Ministry of Climate Change
and Environmental Coordination
Government of Pakistan

SPAR6C
Supporting Preparedness for
Article 6 Cooperation

Sectoral Study

Decarbonization of Pakistan's Transport Sector: Technologies, Policy Options and Carbon Market Opportunities

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List of Abbreviations

ADB - Asian Development Bank
AFD - French Development Agency (Agence Française de Développement)
AIIB - Asian Infrastructure Investment Bank
ASI - Avoid-Shift-Improve
BAU - Business As Usual
BRT - Bus Rapid Transit
CNG - Compressed Natural Gas
CO_2 - Carbon Dioxide
CO_2e - Carbon Dioxide Equivalent
COP - Conference of the Parties
CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
CSR - Corporate Social Responsibility
DISCOs - Electric Distribution Companies
ETS - Emissions Trading Systems
EV - Electric Vehicle
FBR - Federal Board of Revenue
FC - Financial Cooperation
GCF - Green Climate Fund
GHG - Greenhouse Gas
HOBC - High Octane Blending Component
HSR - High-Speed Rail
ITMOs - Internationally Transferred Mitigation Outcomes
JCM - Joint Crediting Mechanism
KCR - Karachi Circular Railway
KT/Y – Kilotonnes/year
LDV - Light-Duty Vehicle
LUCF - Land Use Change and Forestry
LRT - Light Rail Transit
MMt-CO_2e - Million Metric Tons of CO_2 Equivalent
MRV - Measurement, Reporting, and Verification
NAMA - Nationally Appropriate Mitigation Actions
NCAP - National Clean Air Policy
NDC - Nationally Determined Contributions
NEVSC - National EV Steering Committee
NEVP - National Electrical Vehicle Policy
NETR - National Energy Transition Roadmap
NIMP - New Industrial Master Plan
NMT - Non-Motorised Transport
NO_x - Nitrogen Oxides
OECD - Organisation for Economic Co-operation and Development

OEMs - Original Equipment Manufacturers
PA - Paris Agreement
PGDP - Punjab Green Development Program
PKR - Pakistani Rupee
PM - Particulate Matter
PKM - Passenger-Kilometer
PPP - Public-Private Partnership
PPM - Parts Per Million
SO_2 - Sulfur Dioxide
SO_X - Sulfur Oxides
SPAR6C - Supporting Preparedness for Article 6 Cooperation
TC - Technical Cooperation
T-VER - Thailand Voluntary Emission Reduction Program
TOD - Transit-Oriented Development
TCO_2e - Tons of Carbon Dioxide Equivalent
TKM - Ton-Kilometer
TSU - Technical Support Unit
UNEP - United Nations Environment Programme
UNFCCC - United Nations Framework Convention on Climate Change
VCIS - Vehicle Inspection and Certification System
VCM - Voluntary Carbon Markets
VCS - Verified Carbon Standard
VKT - Vehicle Kilometers Traveled

Executive Summary

Carbon markets provide a critical pathway to mobilize both domestic and international financial resources toward climate mitigation efforts. These markets exist in a diverse landscape, functioning at both international and national levels, and serving dual purposes: voluntary and compliance-driven. Voluntary carbon markets enable entities to achieve self-imposed climate targets beyond regulatory requirements. In contrast, compliance markets are designed to fulfill obligations mandated by national laws or international frameworks, including domestic emissions trading systems, nationally determined contributions (NDCs) under the Paris Agreement's Article 6, or sector-specific mechanisms like the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The diversity of carbon markets offers governments a spectrum of strategic options for participation, depending on their climate policy objectives and economic contexts. This flexibility allows for tailored approaches to market engagement, ranging from establishing or linking domestic emissions trading schemes to participating in international crediting mechanisms. Understanding the nuanced dynamics of these markets, including regulatory frameworks, market linkages, and pricing signals, is essential for policymakers to effectively leverage carbon markets as a tool for achieving both domestic and global climate goals.

Objective and Scope of This Report

To engage effectively in carbon markets, governments must clearly define their objectives for participation and thoroughly understand the interactions among various carbon market mechanisms. Countries have the option to establish domestic crediting schemes to produce carbon credits or to adopt and adapt international carbon credit standards. These credits, once generated, can serve multiple purposes depending on the national context: for domestic compliance within a carbon tax or cap-and-trade system, for meeting international compliance obligations, or for voluntary use both domestically and internationally.

Article 6 of the Paris Agreement allows for voluntary cooperation between countries in achieving their nationally determined contributions (NDCs) through the international transfer of mitigation outcomes. When applied with robust environmental integrity, Article 6 has the potential to accelerate climate mitigation investments and enhance overall ambition. Key components of the guidance and rules for operationalizing Article 6 have been agreed upon, providing a clear framework for implementation and enabling countries to engage in bilateral cooperative arrangements. With these guidelines in place, the focus now shifts to developing the necessary national frameworks and processes to facilitate international cooperation under Article 6.

This study seeks to support the Government of Pakistan in developing and operationalizing strategies to engage effectively with carbon markets under Article 6 of the Paris Agreement, particularly focusing on the transport sector. This study aims to evaluate existing policies, regulatory frameworks, and institutional capacities that influence GHG emissions from the transport sector, identifying both challenges and opportunities for reducing emissions in line with Pakistan's updated NDCs. By examining the sector's current dynamics, including infrastructure development, modal shifts, fuel standards, and technology adoption, the study seeks to identify strategic interventions that can enhance the transport sector's contribution to achieving the country's climate objectives. As of 2023, the landscape of carbon markets presents multiple pathways for countries like Pakistan to participate and capitalize on market-based mechanisms under Articles 6.2 and 6.4. These pathways enable the transfer of mitigation outcomes and the generation of carbon credits that can be traded internationally, providing an avenue for Pakistan to leverage global finance for climate mitigation.

Strategic Elements to Engage in the Carbon Markets

- **NDC Strategy Development:** Pakistan should establish a comprehensive strategy to achieve its NDCs, involving consultations with government bodies, institutions, and civil society to ensure broad support. This strategy should prioritize areas aligned with Pakistan's specific circumstances and development needs, creating a detailed roadmap of policy instruments and financial requirements necessary for long-term implementation.
- **Carbon Market Strategy:** Pakistan needs to develop a clear carbon market strategy that outlines its objectives for engaging with carbon markets. This strategy should define the extent of Pakistan's participation in international cooperation under Article 6, balancing the use of domestic versus international markets, and addressing the role of Voluntary Carbon Markets (VCMs). Additionally, the strategy should consider national regulatory or taxation requirements, including those applicable to international transfers under Article 6.
- **Article 6 Engagement Objectives:** Building on the established long-term strategy, Pakistan should set strategic objectives to guide its engagement with Article 6. This includes developing guiding principles and criteria for mitigation outcomes eligible for international transfer. The principles should ensure that international carbon finance is directed toward sectors that are challenging for Pakistan to finance domestically and that the benefits of selling and transferring these outcomes internationally are maximized for the country.

Operational Requirements

- First, there is a need to establish clear processes for authorizing the international transfer of mitigation outcomes, including the appropriate timing for such authorizations. This involves setting up formal mechanisms for decision-making to

ensure timely and efficient approvals. A robust governance framework must be developed, with clear allocation of roles and responsibilities across government ministries. This framework should result from thorough cross-ministerial consultations, ensuring that the structures and safeguards necessary to support Article 6 activities are in place and that decision-making processes are streamlined.

- Pakistan should create a process to transition existing Clean Development Mechanism projects to the Article 6.4 mechanism. This transition must align with the guidelines to be established by the Conference of the Parties to the Paris Agreement.
- There must be a designation of contact points within the government responsible for negotiating and concluding bilateral agreements under Article 6.2, coupled with clear interministerial or interagency approval processes to ensure seamless coordination.
- Additionally, the country must develop its accounting and reporting capabilities to comply with Article 6 requirements. This includes building the necessary infrastructure to track and report mitigation outcomes accurately.
- Moreover, while not directly under Article 6, it is important to provide guidance on claims made by voluntary purchasers of mitigation outcomes generated domestically, ensuring alignment with the principles set by leading carbon market integrity bodies.
- Lastly, aligning Article 6 transactions with domestic emissions pricing or trading schemes, where applicable, will ensure coherence between national policies and international carbon market participation.

