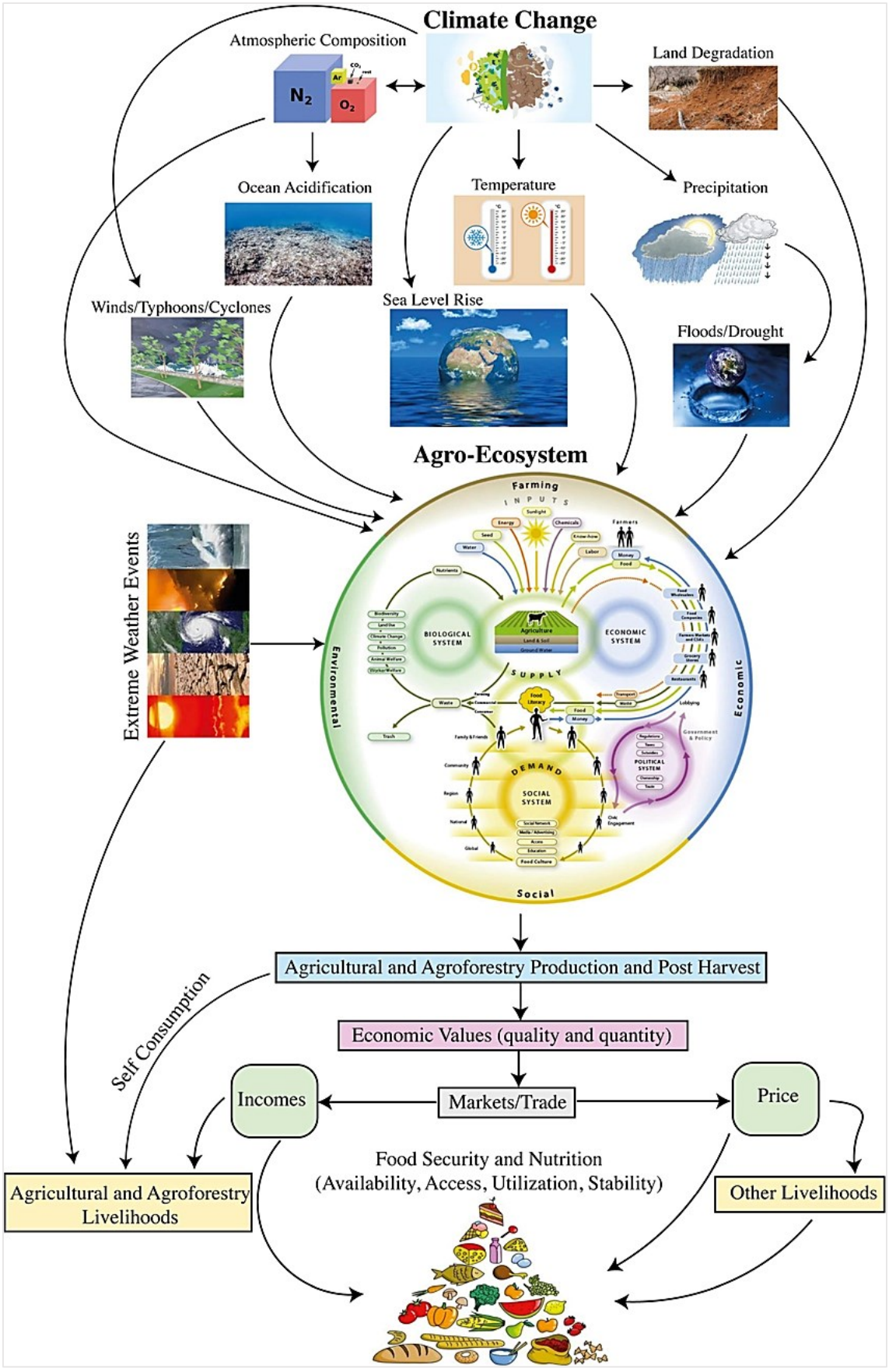

Figure 3. Schematic representation of climate change impacts on global food security and nutrition. Source: (Farooq et al., 2022).

The transportation that generates the most of these emissions is mainly from passenger vehicles, freight trucks, and motorcycles (Analytics, 2024; Kumar et al., 2024). While Karachi, Lahore, and Islamabad are experiencing more people owning vehicles, this is leading to increased emissions and more air pollution (Kumar et al., 2024). As shown in (Figure 4) registered vehicles in Pakistan have grown significantly between 2006 and 2018, causing concerns about greater emissions and more congestion, mainly in cities (Asim et al., 2022).

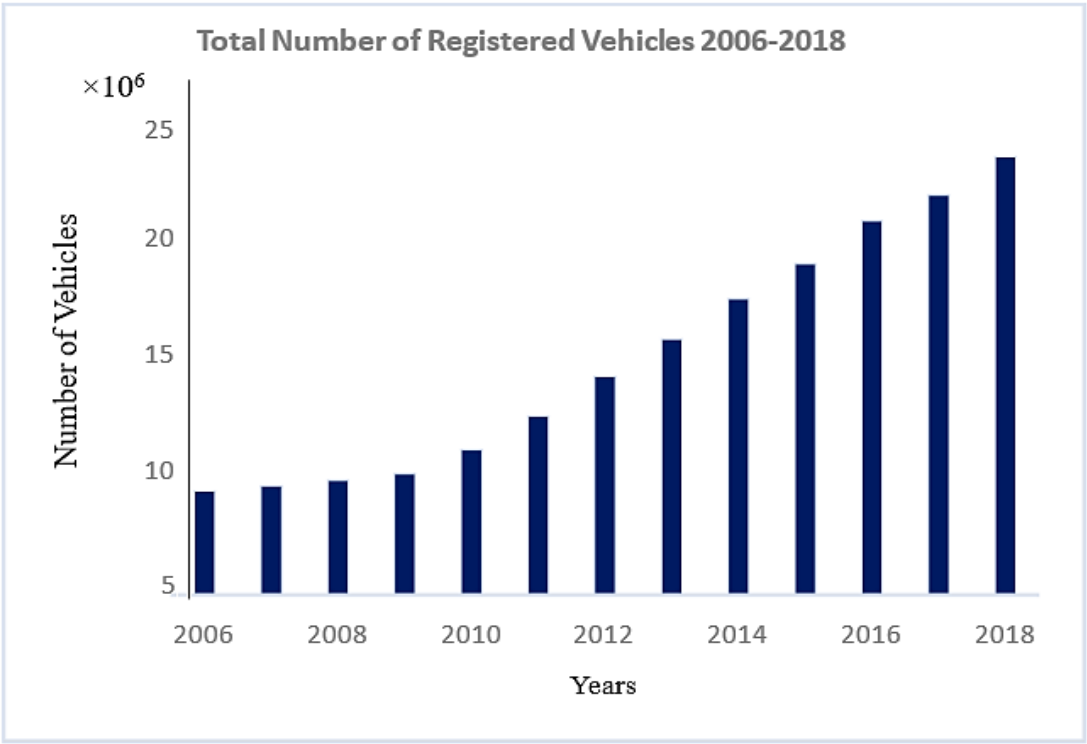

Figure 4. Number of registered vehicles in Pakistan from 2006 to 2018.
Source: (Asim et al., 2022).

As more people use cars in the country, along with their use of gasoline and diesel, the problem of emissions has become much bigger. The report pointed out that, because Pakistan relies on oil and natural gas for transport, its older vehicles use more energy and release higher amounts of pollutants (Kumar et al., 2024; Observatory, 2023). In addition, air pollution around cities such as Lahore, Karachi, and Islamabad gets worse because too many cars are stuck for long periods, releasing extra CO_2 due to wasted fuel (Analytics, 2024; Observatory, 2023).

The assessment of CO_2 emissions in Lahore shows that more cars on the roads are being added faster than new public transportation and roads are being built. As a result, there is much more traffic, higher energy waste and more pollution (Observatory, 2023). According to (Figure 5), energy used in transport increased year after year from 2003 to 2018 mainly because of heavy reliance on fossil fuels and inefficient vehicles (Asim et al., 2022).

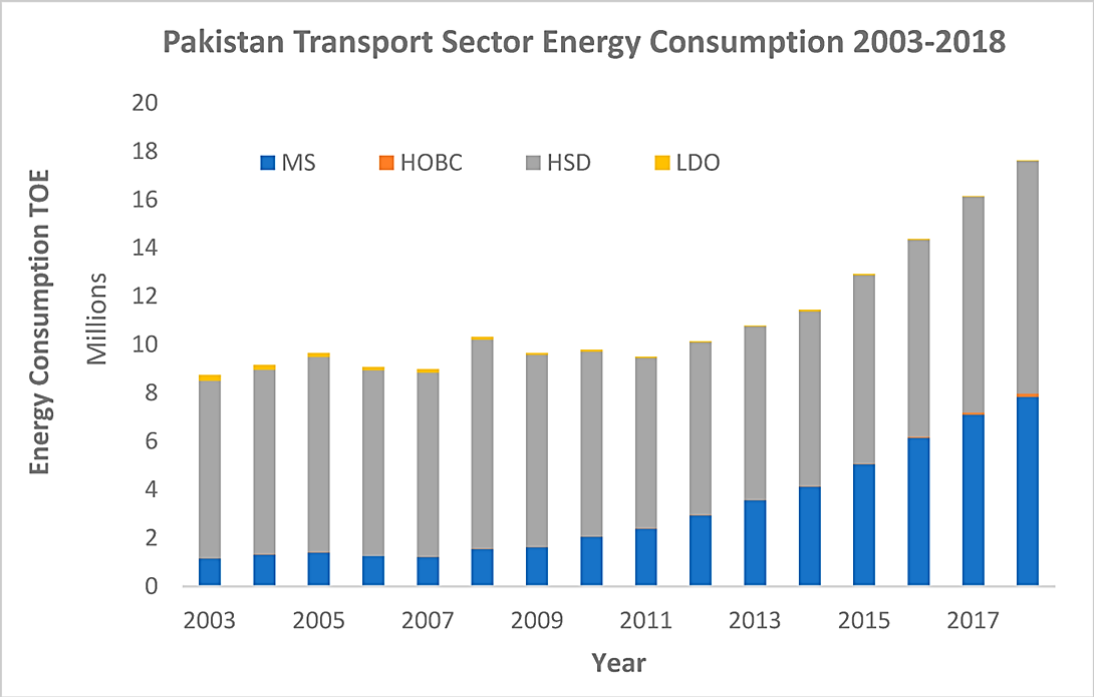

Figure 5. Pakistan Transport sector's energy consumption from 2003-2018.

Source: (Asim et al., 2022).

Contributing to climate change, the transportation sector has serious effects on both the society and health of citizens, mainly in fast-growing cities such as those in Pakistan (Asim et al., 2022; Qureshi, Lu, 2007). As people move to the outskirts of cities, the resulting traffic uses more gas and increases emissions into the air (Arif et al., 2023). Since public transportation in major cities is not well-developed, people have to use private cars, causing mayor traffic jams and higher pollution (Herath Bandara, Thilakarathne, 2025). Due to industrial growth and population increase in Pakistan, more cars are being bought, but because the transportation infrastructure is outdated and cars are inefficient, the sector is moving toward an environmental emergency.

Transportation emissions will still increase due to the rapid growth of cities and insufficient infrastructure, unless quick steps are taken to fix them (Ali et al., 2019; Imran, 2010). Emissions from these fossil fuels cause major economic problems. Based on a World Bank traffic report, missing productivity and wasting fuel amount to about $4 billion annually in Lahore (Bank, 2022). These inefficiencies cause individuals to be less productive and add pressure to the country's economy, mostly in urban areas that support much of the nation's trade, employment and commerce (Herath Bandara, Thilakarathne, 2025).

Emissions from vehicles have led to extra healthcare costs as a result of economic damage caused by air pollution (Ain et al., 2021; Ilyas et al., 2010). As air quality declines, mainly in Lahore, Karachi and Rawalpindi, where many people live, the country's healthcare system is under additional stress, as more patients with respiratory and cardiovascular diseases seek treatment and deepen existing health gaps (Ilyas et al., 2010; WHO, 2023).

Transportation-related pollution is affecting health in a similar major way. Breathing in polluted air because of vehicles has been related to a rise in both respiratory and cardiovascular diseases in Pakistan (Arif et al., 2023; Iqbal, 2020). Figure 6 clearly shows the problems related to air pollution, one of which involves serious cases of respiratory and cardiovascular illnesses in Lahore and Karachi (Khan et al., 2022). As vehicle levels are very high in places such as Lahore, Karachi and Rawalpindi, the pollution sometimes becomes harmful to people's health. WHO reports that air pollution from transportation is responsible for thousands of early deaths each year in Pakistan (WHO, 2023).

People who are children, elderly or have existing problems with their respiratory health are most affected by these pollutants (Herath Bandara, Thilakarathne, 2025; Sarfraz, 2020). Detailed in the Role of Sustainable Technological Innovations report, breathing polluted air raises the number of asthma, lung cancer and heart disease cases which puts more stress on the public health system and decreases national productivity (Parekh et al., 2001). There is no doubt that emissions from transportation harm public health, so new policies must be developed to address air pollution and improve air quality (UNFCCC, 2015).

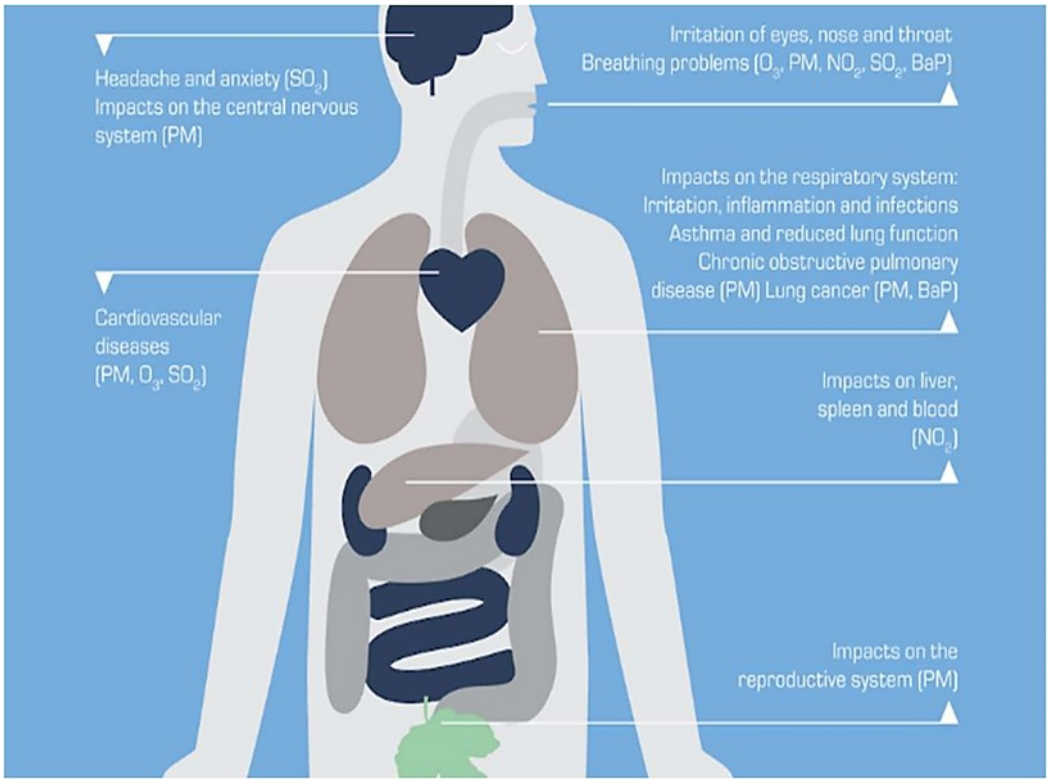

Figure 6. Potential health impacts of major sources of air pollution.

Source: (Khan et al., 2022).

Pakistan faces a higher risk from climate change than many other countries. Asia's geography and certain economic and social weaknesses leave it vulnerable to floods, heatwaves and monsoons that are hard to predict. They create serious threats to both transportation systems and the safety of the public (Bank, 2023; UNFCCC, 2021). Flooding has often damaged

important parts of our infrastructure, causing problems for travel and financially affecting various industries.

According to the Climate Change Vulnerability Assessment Report (2020), flood-prone areas place the roads there at greater risk since they are often blocked during the monsoon (Bank, 2023; UN-Habitat, 2023). In figure 7, the regions hit by flooding along the Indus River in 2014 are shown, demonstrating the risks to Pakistan's transportation infrastructure from extreme weather and identifying places at risk from repeated monsoon floods (Azmat, 2015).

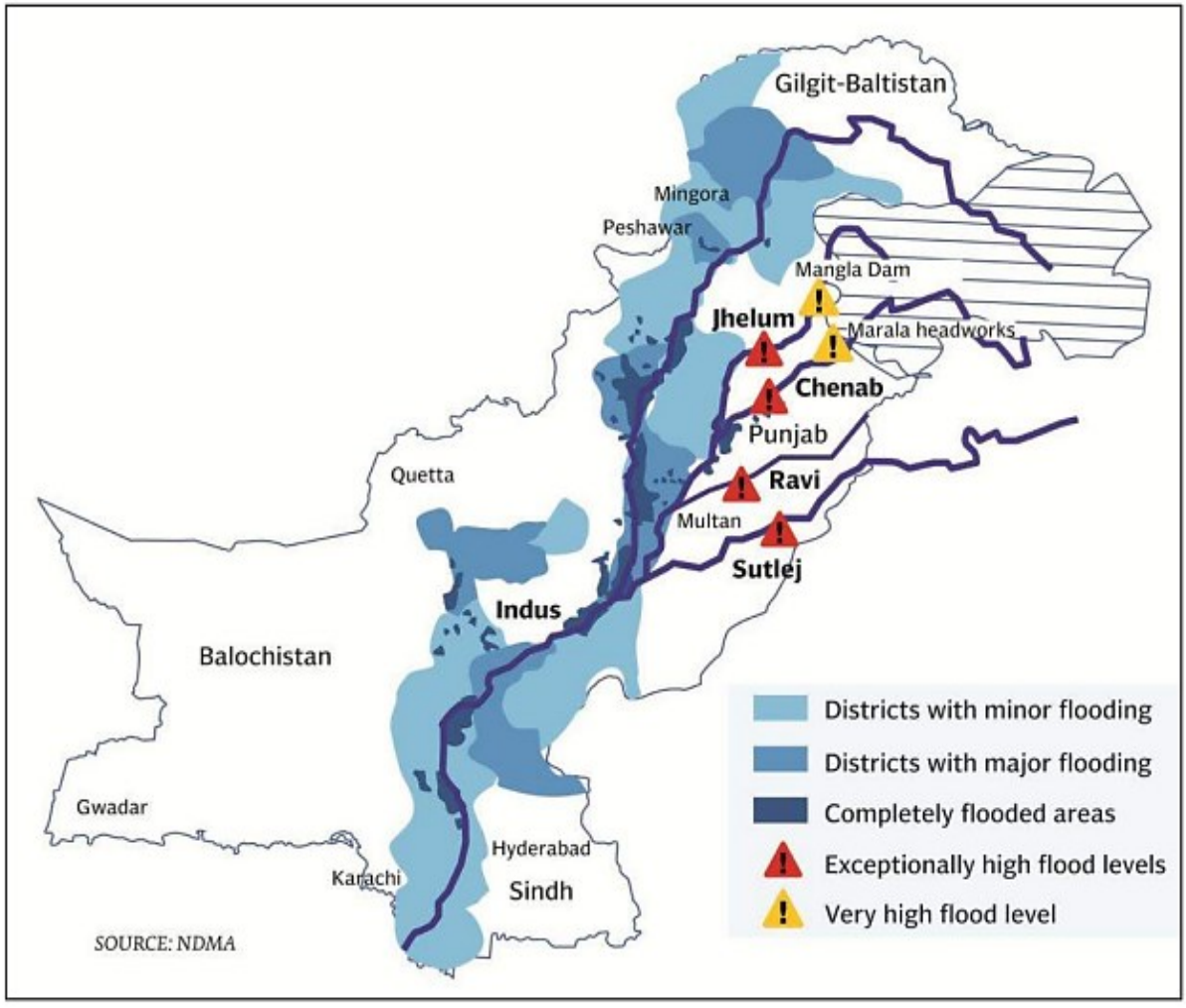

Figure 7. Map showing the flood-affected areas of Pakistan in 2014 and the track of the flood wave along the Indus River.

Source: (Azmat, 2015).

It is predicted that rising heat waves will cause roads and railways to deteriorate more rapidly. Heat can make roads crack and railways bend, which results in serious damage and more money needed for repair (Qin et al., 2022; Regmi, Hanaoka, 2009). Because of these impacts, repairing and maintaining transportation infrastructure due to the climate costs a lot, adding more burden to the country's resources (Bank, 2023; UNFCCC, 2021). The photos in figure 8 highlight the destruction of infrastructure caused by the 2010 floods and reveal why

Pakistan's transport systems need to be more sustainable, as if not, the floods caused widespread devastation (Shah et al., 2020).