By addressing these operational requirements, Pakistan can provide clarity and confidence to both domestic stakeholders and international partners, including private sector participants, facilitating seamless integration into global carbon markets. This approach ensures that Pakistan's participation in carbon markets aligns with its national policies and international commitments, particularly under Article 6. With a solid foundation guided by the Article 6 framework and the rules established at COP26, COP27, and COP28, Pakistan can strategically tap into sectors with high emission reduction potential, such as transport. Leveraging these opportunities will allow Pakistan to attract international carbon finance, drive sustainable development, and enhance its climate ambition through targeted mitigation efforts in key sectors.

1. Background

The Paris Agreement (PA), adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), sets a global objective to limit temperature increases to well below 2°C above pre-industrial levels, with aspirations to limit this increase to 1.5°C. Achieving this target necessitates robust measures across all sectors, including transport, which is a significant contributor to global greenhouse gas (GHG) emissions. The Agreement also emphasizes enhancing adaptive capacity and aligning financial flows with low-GHG and climate-resilient pathways.

To meet these objectives, the Paris Agreement requires Parties to formulate and communicate their Nationally Determined Contributions (NDCs), outlining domestic actions to reduce emissions. Notably, over 50% of the submitted NDCs reference the use of carbon markets as a strategy to achieve their GHG reduction targets. Carbon markets, therefore, emerge as a critical tool for facilitating cost-effective and scalable emissions reductions, particularly in hard-to-abate sectors such as transport. There is a growing global interest among countries in leveraging carbon markets to finance low-carbon development initiatives. Carbon market mechanisms provide a framework for participating entities to trade units representing GHG emission reductions and removals. The landscape of carbon market opportunities is diverse, offering both countries and the private sector various pathways to engage in emission reduction efforts. These carbon market instruments, mechanisms, and schemes can be implemented at both international and domestic levels, either across multiple countries or within a single country. The trade within carbon markets is primarily driven by the demand for unitized mitigation outcomes. Market participants, or buyers, engage in these markets for both voluntary and compliance purposes. Voluntary participation allows entities to fulfill self-imposed climate commitments, while compliance-driven participation is aimed at meeting regulatory requirements. These requirements may stem from domestic emissions trading systems, NDCs under the Paris Agreement's Article 6, or international schemes such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (Figure 1).

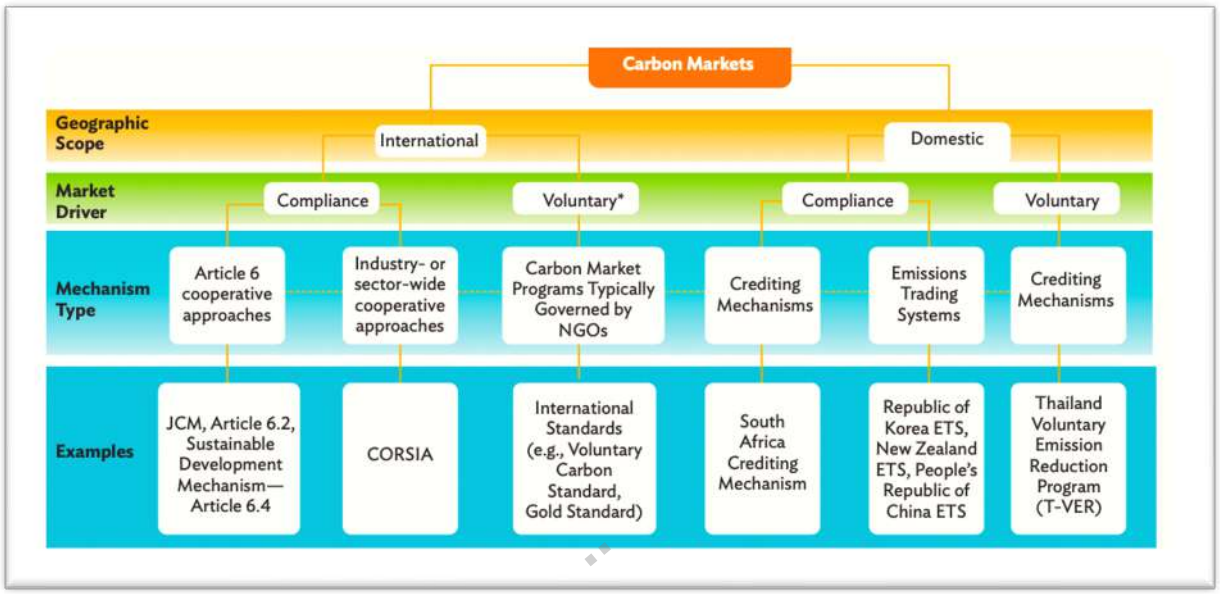

Figure 1:General Landscape of Carbon Market Instruments

International compliance carbon markets can be strategically categorized into two distinct groups: cooperative approaches and industry- or sector-wide approaches. The fundamental distinction between these categories lies in the level of regulatory control exerted over market participants. Cooperative approaches are generally linked to the implementation of NDCs, which set emission reduction targets at the national or sectoral level rather than at the level of individual entities. A prominent example of such cooperative approaches includes ITMOs under Article 6 of the Paris Agreement, such as bilateral agreements within the JCM. Conversely, industry- or sector-wide cooperative approaches are emerging as innovative mechanisms that apply a more uniform strategy across a specific sector. An example of this is the CORSIA, the first global initiative to standardize the use of carbon markets to achieve emission reductions across a particular sub-sector of the global economy, namely the aviation sector.

International voluntary carbon markets, on the other hand, provide a flexible platform for organizations—predominantly from the private sector—to engage in carbon mitigation activities that align with their own sustainability goals, such as carbon neutrality or net-zero commitments. The targets and commitments made by these entities are self-determined and non-binding, meaning they do not carry legally enforceable obligations to achieve specific mitigation outcomes. This segment of the market, known as the Voluntary Carbon Market (VCM), operates without a centralized governance structure. VCM transactions are primarily international, taking place through direct business-to-business agreements or through commodity exchanges and ETFs, reflecting a dynamic and decentralized approach to carbon trading.

1.1. Domestic Carbon Markets

Many countries are actively developing or have already established domestic carbon markets to bolster their decarbonization efforts, both within their borders and across their regions. These domestic carbon markets often utilize a range of mechanisms tailored to the specific economic and regulatory contexts of each country.

Domestic Compliance Markets typically encompass ETS, or a combination of ETS and carbon taxes. In some instances, domestic crediting mechanisms are also introduced to enhance flexibility for entities subject to regulation. These mechanisms allow regulated entities to generate or acquire credits from emission reduction activities, thereby providing an alternative means of compliance within a carbon pricing framework.

An ETS represents a structured approach to carbon pricing that differs fundamentally from crediting mechanisms. Unlike crediting, which involves the generation of credits from specific emission reduction activities, an ETS establishes a market-based cap-and-trade system. This system sets a cap on the total allowable emissions within a particular sector or multiple sectors and allocates emissions allowances—each representing the right to emit one metric ton of carbon dioxide equivalent (CO_2e)—to regulated entities. These allowances can be distributed for free or sold via auctions by a regulatory authority. Entities that exceed their allotted emissions must either purchase additional allowances in the market or face penalties for non-compliance. Furthermore, domestic crediting mechanisms can operate independently of carbon pricing instruments and may function on a voluntary basis, as seen in programs like the Thailand Voluntary Emission Reduction Program T-VER. Such voluntary mechanisms are designed to encourage emission reductions outside of mandatory compliance frameworks, allowing entities to engage in carbon mitigation efforts driven by corporate sustainability goals or other voluntary commitments.

Linkages and Interactions between domestic and international carbon markets are becoming increasingly significant. Domestic markets, with their unique configurations and regulatory underpinnings, influence the supply and demand dynamics of international carbon markets and VCMs. This interplay creates both opportunities and complexities, as the boundaries between domestic compliance markets, international voluntary markets, and international compliance markets continue to blur. Understanding these linkages is crucial for stakeholders aiming to navigate the evolving carbon market landscape strategically.

1.2. Strategic Considerations for Governments Engaging in Carbon Markets

Governments must navigate the complexities of carbon markets with a strategic lens, balancing the need to attract carbon finance through the sale of Internationally Transferred Mitigation Outcomes (ITMOs) under Article 6 of the Paris Agreement while ensuring the ability to meet their own Nationally Determined Contribution (NDC) targets and enhance their climate ambitions. Key actions for governments include:

- **Clarifying Objectives**: Clearly define the objectives of participation in carbon markets, whether for revenue generation, supporting national climate goals, or driving higher ambition.
- **Regulatory and Legal Frameworks**: Develop or refine domestic regulations and legal frameworks to enable effective participation in both domestic and international carbon markets.
- **Article 6 Policy Framework**: Establish a robust Article 6 policy framework to guide the authorization of mitigation outcomes for international trade and to ensure alignment with national climate strategies.
- **Administrative Capabilities**: Build administrative capacities to manage credit authorization processes and implement corresponding adjustments to avoid double counting of emission reductions.
- **Voluntary Market Oversight**: Evaluate the role of voluntary carbon markets within the national context, considering options to support, regulate, or restrict these activities to align with national interests and policy objectives.

By taking these steps, governments can strategically position themselves to maximize the benefits of carbon market participation while safeguarding their domestic climate commitments.

1.3. Pakistan Climate Ambition

Article 6 of the PA provides an opportunity for Parties to voluntarily cooperate to collectively achieve the long-term goals mentioned above. Pakistan continues its efforts to meet its climate objectives as outlined in its updated NDCs submitted in 2021. To achieve Pakistan's climate objectives as outlined in its updated NDC submitted in 2021, a detailed sectoral analysis is essential to identify mitigation opportunities. Pakistan has committed to reducing its projected GHG emissions by 50% by 2030, relative to a business-as-usual scenario. This target includes an unconditional reduction of 15% and a conditional reduction of 35%, contingent upon the availability of international financial support, technology transfer, and capacity building[1]. Achieving these NDC targets ne-

[1] https://unfccc.int/sites/default/files/NDC/2022-06/Pakistan%20Updated%20NDC%202021.pdf

cessitates the implementation of comprehensive measures across various sectors, including energy (with a focus on buildings and transport), industrial processes (such as cement production and fluorinated gas management), agriculture, forestry and other land use (AFOLU), and waste management.

In this context, the transport sector in Pakistan presents a significant opportunity for emission mitigation, given its considerable contribution to national GHG emissions.

This sector report, developed for the Government of Pakistan, provides a comprehensive analysis of the transport sector's current landscape, challenges, and opportunities in the context of carbon markets, particularly under the framework of Article 6 of the Paris Agreement. It aims to support the government in formulating strategic approaches for effective participation in carbon markets, enabling the transport sector to achieve emissions reduction targets while accessing new streams of carbon finance. By examining innovative market mechanisms and potential policy interventions, this study offers critical insights to help Pakistan navigate the complexities of the global carbon market, fostering a transition towards a sustainable and low-carbon transport sector. The findings will inform policymakers on the design of targeted measures to reduce emissions, attract climate finance, and foster public and private investments in sustainable transport solutions, ultimately contributing to Pakistan's transition to a low-carbon economy.

This work is being conducted under Supporting Preparedness for Article 6 Cooperation (SPAR6C)[2] Program. The initiative aims to enhance global climate action by preparing countries to participate effectively in international carbon markets under Article 6 of the Paris Agreement. Pakistan, as one of the four target countries under the SPAR6C initiative, is set to gain significantly from this program. The project's primary goal in Pakistan is to strengthen the country's ability to engage in international carbon markets by refining its policy and regulatory frameworks and fostering greater involvement from the private sector.

[2] https://www.spar6c.org/

2. Current Overview of the Sector and its GHG Emissions

The transport sector is a cornerstone of a country's infrastructure and economic framework, driving the movement of people, goods, and information. It is fundamental to a nation's development and prosperity, underpinning economic growth, facilitating trade and business activities, creating jobs, enhancing social connectivity, and providing access to essential services like education, healthcare, and emergency response. Modernizing infrastructure and enhancing regional connectivity are top priorities for the government, as outlined in Pakistan Vision 2025[3]. To achieve these objectives, the government has prioritized increasing bilateral and multilateral cooperation in this sector and consistently allocates a significant portion of its development budget to transport infrastructure investment each year. The transport sector is a significant driver of Pakistan's economy, accounting for approximately 10.7% of the country's GDP and employing over 5.8% of the workforce[4].

Figure 2 shows that the transportation landscape in Pakistan is overwhelmingly dominated by road networks, which handle 95% of freight traffic and 94% of passenger traffic[5]. In contrast, rail accounts for a mere 6% of freight and 3% of passenger transport, while air transport carries 2% of passenger traffic and none of the freight. This heavy reliance on road transport highlights a significant imbalance, underscoring the need for diversification and investment in other modes of transportation to improve efficiency, reduce congestion, and promote sustainable economic growth.

Figure 2: Transport Modal Share in Pakistan

[3] https://www.pc.gov.pk/uploads/vision2025/Pakistan-Vision-2025.pdf
[4] https://file.pide.org.pk/pdfpideresearch/rr-transports-and-logistics.pdf
[5] https://www.finance.gov.pk/survey_2023.html

Figure 3 illustrates the population growth trends in Pakistan and its provinces (Punjab, Sindh, KPK, and Balochistan) from 1951 to 2023. It shows a significant increase in Pakistan's overall population, which has surged from around 35 million in 1951 to approximately 280 million by 2023[6]. The provincial data indicates that Punjab remains the most populous province, followed by Sindh, KPK, and Balochistan. This growing population has implications for various sectors, including transport, where increased demand for both public and private transportation services contributes to rising emissions, especially in urban centers.

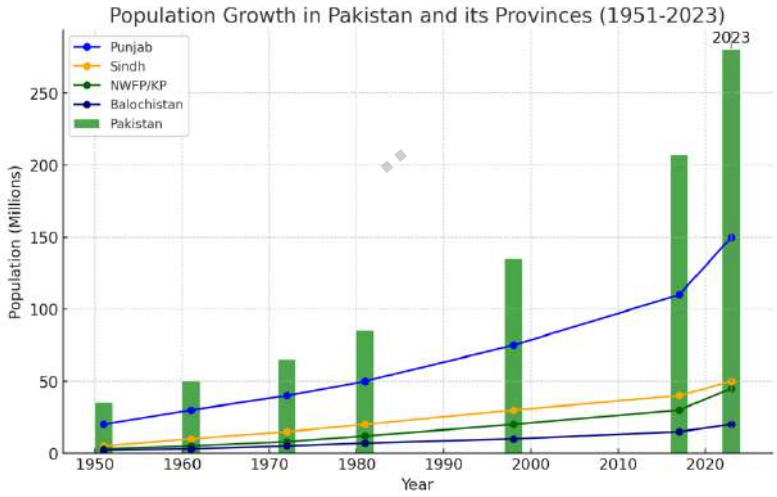

Figure 3: Population Increase of Pakistan (1951 – 2023)

The rapid growth of Pakistan's population, which has expanded from approximately 35 million in 1951 to nearly 280 million by 2023[7], has significantly increased the demand for transportation, particularly in major urban centers like Karachi, Lahore, and other burgeoning cities. This demographic surge has led to a substantial rise in the number of vehicles (Figure 4), especially light vehicles like motorcycles, which are a preferred mode of transport due to their affordability and maneuverability in congested urban environments. As a result, cities like Karachi and Lahore have seen an exponential increase in motorcycle usage, contributing to traffic congestion and heightened emissions. Meanwhile, the rise in heavy vehicles, such as trucks and buses, reflects the growing need for freight transport and public transit options to support the expanding urban economy and population (Figure 5).