Figure 8. Impact of 2010 floods on the infrastructure in Pakistan, the massive rescue & relief mission, and the shelters set up for those displaced in the floods.

Source: (Shah et al., 2020).

To deal with the rising problems caused by emissions from vehicles, Pakistan has begun to use several strategies to bring down its carbon output. The National Electric Vehicle Policy (NEVP) which was launched in 2019, aims to increase the use of electric vehicles (EVs) to cut down pollution in road transport. By 2030, the NEVP aims for EVs to take up a large share of 30% in the country's passenger vehicles (CPDI, 2023; Ministry of Climate Change, 2019). This policy offers tax breaks, helps pay for EV manufacturing and rewards companies developing EV charging, all to push more people to switch to electric vehicles. For now, it is hard to get EVs into widespread use, because of their upfront prices, the shortage of charging stations and people not knowing all about EVs' lasting benefits (CPDI, 2023; Haq, 2019; Unit, 2024).

Along with encouraging electric cars, Pakistan is upgrading public transport to make it easier for people to use it rather than their private vehicles. Bus rapid transit systems and metro lines are being built in Lahore, Karachi and Islamabad to provide economical, efficient, and earth-friendly alternatives for their expanding cities. Private car riders in Lahore are now shifting to the Metrobus system, including the Orange Line Metro which has led to less emissions in the city. The Orange Line which uses its own tracks, has helped decrease traffic

jams and given people a greener form of transportation. Figure 9 highlights where the Metrobus in Islamabad runs and how this supports more riders and better, environmentally friendly city transport planning (Metrohub, 2024). Similarly, efforts are being made by the government to grow both cycleways and walkways to support the idea of using non-motorized transport (NMT). Implementing these projects plays a key role in cutting the carbon gas emissions associated with the transportation sector (Khan et al., 2022; Unit, 2024).

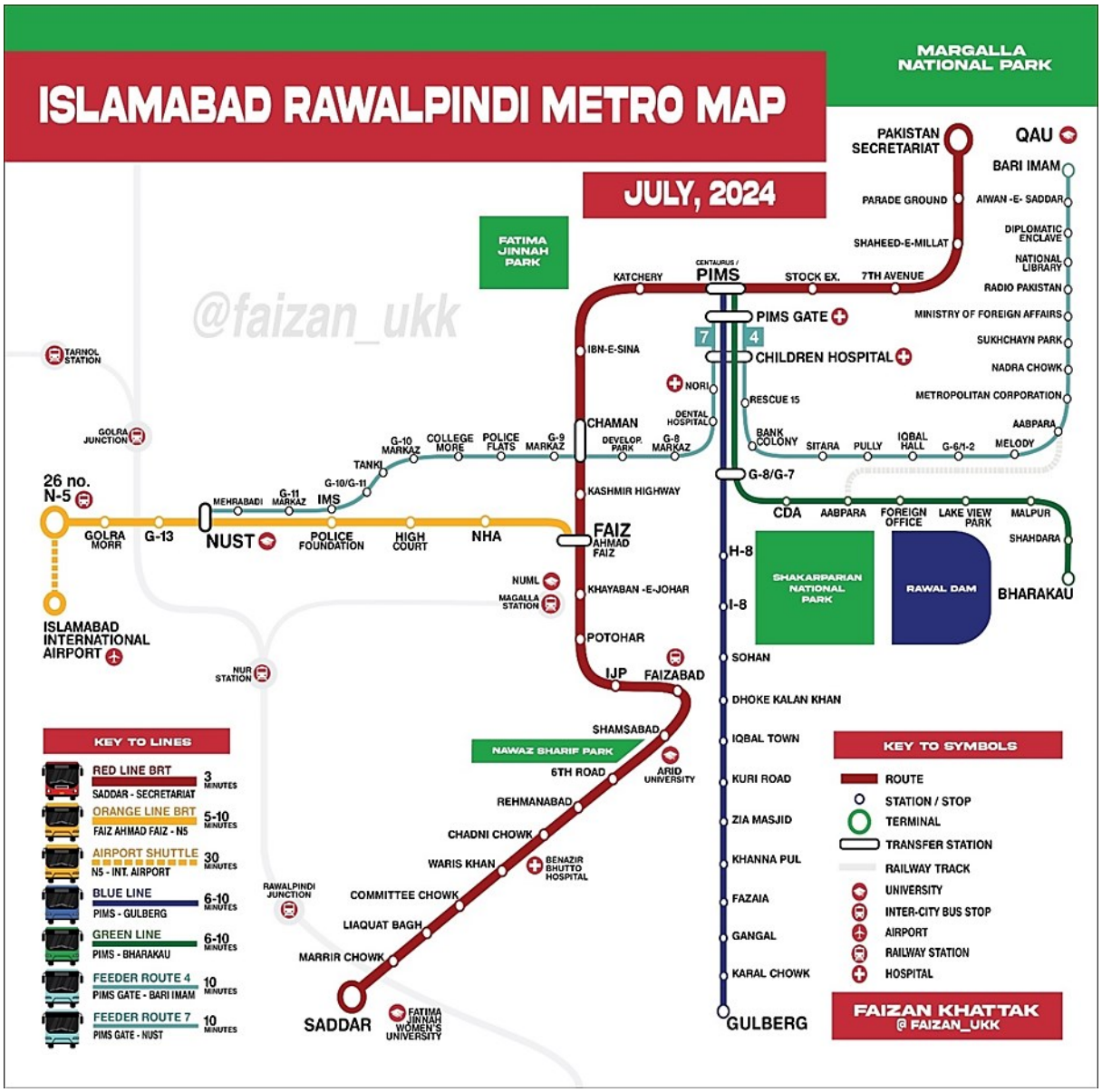

Figure 9. Metro Buses Routes of Red Line, Orange Line, Blue Line and Green Line Metro Service. Source: (Metrohub, 2024).

More people have been using the Islamabad Metrobus service in recent years. The ridership in 2015 was 22,363,321 passengers, and by 2018 it had grown to 40,938,787, reducing only slightly to 37,381,198 in 2019, as you can see in Figure 10. More riders on Metrobuses means the service has encouraged people to use public transport instead of their vehicles. More people using public transport, mainly in cities, helps to lower emissions, ease traffic, and improve the air people breathe (Saqib, Anwar, 2022).

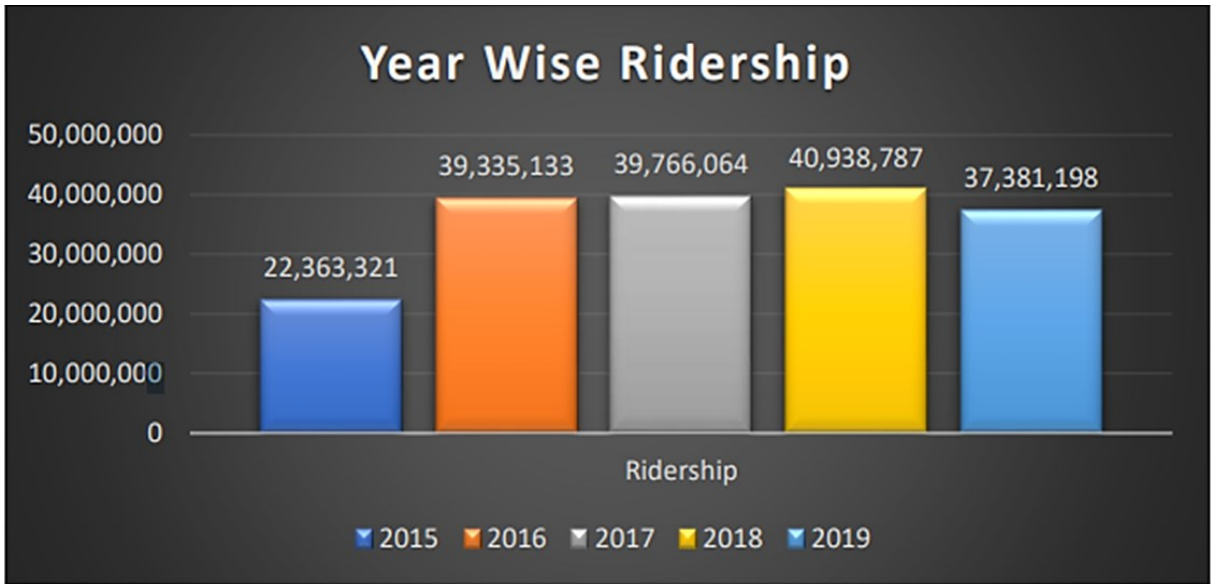

Figure 10. Total ridership of Islamabad Metrobus Services from 2015 to 2019.

Source: (Saqib, Anwar, 2022).

In addition, Pakistan is also working on solar power and other renewable options to reduce how much carbon its transportation units produce. The government's goals for cleaner, renewable energy are supported by using solar panels to charge buses and at stations (Imran, Shutsha, 2024; Observatory, 2023). Using alternative fuels like compressed natural gas (CNG) has worked well to some extent in reducing emissions, but some problems remain, including a lack of refilling stations and changing gas prices (Kumar et al., 2024). While CNG gives us hope now, it's not clear how long it will be useful in the future. Implementing electric vehicles, renewable sources and alternative fuels and boosting cycling and walking, is needed to cut greenhouse gas emissions significantly (Imran, Shutsha, 2024).

Even so, for this to become a reality, Pakistan must deal with its financial and infrastructure problems (Analytics, 2024). This study analyses the part played by transportation in climate change in Pakistan, points out its main sources of greenhouse gases, considers ways to address the issue, and suggests adaptation solutions. It points out that policies and structures should be reformed and new infrastructure must be built to make the transport system more sustainable and better able to cope with climate change. It gives suggestions for policies intended to lower emissions, boost public transit, and deal with the problems of climate change. Making electric vehicles, new fuels, and resilient roadways available is one way to ensure long-term environmental care and lower climate impacts in Pakistan's transportation sector (Analytics, 2024; Imran, Shutsha, 2024; Kumar et al., 2024).

2. Systematic Methodology

To compile this review article, a systematic approach was utilized to identify and investigate sources related to GHG emissions in Pakistan's transportation sector, as well as the approaches and remedies employed to mitigate these emissions. The procedure adheres to the PRISMA workflow's (Chapter 2.7 - Figure 11) standard phases (Page et al., 2021). Firstly, a study question was developed that examined transportation-related emissions, their impacts, and the effectiveness of solutions in Pakistan.