[6] https://pgdp.pk/Download/publications/Files/15/2024/SOE%20Report%204-June%20final.pdf
[7] https://finance.gov.pk/survey/chapter_24/Economic_Survey_2023_24.pdf

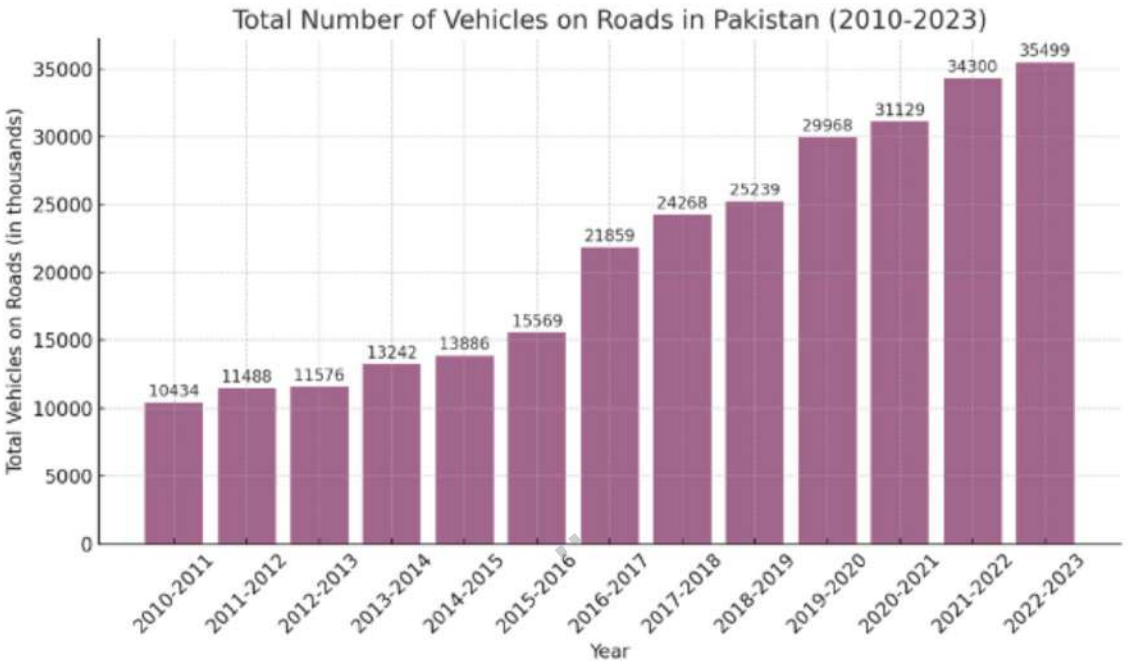

Figure 4: Total Vehicles on Roads

This dual increase in both light and heavy vehicles has led to worsening air quality, with urban areas particularly affected by higher emissions of greenhouse gases and pollutants. Heavy vehicles, essential for the supply chain and public transport, add to this pollution burden, particularly in areas with dense traffic and inadequate road infrastructure. The convergence of these factors has created a complex urban pollution scenario, where emissions from both vehicle categories exacerbate smog and respiratory illnesses, posing significant public health risks.

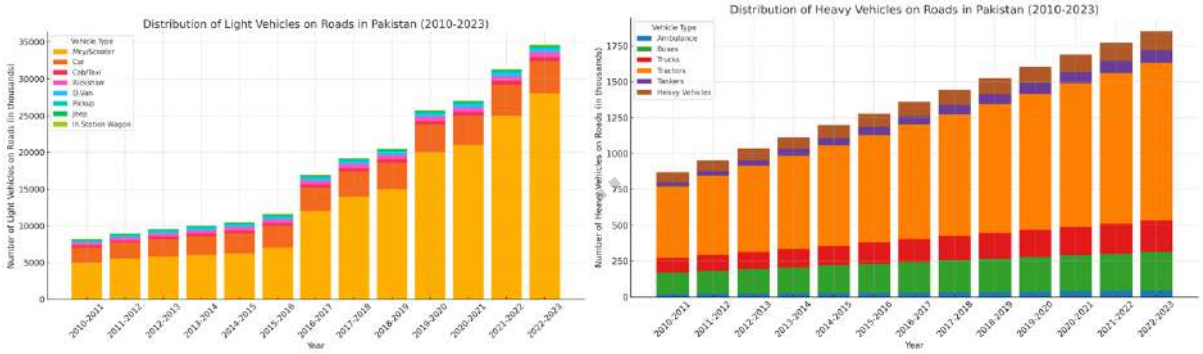

Figure 5:Distribution of Light and Heavy Vehicles on Road

The per capita transport-related emissions in the country have been estimated at 0.27 tons of CO_2[8]. The flexible rental system by credit institutions also causes an upsurge in rickshaws, cars, and other two-stroke vehicles[9]. Pakistan's fuel quality falls under the

[8] Climate Transparency. (2020). CLIMATE TRANSPARENCY REPORT PAKISTAN'S CLIMATE ACTION AND RESPONSES TO THE COVID-19 CRISIS. (https://www.climate-transparency.org/countries)
[9] Anjum, M. S., Ali, S. M., Subhani, M. A., Anwar, M. N., Nizami, A. S., Ashraf, U., & Khokhar, M. F. (2021). An emerged challenge of air pollution and ever-increasing particulate matter in Pakistan; a critical review. Journal of Hazardous Materials, 402, 123943

Euro-II standard, which is far behind the Euro-VI standards adopted by India and other developing countries. In addition to fuel quality, two-stroke vehicles including motor-cycles and auto-rickshaws make up the major share of vehicles in the largest cities such as Lahore and Karachi. Inefficient and poorly maintained engines are responsible for generating higher emissions[10]. Traffic Congestion is another factor that contributes to higher emissions. It is mainly caused by weak mass-transit system and road networks, pedestrian obstructions, limited freight transport, illegal parking, encroachments, as well as lack of awareness of the same.

The transport sector in Pakistan is a significant contributor to the country's greenhouse gas (GHG) emissions, with a total output of 51.34 Mt CO_2e in 2018[11]. This places it as the third-largest sub-sector within the broader energy category, which collectively emitted 218.94 Mt CO_2e. The transport sector's emissions account for approximately 10.5% of the total national GHG emissions across all sectors, which sum up to 489.87 Mt CO_2e. The emissions are predominantly driven by Light-Duty Trucks (20.98 Mt CO_2e) and Cars (15.30 Mt CO_2e), which together constitute over 70% of the road transport emissions. Aviation contributes a relatively small share of GHG emissions in Pakistan, at 3.8% of the transport sector's total (Figure 6[12]). This limited impact is due to the relatively low volume of domestic air travel, driven by the country's economic structure, population distribution, and the availability of more affordable road and rail transport options for most internal travel needs.

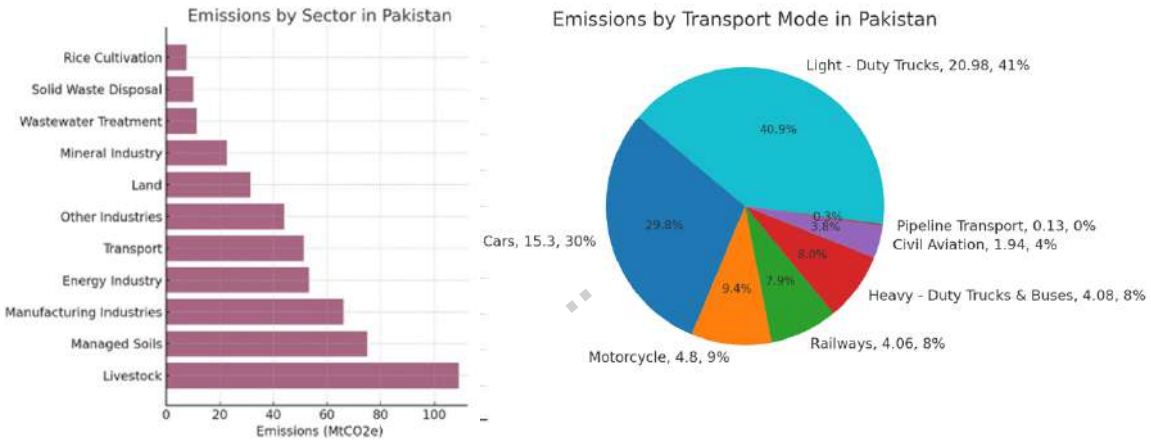

Figure 6: Summary of Sectoral GHG Emissions and Emissions from Transport Sector 2018 ($MtCO_2e$)

This substantial output is primarily attributed to the combustion of fossil fuels—namely gasoline and diesel—in internal combustion engines (ICEs) across various modes of

[10] Habib, A., Nasim, S., & Shahab, A. (2021). Charting Pakistan's Air Quality Policy Landscape. International Growth Centre: London, UK.
[11] https://www.unescap.org/sites/default/d8files/event-documents/Day2_Session6.3_Pakistan.pdf
[12] https://unfccc.int/documents/470405

transport, including road vehicles, railways, and aviation. The data on CO_2 emissions from transport as a percentage of total fuel combustion in Pakistan shows a slight increase from 28.3% in 2000 to 28.9% in 2014[13]. This upward trend indicates that the transport sector's share of overall CO_2 emissions is growing, reflecting increased vehicular activity and possibly higher dependence on road transport. The rising share of transport emissions reflects inefficiencies in fuel use and suggests limited adoption of cleaner technologies and fuels. This trend has implications for Pakistan's energy security and balance of payments, as the country relies heavily on imported fossil fuels. Moreover, the growing emissions intensity in transport underscores the need for an integrated approach to sectoral planning, encompassing fuel economy standards, investment in mass transit systems, and incentives for electric and hybrid vehicles.

Pakistan's transport sector shows an emissions intensity of 33 grams of CO_2 per USD measured against Gross Value Added (GVA)[14], indicating a moderate level of carbon efficiency compared to other countries (Figure 7). Despite not being among the highest emitters, Pakistan's domestic transport sector contributes significantly to its overall greenhouse gas (GHG) emissions, highlighting a reliance on fossil fuels and older vehicle fleets. This high share of domestic transport GHG emissions underscores the need for targeted strategies, such as upgrading to cleaner vehicle technologies, improving fuel standards, and enhancing public transport infrastructure.

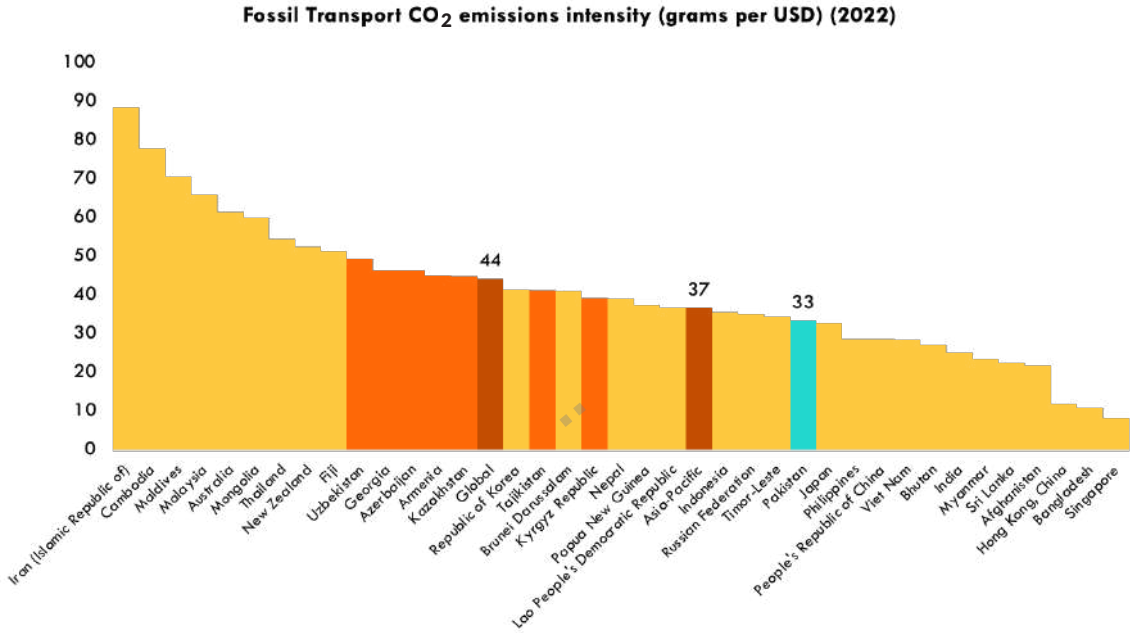

Figure 7: Fossil Transport CO_2 Emissions Intensity (2022)

[13] https://databank.worldbank.org/source/world-development-indicators/Series/EN.CO2.TRAN.ZS
[14] https://asiantransportobservatory.org/

Pakistan's transport sector exhibits a high CO_2 emissions intensity, measured at 33 grams per USD in 2022, reflecting systemic inefficiencies driven by rapid urbanization, rising motorization rates, reliance on private vehicles over public transport, and an aging fleet with poor fuel efficiency. The disparity between economic output and emissions highlights the need for targeted interventions, including investments in modern, fuel-efficient public transport systems, policy incentives for low-emission vehicles, and integrated urban mobility planning. Addressing these structural issues is critical for aligning Pakistan's transport sector with national decarbonization targets and optimizing economic output per unit of emissions.

The calculation of this emissions intensity is based on data from the EDGAR v5.0 database, which provides detailed global emissions data for various sectors, including transport. According to Crippa et al. (2020)[15], the EDGAR database compiles emissions data using country-specific information on fuel consumption, vehicle types, and transport activity.

2.1. Overview of the Transport Sector Emissions – Lahore, Punjab:

Lahore, Pakistan's second-largest urban center with a population of 11.2 million, is facing a severe decline in air quality, which is increasingly undermining the living standards of its residents. This deterioration is driven by a multitude of interlinked challenges that have intensified over time. The city's rapid and largely unplanned urbanization has outpaced infrastructure development, resulting in significant traffic congestion and an exponential rise in the number of vehicles on the roads, particularly motorbikes. The limited coverage of an effective mass transit system further exacerbates the problem, as the majority of the population relies on private vehicles for daily commuting, leading to higher emissions.

In 2020, the transport sector emerged as the predominant contributor to Punjab's emissions, accounting for 2,763 KT/Y, which represents 39% of the city's total emissions of 7,017 KT/Y[16] (Figure 8). This high proportion is indicative of several underlying factors unique to Punjab's urban dynamics. The rapid urbanization and economic growth in Lahore have led to a substantial increase in vehicle ownership, especially private vehicles, which are often older models lacking efficient emission controls. The city's road network has not expanded proportionally, leading to severe congestion and high levels of vehicle idling, both of which significantly amplify emissions. Furthermore, the transport sector's reliance on high-sulfur diesel and gasoline exacerbates the situation, as poor fuel quality leads to higher emissions of sulfur oxides (SOx), nitrogen

[15] Crippa et al. (2020). EDGAR v5.0 Global Atlas of the Three Major Greenhouse Gases (CO2, CH4, N2O): Emissions for the period 1970-2015. *Earth System Science Data, 12*, 3269–3289. DOI: 10.5194/essd-12-3269-2020.
[16] https://urbanunit.gov.pk/Download/publications/Files/8/2023/Emission%20Inventory%20of%20Punjab%201990-2020_FD.pdf

oxides (NOx), and particulate matter (PM). These trends underscore the transport sector's outsized role in the city's air quality challenges and its contribution to greenhouse gas emissions in Punjab.

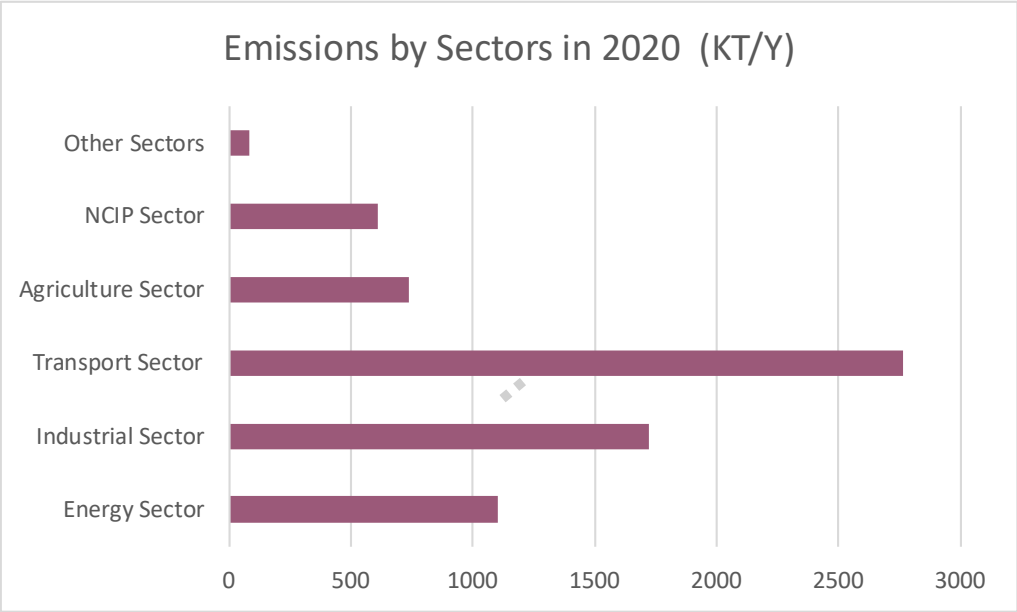

Figure 8: Emissions by Sectors in Punjab (2020)

Between 1990 and 2020, emissions from Lahore's transport sector saw significant increases across all major pollutants. The most substantial growth was observed in CO emissions, which more than quadrupled from 441 kT/Y to 2,057 kT/Y, reflecting the impact of higher vehicular density and aging, inefficient vehicle fleets[17].