A comprehensive literature search was carried out using Google Scholar, Scopus, Web of Science, and IEEE Xplore databases to locate relevant papers, reports, and studies. The terms searched for are "greenhouse gas emissions caused by transport", "electric vehicles in Pakistan", "ways for reducing transport emissions", "adapting to climate change in transport", or "environmentally friendly transportation in Pakistan" (Chapter 2.7 - Figure 11). Only studies published between 2000 and 2025 were examined in order to get the most recent findings. The time span chosen is intended to document the effects of new technology and policies, as well as how the sector responds to climate change.

2.1. Inclusion Criteria: Only articles that met the following criteria were included:

- Investigations into GHG emissions caused by road, public transit, and freight transport in Pakistan.
- Studies or articles that discuss ways to reduce emissions or create new approaches to manage challenges to transportation infrastructure brought by climate change.
- Articles featured in peer-reviewed journals, conference documentation, or recognized with-standing reports from bodies such as the World Bank, UN Environment Programme, and the Pakistan Ministry of Planning.

2.2. Exclusion Criteria: Articles were excluded if:

They did not focus on issues of GHG emissions, managing them or ways to adapt in relation to transportation in Pakistan. They included sources that hadn’t undergone review by other researchers such as articles expressing opinions or reports without strong methods. They did not concentrate on transportation or had nothing to do with Pakistan. Firstly, 180 articles were identified during the initial search for the study. The titles and abstracts of these articles were used to make the screening decision. Further analysis was done on 122 full-text articles that were selected from the literature. Following the review of the articles against the inclusion and exclusion criteria, 115 articles were selected for further analysis (Figure 11). These articles explained important aspects of emissions, new ways to address them, adapting to climate change and analysing public policy**.**

2.3. Data Extraction and Synthesis

Once the chosen articles were identified, a step-by-step process was followed to collect important information such as what the studies aimed to do, their research procedures, main findings, and recommendations for better emissions management in Pakistan's transport sector. The data was brought together to spot similar topics, like electric vehicles (EVs), compressed natural gas (CNG), and the role of public transportation. They were investigated for their potential to cut transport emissions and to improve society's ability to cope with climate change. Information gaps were discovered in the literature, including not having enough research on the economics of mitigation and adaptation strategies and their long-term success. All of the findings were presented in tables and graphs so that the various measures and their abilities to lower emissions could be easily compared.

2.4. Research Question

This review was guided by the question, "What are the main contributors to GHG emissions in Pakistan's transport system, and what approaches are the most useful for both controlling and coping with them?

2.5. Literature Search

A series of searches was made using Google Scholar, Scopus, Web of Science, and IEEE Xplore. Top search terms were "GHG emissions transportation Pakistan", "electric vehicle adoption in Pakistan", "transportation mitigation strategies", "how Pakistani cities are using public transportation", and "climate action in the transport sector".

2.6. Article Selection

At the outset, articles were shortlisted using only their titles and abstracts, and the chosen abstracts had their full texts reviewed. Criteria used to decide which studies to include covered GHG emissions in transport, the use of EVs, different fuels, public transit services, and policies. Articles not linking directly to transportation or appearing in peer-reviewed journals were not included.

2.7. Quality Evaluation

The quality of the studies was checked by examining their methods, sizes of their samples, fit with the research questions, and how useful their results are. Advanced insights were selected if the studies included standardized measurements and supported them with empirical evidence.

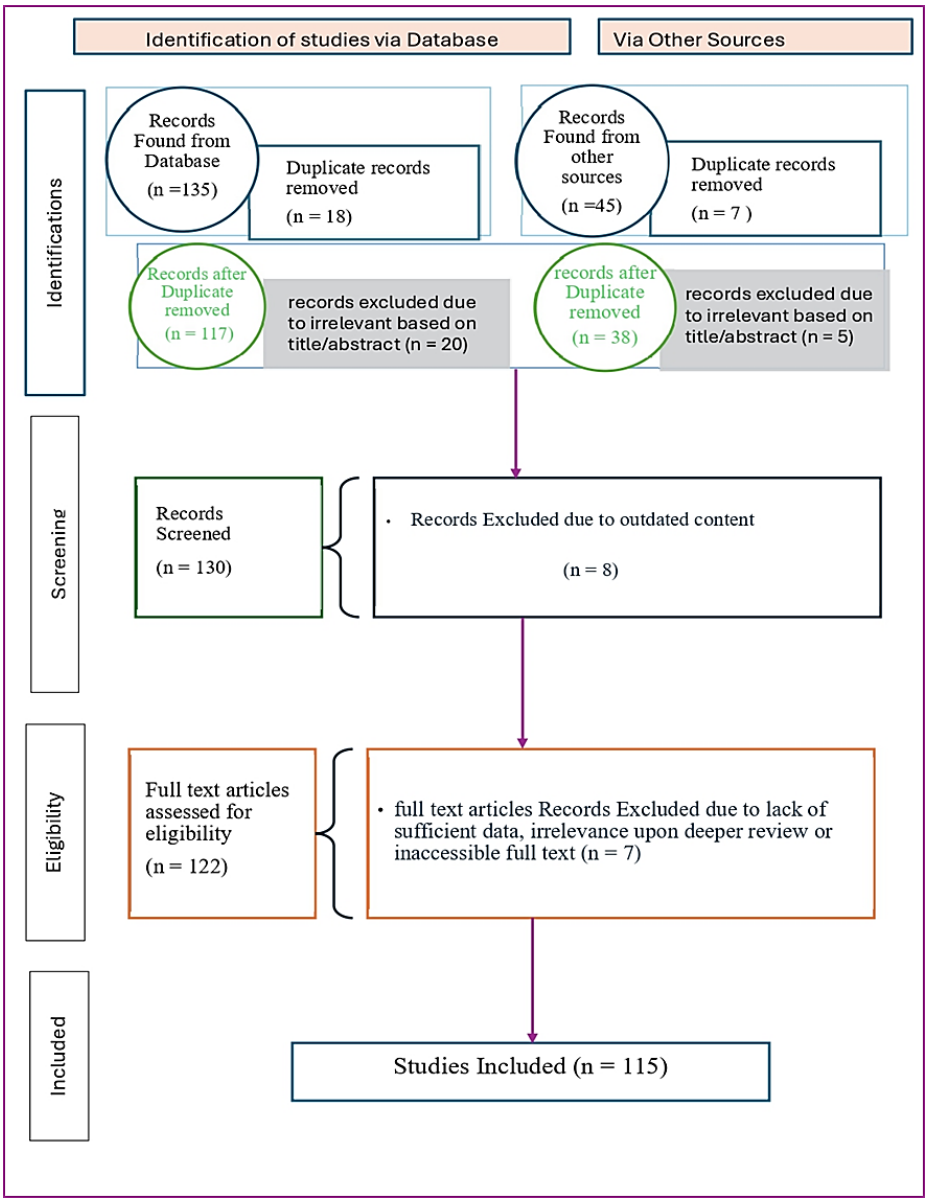

Figure 11. PRISMA Flowchart for article selection process.

3. Greenhouse Gas Emissions from Transportation in Pakistan

The transportation sector plays a big role in adding to Pakistan's greenhouse gas (GHG) emissions. Because it emits a lot of CO_2, it makes an important contribution to climate change. Transportation accounts for an overwhelming majority of Pakistan's GHG emissions, leading to about 98% of the energy sector's emissions, based on several studies (Observatory, 2023). Road transport is the main source of transportation emissions in Pakistan, because it is the most used method of travel (Kumar et al., 2024; Saqib, Anwar, 2022; Transparency, 2020). The main reason is that there are too many private cars and freight vehicles which perform poorly in fuel economy and pollute the environment (Analytics, 2024; Kumar et al., 2024). Pakistan's

transportation sector is mainly reliant on road transport which is also its main contributor to pollution (CDKN, 2023; Observatory, 2023).

3.1. Sources of Emissions

According to the Assessment of Sustainability of Freight Transportation in Pakistan, the sector's main source of CO_2 emissions is private vehicles and freight transport (Observatory, 2023). City areas like Karachi, Lahore, and Islamabad, where traffic often stacks up, make the emissions issue worse. Because many cars are packed on the roads, inefficiencies caused by old and rundown vehicles increase fuel consumption and CO_2 emissions (Kumar et al., 2024). The biggest part of urban emissions comes from cars, motorcycles, and small trucks. Because traffic is so congested in Karachi and Lahore, private cars cause more than their share of greenhouse gas emissions (Observatory, 2023; Tariq, Ali, 2017).

A further study by Spatiotemporal Assessment of CO_2 Emissions finds that the vehicle densities in these cities are among the highest in the country, which means their residents produce more emissions relative to others (Ilyas, 2007). Using a lot of private vehicles means more energy is wasted and there are higher emissions, due to poor traffic organization and infrastructure (Tariq, Ali, 2017). From the data in (Table 1), road transport accounts for most of Pakistan's transport-related CO_2 emissions for 2022, representing 97.9% of the sector's emissions. Similarly, rail, aviation, and domestic navigation play a small role, revealing the need for urgent changes in road-based transportation (Saqib, Anwar, 2022).

On the other side, the inefficient fuel use by long-haul trucks means their freight transport activities add significantly to emissions. The Assessment of Sustainability of Freight Transportation indicates that freight transportation uses up more fuel and emits relatively more gas than passenger vehicles (Observatory, 2023). Often built years ago and treated poorly, these large trucks emit large levels of diesel fumes and cause high amounts of CO_2, nitrogen oxides (NO_x), and particulate matter to be released (Kumar et al., 2024). This situation is a major obstacle to achieving Pakistan's sustainability aims (Observatory, 2023).

Table 1.
Share of CO_2 emissions by different transport sectors in Pakistan in 2022

Transport Mode	Share of Transport CO_2 Emissions (2022)	Key Details
ROAD (ALL TYPES)	97.9%	Includes private vehicles, freight trucks, buses, and motorcycles
RAIL	1.7%	Minor share, mostly passenger and some freight
AVIATION (DOMESTIC)	0.4%	Includes domestic air transport
SEA/NAVIGATION (DOMESTIC)	0.0%	Negligible for domestic emissions

Source: (Saqib, Anwar, 2022).

3.2. The Role of Urbanization

The rapid growth of cities in Pakistan has greatly increased transportation emissions in recent years. The population living in cities has gone up, resulting in a greater demand for travel all around, especially in Lahore, Karachi, and Islamabad (Ilyas, 2007; Tariq, Ali, 2017). According to Urbanization Effects on Temperature Trends of Lahore During 1950-2007, the rise in transportation due to urbanization has boosted CO_2 emissions in Lahore (Sajjad et al., 2009). Growing urban places have caused more cars to travel on roads, which has increased the amount of fuel used and the amount of greenhouse gas released (Ilyas, 2007).