Table 1: Transport Sector Emissions (1990 – 2020)

Unit (kT/Y)	1990	1995	2000	2005	2010	2015	2020
PM10	23	26	26	22	22	35	44
PM2.5	21	24	25	20	20	29	37
NOx	96	150	197	186	187	268	339
SO2	21	31	40	38	45	41	54
CO	441	577	663	708	1,111	1,498	2,057
VOC	114	116	104	103	157	171	232
Total	715	924	1,055	1,077	1,541	2,042	2,763

Figure 9 shows the significant growth in the number of registered vehicles in Punjab from 1990 to 2024. The data reveals a dramatic increase from approximately 643,738 vehicles in 1990 to over 24 million by March 31, 2024[18]. This sharp rise reflects the rapid urbanization and economic growth in Punjab, leading to increased private vehicle

[17]https://urbanunit.gov.pk/Download/publications/Files/8/2023/Emission%20Inventory%20of%20Punjab%201990-2020_FD.pdf
[18] https://excise.punjab.gov.pk/system/files/TOTAL.pdf

ownership and a substantial expansion of the vehicle fleet. The trend underscores the growing pressure on urban infrastructure and the corresponding environmental challenges due to heightened vehicular emissions.

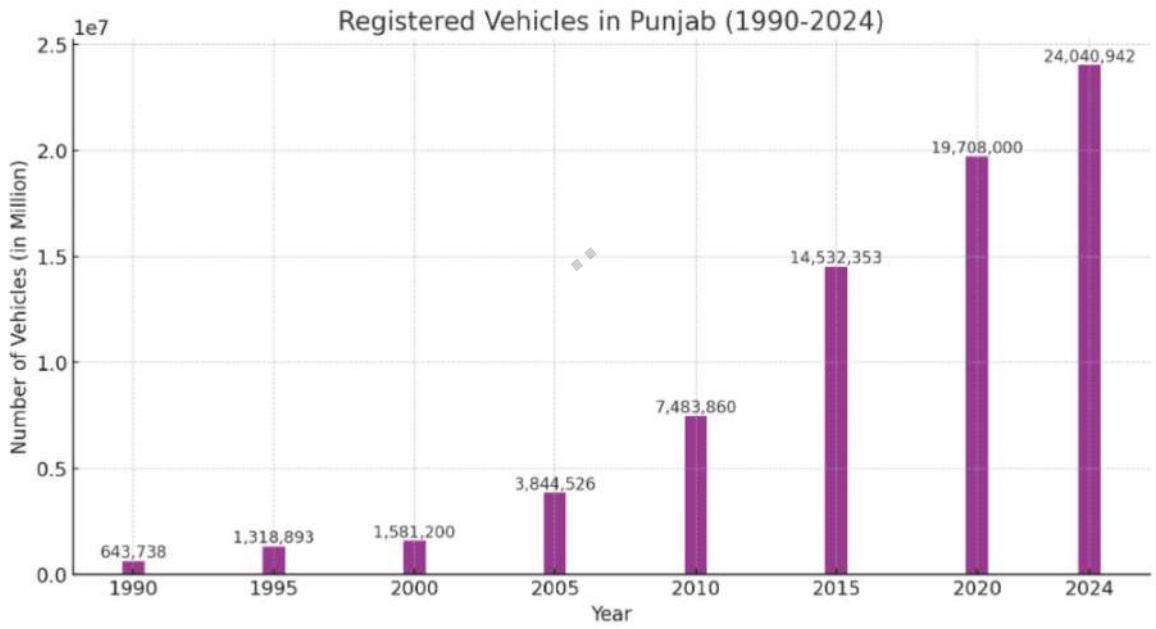

Figure 9: Registered Vehicles in Punjab (1990 – 2024)

Emissions inventory of Lahore for 2021, clearly shows that the transport sector is the most significant emitter, contributing 127 Gg, mainly due to carbon monoxide (CO) emissions[19] (Figure 10). The industry sector follows with 13.87 Gg, while agriculture (crop residue burning) and waste burning contribute 5.97 Gg and 5.57 Gg, respectively. Other vehicle categories, including tractors, pick-ups/delivery vans, trucks, mini buses/buses/luxury coaches, and taxis, collectively contribute a smaller share of emissions, reflecting their relatively lower presence or use compared to two-wheelers and private cars.

[19]https://urbanunit.gov.pk/Download/publications/Files/8/2023/Emission%20Inventory%20of%20Lahore%202023.pdf

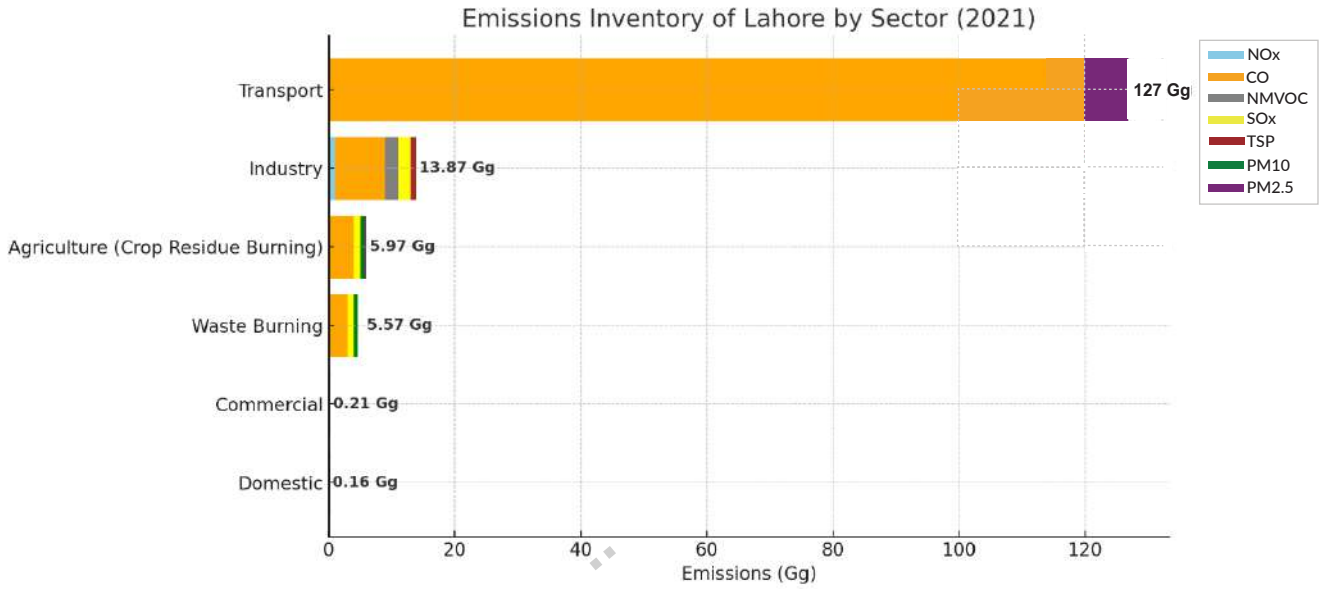

Figure 10: Local Pollutant Emission Inventory of Lahore 2021

2.1.1. Transport Scenario Lahore:

2.1.1.1. Challenges in Road Infrastructure and Congestion Management:

Lahore's urban transport infrastructure is under considerable strain due to its high population density of 10,600 people per square kilometer and a critically low road per capita availability of 0.6 meters, which falls below both national and regional benchmarks[20]. This inadequate road infrastructure exacerbates traffic congestion, limits mobility, and contributes to rising CO_2 emissions from private vehicles. The Urban Transport Master Plan[21] projects a strained road network by 2030, operating at a volume-to-capacity ratio of 0.71. This underscores the urgent need for comprehensive road network enhancements, including both capacity expansion and traffic demand management measures to mitigate congestion and improve flow efficiency.

2.1.1.2. Expanding Public Transport Accessibility:

The limited accessibility of Lahore's public transport system, currently catering to only 31% of the urban population, reflects a critical gap in the city's mobility framework. This heavy reliance on private vehicles significantly escalates emissions and congestion. The city's efforts to develop public transport infrastructure—such as the early-stage deployment of Bus Rapid Transit (BRT) and Light Rail Transit (LRT) systems—are currently serving just 7% of the population. The Urban Transport Master Plan projects a

[20] https://www.pbs.gov.pk/census-2017-district-wise/results/053
[21] https://tepa.punjab.gov.pk/system/files/LUMTP%20Executive%20Summary.pdf

45% rise in public transport demand by 2030, necessitating a strategic expansion of public transport networks and services.

2.1.1.3. Environmental Impacts and Climate Challenges:

Lahore's transport sector poses significant environmental challenges, particularly with high levels of PM2.5 emissions resulting from dense vehicle ownership and reliance on fossil fuels. Current emissions stand at 172.2 grams per capita annually, positioning Lahore among the most polluted cities in Pakistan. Addressing these environmental impacts requires a pivot towards sustainable transport policies that prioritize low-emission technologies and cleaner fuels.

2.1.1.4. Pathways to Sustainable Urban Mobility:

Despite the current challenges, Lahore has significant potential to advance towards a sustainable and resilient urban transport system. The city's high population density inherently supports walkability and transit-oriented development, offering a strategic advantage for promoting sustainable urban mobility. Future strategies should focus on enhancing the public transport network, encouraging active transportation (walking and cycling), and embedding sustainability principles into urban planning processes.

2.2. Overview of the Transport Sector Emissions – Karachi, Sindh:

Karachi, Pakistan's largest city and principal seaport, serves as the country's economic and financial hub, with a population of approximately 15 million within the city limits and around 23 million in the metropolitan area, as of the 2017 census. This rapidly growing megacity is one of the most densely populated urban centers globally and frequently ranks among the world's least livable cities, primarily due to severe traffic congestion and the resulting air and noise pollution[22]. Despite relatively low car and motorcycle ownership, these figures are rapidly rising, driven by an expanding middle class and inadequate public transportation infrastructure. This rapid motorization, compounded by weak traffic management and inefficient public transport, exacerbates congestion and pollution levels. Notably, Karachi is among the largest cities worldwide lacking a formal public transport and mass transit system, with historical investments heavily skewed towards road infrastructure, such as flyovers, favoring private vehicles over public transit solutions. This lack of focus on developing sustainable public transportation has significant implications for urban mobility, air quality, and overall urban livability, necessitating urgent strategic interventions to rebalance transport investments towards more sustainable, mass transit options.

Karachi faces significant challenges in managing its greenhouse gas (GHG) emissions due to its dense population, economic activities, and urban footprint. Each resident is responsible for emitting 2.1 tCO_2e per year, reflecting a high per capita contribution driven by energy consumption and transport sector inefficiencies. The city's emissions per unit of GDP are 247 tCO_2e per US$ million, indicating a high carbon intensity of economic activities, largely due to reliance on fossil fuels and limited adoption of clean technologies. Furthermore, Karachi's emission density is 12,342 tCO_2e per square kilometer, highlighting the environmental pressures associated with urban sprawl and concentrated industrial activity[23]. To mitigate these challenges, Karachi must prioritize integrated urban planning, enhance sustainable transport options, and adopt energy-efficient practices to ensure that economic growth is aligned with environmental sustainability goals.

Figure 11 illustrates the distribution of greenhouse gas (GHG) emissions in Karachi. The total GHG emissions for Karachi amount to 43.5 million metric tons of CO_2 equivalent ($MMt\text{-}CO_2e$) in 2023[24]. The majority of GHG emissions come from stationary energy sources, contributing 67.5% (29.4 $MMt\text{-}CO_2e$) to the total emissions. This includes

[22] The Economist Intelligence Unit. 2018. Global Liveability Report 2018. London. Karachi ranks 137th out of 140 cities.
[23] https://urbanunit.gov.pk/Download/Project%20files/8/KCAP_Deliverables%20B%20&%20C%20GHG%20inventory%20Pathway%20Projects.pdf
[24] https://urbanunit.gov.pk/Download/Project%20files/8/KCAP_Deliverables%20B%20&%20C%20GHG%20inventory%20Pathway%20Projects.pdf

emissions from residential, commercial, and industrial energy use, highlighting the substantial impact of stationary energy consumption on Karachi's overall carbon footprint.

The transport sector is the second-largest contributor, responsible for 13.8% (6.01 MMt-CO_2e) of the total GHG emissions. This significant share underscores the role of vehicular emissions in Karachi's urban environment. The transport emissions are primarily driven by the use of fossil fuels in road transport, with limited use of public and non-motorized transport options. Karachi's reliance on private vehicles, coupled with inadequate public transportation infrastructure, has led to increased fuel consumption and higher emissions.

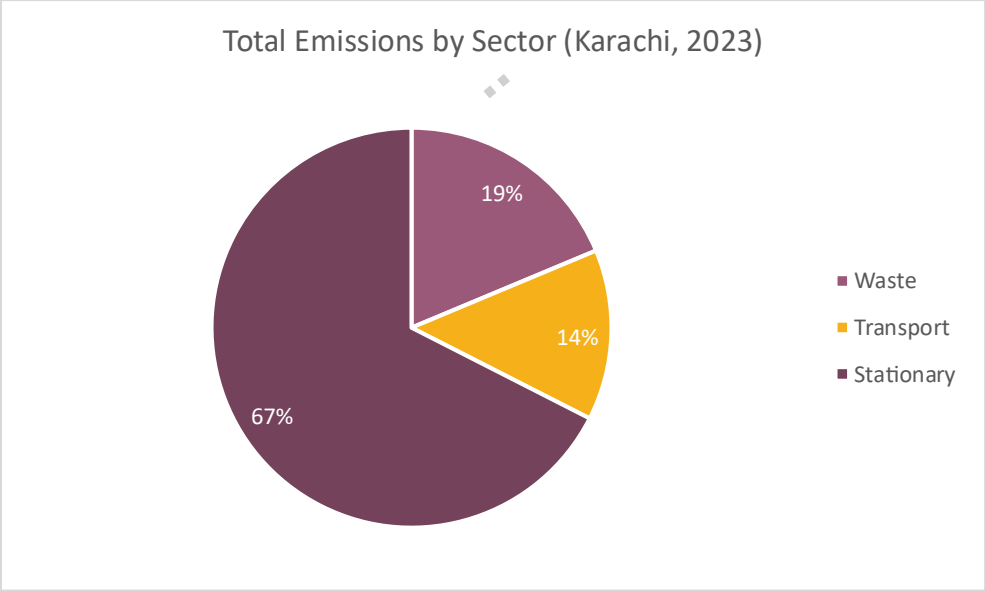

Figure 11: Total Emissions by Sector

The transport sector in Karachi is overwhelmingly dominated by on-road transportation, which accounts for 99.77% of the sector's total emissions, equating to 5.99 MMT-CO_2e. In contrast, railways contribute a mere 0.33% to the transport emissions, underscoring the minimal role of rail in urban mobility. This heavy reliance on road-based transport indicates a critical need for policy shifts towards diversifying transport modes and enhancing low-emission alternatives to achieve sustainable urban mobility. Table 2 shows that petrol is the largest contributor to emissions, accounting for 58% (3.5 MMt-CO_2e), followed by diesel oil at 35% (2.08 MMt-CO_2e). Diesel oil (informal) contributes 5% (0.32 MMt-CO_2e), while HOBC accounts for 2% (0.1 MMt-CO_2e). This distribution highlights the significant impact of traditional fuels on emissions, underscoring the need for strategies to promote cleaner alternatives and reduce reliance on high-emission fuels in Karachi's transportation network.