A big part of the issue is that public transportation is not accessible enough. It is proving increasingly hard for cities to establish mass transit as people use more and more personal cars (Observatory, 2023). The Figure 11 highlights that the rising urban population in Pakistan leads to an increased amount of emissions (Tariq, Ali, 2017). Because public transport is limited in places like Lahore, the number of cars on the roads is going up. As a result, the problem has grown more serious, as people often drive themselves to work and other places (Ilyas, 2007).

It gets even worse because urban sprawl means people depend more on their cars, leading to greater fuel use and higher CO_2 emissions (Sajjad et al., 2009; Tariq, Ali, 2017). As people keep moving to cities, the need for personal cars gets bigger. This trend makes our environment suffer more. In addition to producing CO_2, vehicle exhausts also release nitrogen oxides (NO_x) and carbon monoxide (CO), causing problems in urban atmosphere and for people's health (Ilyas, 2007; WHO, 2018).

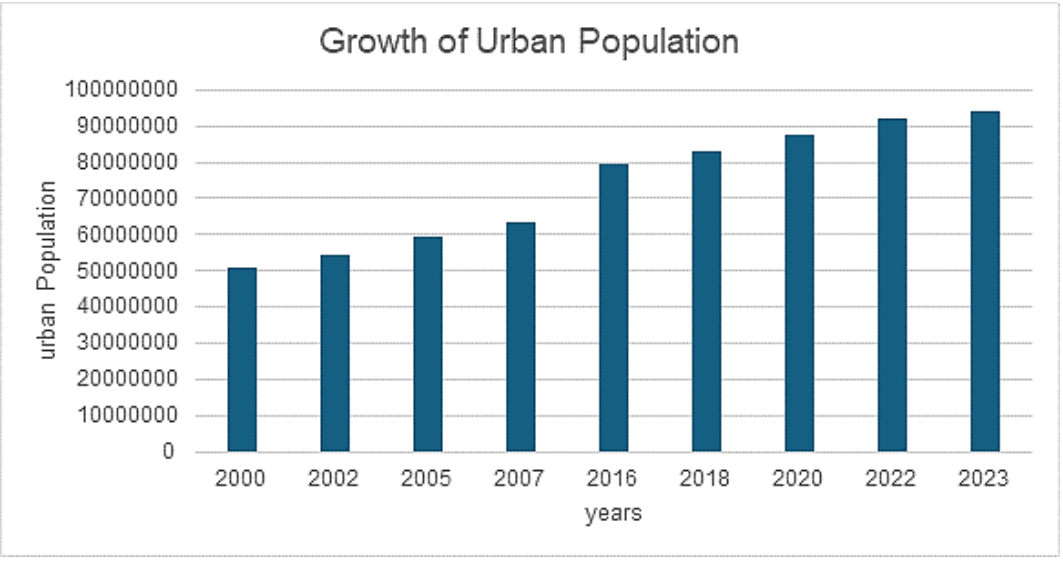

Figure 11. Growth of Urban population in Pakistan from 2000-2023.
Source: (Bank, 2022).

3.3. Fuel Efficiency and Vehicle Fleet Age

Efficiency issues with the country's vehicles are a major reason for transportation emissions in Pakistan. Most of the country's cars are older and usually not well taken care of, resulting in them using extra fuel (Kumar et al., 2024). The report Impact of Green Energy Transportation Systems on Urban Air Quality found that switching to fuel-efficient vehicles can lessen the use of CO_2 (Ilyas, 2007). But, because Pakistan's cars are often older and regulations are lenient, both fuel consumption and emissions keep getting higher (Observatory, 2023). The efficiency of fuel use in Pakistan depends greatly on how old the fleet of vehicles is. Because old vehicles tend to burn more fuel and release more pollutants, this problem affects commercial and freight vehicles, as many of these vehicles are decades old (Kumar et al., 2024). Most of them do not meet the current emission standards which means they use too much energy and pollute the environment (Analytics, 2024).

To increase fuel efficiency, the government of Pakistan has introduced stronger emission rules and encouraged more EVs. Nonetheless, the high cost of owning an electric vehicle, insufficient charging stations and slow acceptance by the public continue to block widespread use of greener technology (CPDI, 2023; Unit., 2024). According to the report, Pakistan's government has started giving incentives to people who buy EVs such as eliminating import taxes and exemptions from paying taxes (Ministry of Climate Change, 2019). Even so, insufficient charging stations and a lack of knowledge about the environment among people are slowing down the use of EVs (Unit, 2024).

3.4. Emerging Solutions and Challenges:

Even though the causes of emissions from Pakistan's transport are known, there are now solutions and strategies to tackle these issues. NEVP outlines that the EV industry is one of the most effective methods for lowering carbon emissions in the sector. Incentives for EVs encourage Pakistan to change from cars powered by fuel to electric vehicles which create fewer emissions (Ministry of Climate Change, 2019). Compressed natural gas (CNG) is proposed as another alternative since it is thought to be cleaner than cars burning gasoline and diesel. CNG, as explained in International Experience with CNG can lower CO_2 emissions most significantly in cities with a lot of traffic. Still, problems such as not enough CNG stations, changing prices for natural gas and lack of required infrastructure (CDKN, 2023; Observatory, 2023).

4. Mitigation Strategies

4.1. Electric Vehicles (EVs)

EVs are considered a great solution for cutting down emissions from the world of transportation. EVs eliminate gasoline or diesel dependency, meaning they do not directly burn fossil fuels that create much of the CO_2 emissions in standard vehicles (IEA, 2023; Kumar et al., 2024). Electric cars play a major role in reducing Greenhouse Gas Emissions since they do not exhaust from the tailpipe and the degree of reduction depends on the source of energy the cars use for charging (IEA, 2023).

Although EVs have taken time to gain popularity in Pakistan, progress is becoming noticeable. Light-duty vehicles make up a larger share of electric vehicles in the market now than they did in 2017 (CPDI, 2023).The Pakistani government understands how important EVs are and has now introduced the National Electric Vehicle Policy (NEVP) to encourage people and companies to use EVs through tax, duty, and subsidy incentives. Pakistan aims to have 30% of all cars on its roads be electric by 2030, putting priority on both passenger and commercial automobiles (Ministry of Climate Change, 2019).

But, despite the attempts, EVs are not widely used in the country yet. A number of problems are blocking EVs from becoming more common, such as their high initial costs, insufficient charging stations, and the need for additional policy support (CPDI, 2023; Unit, 2024). To many consumers, EVs are not attractive because expensive batteries used in them and the fact that most are made overseas make them costly (Kumar et al., 2024). The presence of a small number of charging stations has made many people hesitant to use electric cars because of what we call range anxiety (Unit, 2024).

The list in table 2 proposes locations for EV charging stations on the major highways in Pakistan and lists the coordinates and distances between each location. It marks a primary and vital milestone on the way to setting up a national EV network. With location on the N5 and M2 highways, these sites are vital for both practical and dependable electric vehicle travel across long distances (Khan et al., 2021). Pakistan's electric vehicle system is just starting up and it requires more significant effort to build a charging network across the country. Based on the Transforming the Transportation Sector report, adding more charging stations, making EVs more affordable and giving out incentives to buy and manufacture EVs is vital for EVs to gain traction (CPDI, 2023; Kumar et al., 2024).

In time, more EVs may protect the environment, especially if the electricity being used comes from renewable sources. Because of this, the whole process of building and using an EV, including charging, will stay low-carbon, so switching to EVs is a key part of Pakistan's overall climate strategy (Khan et al., 2021).

Table 2.
Proposed Charging Station Locations and Distance

Sr. No.	City	Longitude, Latitude	Distance
A	**N5 network**		
1.	Rawat	32.4805288, 72.687214	15.7
2.	Mandra toll plaza	32.4277489, 72.40935	59
3.	Deena	33.0285967, 73.598110	20
4.	Sarae Alamgir	32.907611040865, 73.730340115134	8
5.	Kharian	32.8830768, 73.7785187	46
6.	Gujrat exit	32.5959182, 74.0378919	9
7.	Gujrat	32.4797136, 74.091663	10.3
8.	Wazirabad	32.4026824, 74.1224383,	13.5
9.	Gakhar	32.317067, 74.143303	13.6
10.	Gujranwala		17
11.	MoreAimanAbad	32.0488448, 74.2085573	11.4
12.	Kamoke	31.995427755973, 74.218015463522	11
13.	Sadhoke	31.862328, 74.24472	12.7
12.	Muridke	31.6420817, 74.2032471	11.4
15.	Kala Shah Kaku	31.7338073, 74.2655666	46.2
B	**M2 network**		
16.	Chakri	33.3203856, 72.7829902	45
17.	KalarKahar	32.869405, 72.65204	73.5
28.	Bhera	32.453259538502, 72.886018340599	46.5
19.	Sial Mor	31.9680162, 73.1120396	77.5
20.	Sukheki	31.906767165001, 73.56816594500	48.6

Source: (Khan et al., 2021).

4.2. Compressed Natural Gas (CNG):

For years, Pakistan has used CNG as a way to reduce pollution by using it instead of petrol and diesel. CNG releases less CO_2 and NO_x, and PM than traditional fossil fuels like diesel or gasoline (Yasar et al., 2013). International Experience with Compressed Natural Gas (CNG) as an Environmentally Friendly Fuel states that CNG can be a useful alternative that cuts emissions in cities such as Lahore, Karachi, and Islamabad (Shah et al., 2020).

The cost difference between CNG and other fuels is one reason why people find it a desirable choice. Besides, Pakistan produces CNG in its own country, saving the nation money from buying oil. Compressed natural gas technology is already in place on public transports like buses and rickshaws in some locations to minimize city pollution and carbon emissions (Observatory, 2023).

Table 3 compares emissions from CNG, diesel, and gasoline cars to show CNG's advantages. Diesel buses emit a lot of smoke and hydrocarbons, with their opacity reaching 51% in smoke and reaching 21,000 ppm in hydrocarbons. CNG buses, by comparison, emit less smoke and far fewer hydrocarbons, their opacity reaching 16% and hydrocarbon emissions measuring around 1500 ppm. NO_x and SO_2 emissions are lower by comparison across all CNG vehicles, proving that CNG is much safer for the environment than conventional fuels (Yasar et al., 2013). These results demonstrate that the use of compressed natural gas benefits air quality, mainly in crowded city areas.

Nevertheless, using CNG is not common because it has issues with infrastructure and its price switching. Because CNG refuelling is rare in many rural regions, it's not a good fuel choice for travelling far from the cities. Also, because the price of natural gas changes, choosing natural gas for fuel may not be financially sound (CDKN, 2023).

Expanding the network for CNG will motivate more people to use it instead of other fuels. Minimizing the travel distance to CNG stations through better access from principle highways and rural areas might encourage more CNG users. Taking CNG as a cleaner alternative, government can also provide subsidies for cars that use CNG and grant tax exemptions to CNG fuelling sites (Yasar et al., 2013). CNG could act as a temporary answer for a few years, until the national shift to electric cars and renewable energy is fully developed (Unit, 2024).

Table 3.
Comparison of different mean emissions by different vehicles

Vehicle Type	Fuel Type	CO (%)	NO (ppm)	SO_2 (ppm)	Smoke Opacity %	HC (ppm)
Bus	CNG	2	45	22	16	1500
	Diesel	0.1	82	120	51	21000
Rickshaw	2-stroke LPG	3.5	2	55	47	13000
	4-stroke CNG	2.5	21	25	10	700
	4-stroke Gasoline	2.6	15	30	16	3100
Van	CNG	1.3	60	23	24	1350
	Diesel	0.15	78	115	40	19000
	Gasoline	2.4	75	28	22	4200
Motorcycle	2-stroke gasoline	4.7	21	45	21	6200
	4-stroke gasoline	1.6	16	21	12	1500
Tractor	Diesel	0.4	110	120	38	20000
Truck	Diesel	0.2	120	123	54	22000
Car	CNG	1.6	16	25	5	610
	Diesel	0.1	45	125	30	15000
	Gasoline	1.8	13	31	6	2800

Source: (Yasar et al., 2013).

4.3. Public Transportation and Non-Motorized Transport (NMT)

One way to decrease traffic-related emissions is to widen options for public transport and support the use of walking and biking. Using buses, metro systems, and light rail is a good way to decrease our use of private cars. This then reduces the use of fuel and emissions by lowering traffic on the streets (Ilyas et al., 2010; Qureshi, Lu, 2007). A boom in city dwellers can be met by using mass transit and NMT, which can help control rising greenhouse gas emissions caused by cars (Ali et al., 2019). Trains, buses, and BRT systems, for example, allow people to move quickly and at the same time help improve the air quality and reduce traffic (Ilyas, 2007; Qureshi, Lu, 2007). As figure 12 illustrates, new bike lanes have been built alongside the Metrobus line to support more people walking and cycling (News, 2025). These projects facilitate switching between various transportation methods and lower daily carbon emissions in highly populated areas.

Moving from personal cars to public systems can play a vital part in Pakistan's efforts to reduce climate change. As of 2013, the Lahore Metrobus System has led the way in making transport cleaner for the city. The Metrobus has solved several transportation problems, making travel easier and helping reduce crowded streets in one of Pakistan's high-density cities. The Sustainability Assessment of Modern Urban Transport points out that the Metrobus system has brought down emissions by taking 200,000 passengers a day off city streets instead of using their own vehicles (Ilyas, 2007). Fewer cars on the road and a green system for urban travel have lowered CO_2 emissions. At the same time, setting up these facilities in other cities across Pakistan would help Pakistan reduce emissions and achieve greater sustainability in transportation (Qureshi, Lu, 2007).

Figure 12. Construction of Bike Lanes along with a dedicated metro bus lane in Lahore.
Source: (news, 2025).

Adding cycling and walking to public transport helps lower emissions as well. Places such as Lahore and Karachi have started to realize that more cycling lanes and walkways for pedestrians are needed (Ali et al., 2019). Linking non-motorised transport(NMT) infrastructure to public transport can provide an overall, sustainable way for cities to move people (Ilyas, 2007). Using cycling and walking gives non-motorised transport(NMT) an easy way to save fuel and cut down on congestion and pollution linked to motorized trips (Ali et al., 2019).

Using non-motorised transport (NMT) in urban planning encourages cleaner cities and also improves public health because more people are active. Strong growth in urban transport use requires an increase in mass transit services and putting non-motorised transport (NMT) in the forefront to keep transportation emissions under control in Pakistan. Using public transport means lower carbon emissions and helps address longstanding traffic problems found in metropolitan areas. With the help of better non-motorised transport (NMT) infrastructure, Pakistan can become a low-emission country that meets climate targets and helps cities become greener (Ilyas, 2007; Qureshi, Lu, 2007).

4.4. Challenges and opportunities in mitigation strategies

While these methods for reducing emissions from transportation in Pakistan look promising, there are many obstacles that must be addressed to ensure they work well. The main reason electric vehicles (EVs) and compressed natural gas (CNG) vehicles are not more popular is the shortage of supporting infrastructure. Electric cars must be charged at many locations, but CNG cars encounter problems with finding and accessing fuelling stations. Because there is not enough infrastructure, it is both costly and difficult to improve SUV fuel efficiency (CPDI, 2023; Observatory, 2023).

Another important challenge is that electric vehicles are very expensive to buy, so the average consumer in a low-income country often cannot afford one. People have to pay a lot up front for EVs, even with the government incentives that are designed to lower prices. Furthermore, not many consumers are aware of the lasting advantages of EVs such as spending less on fuel and upkeep by using them, so less people are buying them. Widening awareness and education efforts are required to have more people use EVs which could help the government accomplish their set goals (CPDI, 2023; Unit, 2024).

At the same time, it is difficult to implement lasting mitigation strategies because of political and regulatory issues. Pakistan has not fully developed its policies for the environment and climate resilience and there can be gaps in the government's strong commitment to them. Stringent and well-managed regulations in clean transport such as emissions limits and vehicle laws, are needed to achieve major emission reductions. Also, because government agencies handle decisions separately, it can reduce the effectiveness of strategies used to address climate change in the transportation system (Ilyas, 2007; Tariq, Ali, 2017).

Still, many possibilities can make a difference and promote progress. Developments in EV battery technology and adding renewable energy to EV charging stations are promising answers to these problems. Making EV batteries less expensive and boosting the charging system will improve access and affordability for EVs. Integrating solar and wind sources at EV chargers can shrink the amount of carbon released by cars and other vehicles. Because of the large amount of renewable energy available in Pakistan, there is a big chance for clean energy to drive its transportation system, turning the country into a leader in this area (Kumar et al., 2024; Nadeem et al., 2022).

In addition, public-private partnerships (PPPs) hold the promise of addressing problems related to finances and infrastructure. Working together with private groups, the government can facilitate the creation of more forms of mass transit, more EV charging stations and alternative fuel stations. By collaborating, nations can support the investment needed to build green technologies and the proper infrastructure to achieve climate targets. Having more EVs and CNG vehicles produced locally would make importing easier, bring jobs, and make moving toward cleaner vehicles easier on the economy (CPDI, 2023; Observatory, 2023).

Implementing cycling and walking as key parts of city planning can do much more for the sustainability of transportation. Eco-conscious cities that encourage NMT can improve the health of their communities by encouraging exercise and cutting air pollution. With this strategy, cities can lessen traffic jams, use less fuel, and help people lead more sustainable ways of life. Facing and benefiting from available solutions is key for Pakistan to successfully put into action mitigation measures. Proper investments in infrastructure, technology, and policies can guide the nation through the tough process to a low-carbon and climate-adaptable transportation sector (Ali et al., 2019; Ilyas, 2007).

5. Adaptation Measures

In response to the current impact of climate change on ecosystems and human life worldwide, the transportation sector must implement robust adaptations. In Pakistan, the resilience of the transportation sector is crucial as climate change brings increasingly extreme weather conditions like heat waves, floods, and unusual rainfall patterns (Bank, 2023; UNFCCC, 2021). In order to prepare Pakistan's transportation sector for climate change, this section examines two essential steps: strengthening infrastructure and taking climate change into account while planning. The objective is to ensure that Pakistan's transportation system can adapt to the consequences of climate change while maintaining its functionality (Bank, 2022; UN-Habitat, 2023).

5.1. Climate-Resilient Infrastructure:

Pakistan’s transport system is at high risk from climate change. Adverse weather such as heavy rain, floods and heatwaves can seriously weaken and shorten the working life of roads and bridges. The Divisional Disparities’ survey on Climate Change demonstrates that building infrastructure that can cope with these disturbances is key. Because more land is being developed and climate extremes are increasing, infrastructure that can stand up to climate conditions is necessary (Ilyas, 2007; Tariq, Ali, 2017).

Climate-resilient roads and bridges should always be designed to resist flood damage. Flooding is a regular problem for many regions in Pakistan, mainly in low-lying areas, during the monsoon season. The situation leads to problems with road access and unsafe journeys. The Divisional Disparities report emphasises that roads and bridges should be built to withstand rain and floods by following flood-resilient standards. They make use of water-resistant materials, elevated roads and drainage systems built to stop water from gathering on transport routes (Ahmed et al., 2021; Ilyas, 2007).

Extreme heat can cause many difficulties for the movement of people and goods. When it's hot, roads and pavements may become softer, so they develop cracks and ruts. High-temperature materials and shift in roadway design are important tools to minimize heat effects. Bridges and overpasses should be designed so they don't warp or bend from intense heat, so that they don't lose their strength (Tariq. Ali, 2017; Zeeshan, Iqbal, 2022).

Besides, modern drainage systems must be added to avoid floods that may happen during rainy days. Karachi and Lahore's drainage is inefficient and water problems and traffic becomes worse. Enhancing drainage is a key step in strengthening transportation against heavy rainfall (Ahmed et al., 2021; Ilyas, 2007).

Using sustainable materials is very important in ensuring infrastructure is resilient to climate change**.** Taking advantage of recycled asphalt and concrete in infrastructure is a way to save the environment and enhance the strength of critical roads and bridges. When green corridors and vegetative cover are added to designs for cities, the use of these materials can make transportation systems more resilient (Ilyas, 2007; Zeeshan, Iqbal, 2022).

Figure 13 proposes a way to include climate resilience in transportation planning and infrastructure in Pakistan by offering an approach that includes analysing climate risks, setting up strong design guidelines, bringing together relevant organisations and thinking ahead about sustainability (Khan et al., 2016). It highlights that planning early and involving a range of people is important to improve the infrastructure's resilience to future climate risks.

Figure 13. Resilient design initiatives.

Source: (Hyder et al., 2024).

5.2. Climate Change in Transport Planning

Transportation plans should include strategies for responding to climate change to help the system stay strong over many years. In Pakistan, the risks from climate change must be analysed at the start of each transportation initiative. Climate Change and the UN-2030 Agenda note that considering climate risks in transport planning allows us to find weaknesses and provide additional protection from changing climate hazards (Iqbal et al., 2024; Nafees et al., 2024). Projections about climate change, covering changes in rain, temperature and extreme events, are important for transport planning (Ali et al., 2019).

As a result, strategies can be developed to keep transportation infrastructure working even as the climate changes. For instance, road and bridge planning in flood-risk areas should address the rising scale of flooding and transportation networks should be built to survive extreme temperatures and heavy rain. Refurbishing current transportation facilities is a key aspect of responding to climate change. It is possible that the designs of our roads, bridges and transportation systems do not consider climate issues. Improving the resistance of these systems to the effects of climate change is necessary (Nafees et al., 2024). This requires increasing roads, strengthening drainage and choosing building materials designed to withstand all kinds of weather. By adding climate-resistant parts to already established infrastructure, its value can last longer, and damage due to climate change can be cut down (Iqbal et al., 2024).

In addition, switching to climate-resistant public transportation is crucial. Building more metro buses and light rail lines, together with more attention to cycling and walking, can cause people to use private cars less, cut down on emissions and lower traffic pile-ups (Iqbal et al., 2024; Nafees et al., 2024). They must be made to stand up to climate stress, so stations are enclosed, tracks are raised, and vehicles are strong enough to run in any weather (Nafees et al., 2024).

5.3. Policy Integration and Planning for Adaptation

Pakistan's climate-resilient transportation infrastructure will succeed most if adaptation strategies are integrated into both national and local policies. Policymakers should ensure that climate adaptation is given top priority in both developing transportation and planning cities. It is important to integrate climate change thinking at every stage of building, maintaining and operating infrastructure (Khan et al., 2023; Tariq, Ali, 2017). A detailed strategy to reduce climate change impacts is found in the national adaptation plan (NAP), especially in the context of ensuring the transportation sector is strong and reliable. The NAP points out that infrastructure must be designed to handle the rising number and intensity of climate-related problems, including flooding, heatwaves and bad weather (Khan et al., 2023; UNFCCC, 2021).

Figure 13 describes a suggested process for developing an action plan using Pakistan's climate change policy and including it in transportation planning. A basic process is outlined, starting with evaluating weaknesses, improving teamwork among institutions and preparing

adaptation plans, then moving to project implementation, keeping an eye on results and updating policy implementation (Khan et al., 2016). It points out that climate adaptation needs to be included in all transportation policies from local to national governments.

Also, regular cooperation between each level of government and teaming up with relevant business leaders is required to ensure the successful execution of adaptation measures. Because of these divisions, adaptation policies can be adapted for each region's special needs and vulnerabilities. Places like Karachi and Hyderabad, which experience flooding, ask for special action to enhance the security of their transportation systems. Some of the steps these interventions involve are raising roads, better managing storm drainage and making sure bridges can handle harsh weather (Ali et al., 2019; Khan et al., 2023). Local solutions must be based on information from the region, its climate and what communities suggest, so that the adaptation steps are appropriate and can be sustained (Tariq, Ali, 2017).

The development of climate-resilient roads and bridges is made possible by using different financial mechanisms. Climate financing from the World Bank, the Green Climate Fund (GCF) and UN Climate Change should be actively sought by the government in Pakistan (Bank, 2022; Khan et al., 2023). They may also help to build major projects that will protect us from climate change, for example, flood-proof roads and bridges and climate-safe transport systems. Just as well, getting the private sector involved through public-private partnerships (PPP) can greatly speed up efforts to adapt to climate change. Points of agreement between public and private organisations can add innovation, experienced staff and funds to build green infrastructure quickly and ensure its sustainability (Observatory, 2023).

Working together, public and private organisations can greatly increase Pakistan's efforts to develop a strong transportation network that can face climate-related changes. Improving expertise and knowledge exchange between all officials and involved parties is important too. It covers teaching engineers and urban planners about climate resilience, strengthening the capacity of local authorities to plan for changing climate risks and encouraging partnerships for sharing strategies on making infrastructure more sustainable (Khan et al., 2023; Tariq, Ali, 2017). By taking such a wide approach, Pakistan's transport system will be able to resist the effects of climate change and continue to aid the economy and improve living standards (Khan et al., 2023; UNFCCC, 2021).

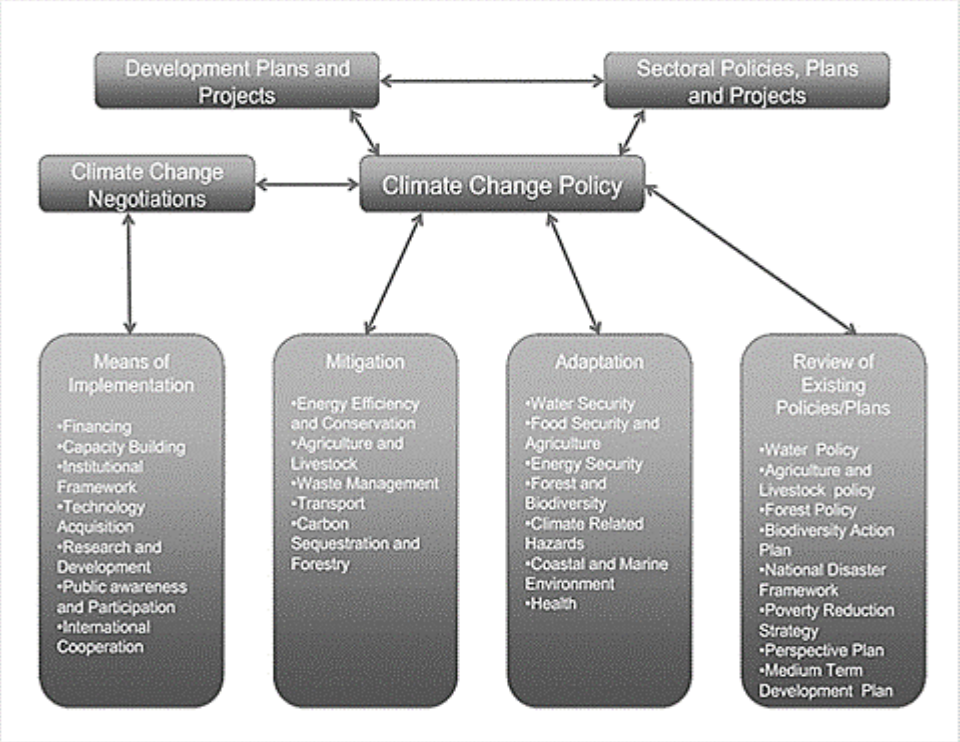

Figure 13. Proposed framework for the development of an action plan based on the climate change policy of Pakistan and its integration in the planning process.

Source: (Khan et al., 2016).

5.4. Challenges in Implementing Adaptation Measures

Addressing climate-related problems in Pakistan's transportation requires efforts on both a structural and organisational level. A main challenge is that there isn't enough funding to finance major improvements to infrastructure. It is necessary to spend a lot on roads and bridges that resist flooding and on building climate-resilient urban transportation. At the same time, Pakistan struggles to find funds because its budget is stretched in many other directions (Khan et al., 2023; Tariq, Ali, 2017). Things become more difficult because political and institutional issues make coordinated adaptation planning challenging. Because federal and provincial governments are not always in agreement, policies can vary widely from one area to another (Khan et al., 2023; Observatory, 2023). Furthermore, weak systems for checking and guiding climate adaptation work lead to problems in spending resources and delaying the start of projects.

Having the needed technical capacity presents a major difficulty for Pakistan's adaptation strategy. To create and use climate-safe infrastructure, people must have experience with sustainable building, tackling floods and adding electric vehicles and alternative energy sources to the transportation system. Having a shortage of skilled and technical personnel prevents countries from creating strong adaptation strategies (Tariq, Ali, 2017).

Moreover, the main political and economic issues of the moment often get in the way of long-term plans for dealing with climate change. Since the government's focus is on fast economic improvements, it does not always prioritise the bigger goals needed for resistance to climate change (Khan et al., 2023). This makes it harder to keep political attention on climate adaptation in the long run.

Addressing these issues requires the introduction of public-private partnerships, climate bonds and climate finance programs fostered internationally. Integrating climate adaptation plans into development plans at the national and provincial levels improves the government's commitment and leads to better and more consistent actions (Bank, 2022).

Additionally, both the public and private sectors must build their capacities to give key stakeholders the necessary knowledge and skills for designing and finalising climate-resilient infrastructural investments (Observatory, 2023). Stronger systems for governing climate adaptation and more cooperation across all government and private sectors are also vital for overcoming obstacles and seeing the planned efforts through (Khan et al., 2023; Tariq, Ali, 2017).

6. Case Studies: shifting from Private vehicles to Public Urban Transport for GHG Reduction in Pakistan

The growth of cities and cars in Pakistan has significantly increased GHG emissions, polluted the air, and led to more traffic jams (Bajwa, Sheikh, 2023). Consequently, main cities have developed mass transit to encourage commuters to use public transport instead of their cars and reduce harmful emissions from transportation (Saleem et al., 2022). This section examines specific case studies from Peshawar, Karachi, Islamabad-Rawalpindi, and Lahore to determine the extent to which these actions reduced GHG emissions.

6.1. Lahore Metrobus and Orange Line Metro Train

The Lahore Metrobus System, which started in 2013, was Pakistan's first bus rapid transit system (Rathore, Ali, 2015). Over 150,000 passengers are served by the Metro line's approximately 27-kilometre section daily (Aziz, 2015). Since the MBS started, private vehicle use has gone down by 15%, which has resulted in about a 31,000-ton annual reduction in CO_2 emissions (Iqbal et al., 2023). Figure 14 illustrates the typical number of boardings at each bus station along the Metrobus route, providing insight into how people throughout Lahore utilise the system. High traffic at main transit stops in big cities reflects the desire for convenient and efficient travel options (Hafiz Usman Ahmed, 2014).

In addition to the MBS, the Lahore Orange Line Metro Train (OLMT) was launched in 2020 and operates as a fully automated 27.1 km rapid transit system between large urban areas (Shahid et al., 2020). The Lahore Orange Line Metro Train has the potential to replace at least 70,000 daily trips by car and motorbike. If so, the service could eliminate over 47,000 tons of CO_2 each year (Anam et al., 2025). Even so, challenges with electricity use and not integrating several modes slow down these benefits (Batool et al., 2020).

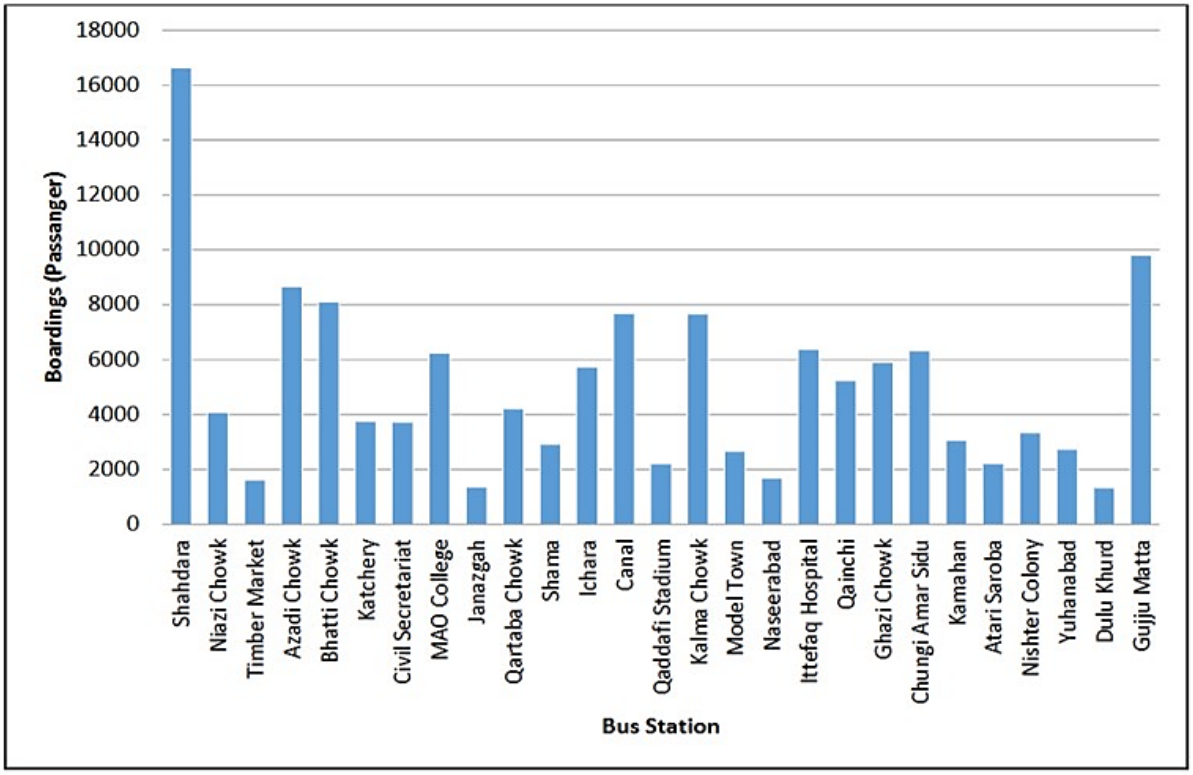

Figure 13. Average boardings at different stops of Metrobus Lahore.
Source: (Hafiz Usman Ahmed, 2014).

6.2. Islamabad – Rawalpindi Metro Bus:

The Islamabad-Rawalpindi Metrobus started operating in 2015, covering a 24 km BRT corridor (Saqib, Anwar, 2022). It was created to help locals find a cleaner way to travel, as the area has many high car owners (Shafqat, 2017). The Capital Development Authority's post-implementation evaluation discovered that the metrobus has resulted in a 22% decrease in vehicle kilometres travelled (VKT) along its route, which means approximately 19,000 tons of CO_2 are saved every year (Capital Development Authority, 2017). Although there have been advances, partial coverage and weak networks at the last mile have slowed the switch from private to public transport. Measures are being planned and implemented to improve these areas, including aligning with other local transport systems (Khan, 2017).

6.3. Peshawar Bus Rapid Transit (Zu Peshawar)

Launched as Zu Peshawar in 2020, Peshawar's BRT operates 27 km and uses hybrid diesel-electric buses (Zhang et al., 2025). Data from a case study by the Asian Development Bank (ADB) shows that the introduction of Zu Peshawar has led to a change in travel options for many, with more than 30% of users being former private vehicle users (Bank, 2022; Saleem et al., 2022). Thanks to cleaner vehicles and less congestion, the system is projected to cut GHG emissions by almost 62,000 tons of CO_2 every year (Arif, 2024). Thanks to its accessibility for all and the well-organised feeder network (Khan, 2020).

6.4. Karachi Green Line BRT

In November 2021, Karachi, the country's largest urban centre, launched the Green Line BRT. This project extends over 21 km and has a planned capacity of serving more than 135,000 passengers each day (Safdar et al., 2022). The Sindh Infrastructure Development Company Ltd (SIDCL) found that under current conditions, the Green Line has reduced car travel by 10%, with the potential for annual GHG savings of around 45,000 tons when ridership returns to normal (World Bank, 2023). Nevertheless, linking private vehicles to the informally run sector in Karachi and finishing the extension of certain lines are still preventing the best effects on the environment (Akber, 2024).

Table 5.
Summary of emissions reductions from urban transit projects in Pakistan

City	Project	Annual CO_2 Reduction (tons)	Modal Shift Impact	Reference
LAHORE	Metrobus	~31,000	15% reduction in private vehicle trips	(Iqbal et al., 2023)
LAHORE	Orange Line Metro Train	~47,000	~70,000 trips displaced per day	(Anam et al., 2025)
ISLAMABAD	Metrobus	~19,000	22% reduction in VKT	(Capital Development Authority, 2017)
PESHAWAR	Zu Peshawar BRT	~62,000	30% of riders shifted from private modes	(Arif, 2024)
KARACHI	Green Line BRT	~45,000 (projected)	10% reduction in private car use	(World Bank, 2023)

7. Discussion

Results from this review suggest that integrated technology-based strategies are essential to decreasing GHG emissions in the Pakistani transport sector. Switching to electric vehicles (EVs), compressed natural gas (CNG), and alternative fuels has become a promising strategy for reducing air pollution in cities where it is a major cause for worry (CDKN, 2023; Qadir,

2002; Qureshi, Lu, 2007). Even so, some problems are preventing wider use of these cars, such as a lack of charging spots for electricity and gas, not many refuelling stations for CNG and expensive initial costs (CPDI, 2023; Observatory, 2023). Integrating vehicle-to-grid V2G technology and smart grids works well to address these issues by supplying extra energy storage and helping regulate energy consumption (Kumar et al., 2024).

Policies, for example, tax breaks and subsidies for producers, along with incentives for individuals, help to encourage cleaner travel (ICCT, 2024; Ministry of Climate Change, 2019). Compared to other means, systems like Lahore's Metrobus reduce emissions by easing crowded roads and saving fuel (Qadir, 2002; Qureshi, Lu, 2007). Still, growing the public transport system is threatened by problems including a lack of funds, difficulties in government institutions and a lack of coordination with city planners (Ali et al., 2019; Bank, 2022).

Pakistan should work to broaden their public transport options, especially by adding a Bus rapid transit network, metro systems and encouraging more people to cycle and walk. Non - motorised transport NMT brings clear advantages, for example, there are no tailpipe emissions, the air is cleaner and public health is better (Ali et al., 2019; Qadir, 2002). Yet, there are challenges in expanding NMT because cities are crowded, and not much money is being spent on it. While CNG has been a smaller part of Pakistan's energy mix, it may not last for many years because of changing prices and scarce stations for refuelling (CDKN, 2023).

A transportation system can be made both sustainable and low in emissions if EVs are popularised, CNG infrastructure is improved, public transport jumps and NMT use increases. It will take the joint action of the government, local businesses and partners from abroad to get past these challenges. Higher awareness among people and research-relevant skills for employees are required to ensure that many use cleaner transportation technologies (CPDI, 2023; Tariq, Ali, 2017).

8. Conclusion

Solving the problem of increased transportation emissions in Pakistan will require many different methods. Rapid growth in cities, a rise in population and dependence on fossil fuels in transportation are the main reasons the country's transportation sector is a key source of greenhouse gas (GHG) emissions. Because of the sector's emissions, there is more global warming, plus higher risks to air quality, health and the environment. Pakistan needs to use a strategy that brings together advances in technology, new infrastructure and more environmentally conscious habits. Switches like the ones from petrol to EVs and CNG can greatly lower emissions in the transportation sector. Still, these new developments are not enough by themselves. Complementary work should include building sufficient EV charging infrastructure and improving public transportation.

Electric cars are a crucial choice that can reduce the emissions linked with personal automobiles. Even though the National Electric Vehicle Policy lays out a plan for more EV adoption, it won't work unless the government overcomes high launch costs, limited charging availability, and few people are aware of electric vehicles. Furthermore, CNG plays an important part since it provides a clean alternative to fossil fuels in the current situation. Although some cities use CNG to decrease vehicle emissions, Pakistan has to ensure that it is widely available and that the infrastructure is improved for everyone. Even though EVs and CNG vehicles will help shrink the sector's carbon footprint, they still depend on joint public measures and lengthy financial backing.

Building up public transportation is vital for encouraging people away from travel by public transportation and decreasing emissions. For example, Lahore Metrobus, Karachi Green Line and Lahore Orange Line help reduce traffic, make the air cleaner and reduce the amount of pollution. Although bringing these systems into urban mobility is great, there are still issues with funding, support from officials and expanding infrastructure. Encouraging walking and cycling (called NMT) can be done by making sidewalks wider and adding special lanes for cyclists. Using more of these alternatives helps reduce congestion and makes the environment better.

Transportation will become more sustainable and low-emission if people also change their behaviour. Campaigns that inform people are essential to help them see the benefits EVs, CNG and public transport offer both to the environment and the economy. The results of these initiatives will depend on cooperation between the public and the private sectors. Laws by the government should encourage energy-saving technologies, higher vehicle fuel economy and adopting clean ways of moving people and goods. Making transportation systems more resilient to climate change is very important. Pakistan should build its transportation systems to remain secure in times of shock from weather disasters and hurricanes. If infrastructure is built to survive climate change, it will keep traffic and transport running smoothly in the event of such changes.

To help create a sustainable transport system in Pakistan, several stakeholders, including the government, businesses and the public, must cooperate. Supporting EVs and sustainable transport requires policymakers to support their adoption, raise fuel standards and build more mass transit networks everywhere. We should also encourage international organisations and experts to help in securing both financing and the needed technology. Even though reaching a sustainable and strong transportation network in Pakistan is hard, it is possible to achieve. Putting together a sustainable manufacturing transportation system calls for future strategies, fresh ideas and reasonable spending on infrastructure for both the environment and the economy. In short, reducing emissions from transportation in Pakistan helps combat climate change, protect public health, build a stronger economy and improve quality of life for everyone. If Pakistan combines new technologies, enacts better policies and improves infrastructure, it can design a transportation network that lasts and can handle both climate change and the need for sustainable development.

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