Table 2: Fuel Specific Emissions in Karachi's Transport Sector

Fuel Type	Emissions (MMt-CO_2 e)	Percentage of Total Emissions (%)
Petrol	3.5	58
Diesel Oil	2.08	35
HOBC	0.1	2
Diesel Oil (Informal)	0.32	5

Figure 12 compares per capita GHG emissions (in tCO_2 e) across various cities in the Asian region. Karachi is highlighted with an orange bar, showing a per capita emission of 2.1 tCO_2 e, which is lower than cities like Bangkok (7.55) and Kuala Lumpur (6.99) but higher than Mumbai (1.96) and Amman (1.79)[25]. This position indicates that while Karachi's per capita emissions are moderate in the regional context, there is still significant potential for reducing emissions through targeted environmental and urban policies.

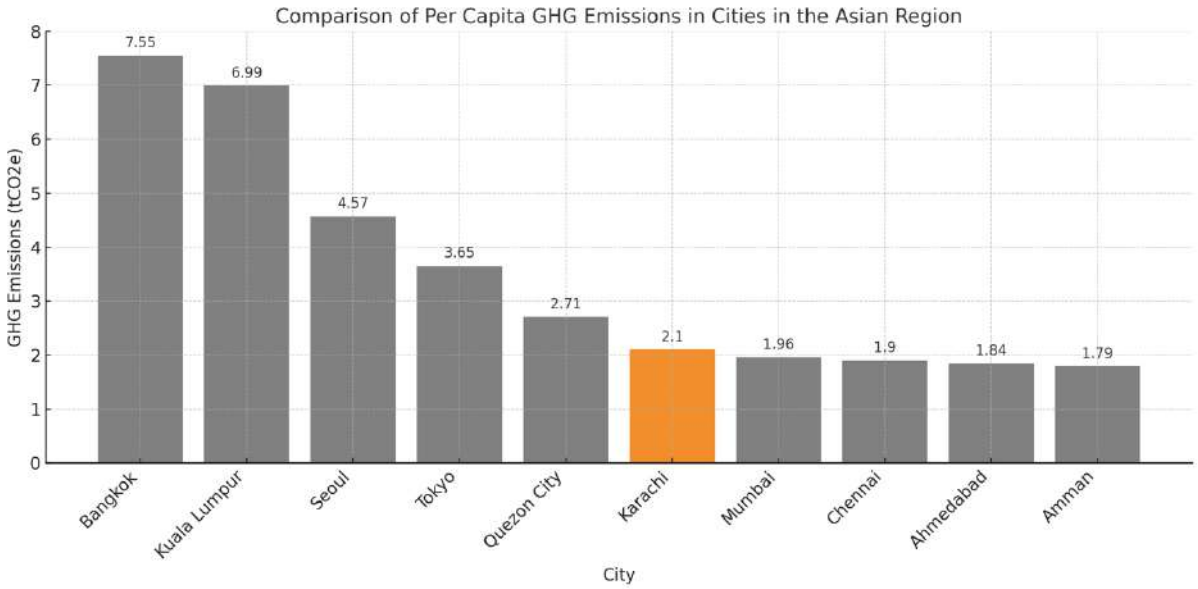

Figure 12: Per Capita GHG Emissions in the Asian Region

2.2.1. Transport Scenario Karachi:

2.2.1.1. Urban Density and Public Transport Utilization:

Karachi's urban density, at 17,400 people per square kilometer, offers a strategic advantage for optimizing public transport systems. The city's compact urban form minimizes travel distances, reducing the infrastructure required per capita. Currently, 68% of the population has access to public bus services within a 500-meter radius, a figure that surpasses other major cities in Pakistan. There is a strategic opportunity to further

[25]https://urbanunit.gov.pk/Download/Project%20files/8/KCAP_Deliverables%20B%20&%20C%20GHG%20inventory%20Pathway%20Projects.pdf

capitalize on this density by enhancing public transport services, reducing the dependency on private vehicles, and promoting sustainable urban mobility. Expanding bus coverage and improving service frequency could lead to a modal shift from private to public transport.

2.2.1.2. Public Transport Infrastructure Development Potential:

The ongoing projects, such as the Karachi Circular Railway (KCR) and BRT systems, represent significant opportunities to strengthen Karachi's public transport infrastructure. The KCR project, with its 43.13 km network, is designed to provide efficient mass transit options, potentially accommodating around 550,000 passengers daily. These projects are strategically aimed at alleviating road congestion and reducing CO_2 emissions through enhanced transit efficiency. The development of these systems is crucial for creating a resilient urban transport network capable of supporting Karachi's growing population while addressing sustainability concerns.

2.2.1.3. Road Infrastructure Deficiencies and Congestion:

Karachi's road infrastructure is critically underdeveloped, with only 0.7 meters of road per capita, well below the national average of 1.15 meters. This deficiency contributes to chronic congestion, particularly during peak hours, leading to significant delays, increased travel times, and heightened emissions. The heavy reliance on private motorized trips exacerbates traffic congestion, further straining the limited road infrastructure and contributing to high levels of CO_2 emissions and air pollution. Strategic interventions are necessary, including the expansion and modernization of road networks, implementing intelligent traffic management systems, and promoting non-motorized transport options to alleviate congestion.

2.3. Comparison of Urban Transport Indicators – Karachi & Lahore:

2.3.1. Access to Public Transport:

The indicator, Percentage Access to Public Transport[26], is calculated as the proportion of the population residing within a walking distance of 500 meters to a low-capacity public transport system, such as buses or trams, and 1,000 meters to a high-capacity public transport system, such as trains or ferries. This analysis includes only mapped

[26] UN-Habitat and European Commission, Global Human Settlement (GHS) Initiative. (2024). *Percentage Access to Public Transport: Global Urban Indicators Database*. United Nations Human Settlements Programme and European Commission. Available at UN-Habitat Data Portal.

public transport stops, encompassing both formal and informal stops[27]. The city of Lahore faces a significant challenge in terms of public transport accessibility, with only 31% of the urban population having adequate access to public transportation (Figure 13). In contrast, Karachi demonstrates a more favorable situation, with 68% of its urban population having access to public transport. This disparity highlights the urgent need for improvement in Lahore's public transport infrastructure and services.

The passenger modal split, as reported by Oke et al. (2019)[28], reflects that in 2017, 24% of trips were made by car, while public transport accounted for 16% of the trips for Lahore. The remainder was covered by other modes of transportation. Furthermore, as of 2024, data from the Institute for Transportation and Development Policy (ITDP) shows that only 7% of Lahore's urban population has access to rapid transit systems, such as BRT, LRT, or Metro rail. This indicates that the development of rapid transit infrastructure in Lahore is still in its early stages, reflecting a significant gap in the city's ability to provide efficient and high-capacity public transport options.

The Lahore Urban Transport Master Plan (2012)[29] projects a 45% increase in public transport travel demand by 2030, compared to the 2010 baseline of 3.4 million trips per day. This translates to an additional 1.6 million person trips needing to be accommodated to maintain the public transport mode share. To meet this growing demand, there is a pressing need to expand and improve the public transport network, enhance service quality, and integrate different modes of transport to ensure a more sustainable and accessible urban mobility system for Lahore's residents.

[27] Notes: This indicator is computed as share of population living within a walking distance of 500m to a low capacity public transport system (eg bus, tram) and 1000m to a high capacity public transport system (eg trains, ferries, etc). Only public transport stops which are mapped are included in the analysis which may include both formal and informal stops.

[28] Oke, J.B., Aboutaleb, Y.M., Akkinepally, A., Azevedo, C.L., Han, Y., Zegras, P.C., Ferreira, J. and Ben-Akiva, M.E., 2019. A novel global urban typology framework for sustainable mobility futures. *Environmental Research Letters*, *14*(9), p.095006.

[29] https://tepa.punjab.gov.pk/system/files/LUMTP%20Executive%20Summary.pdf

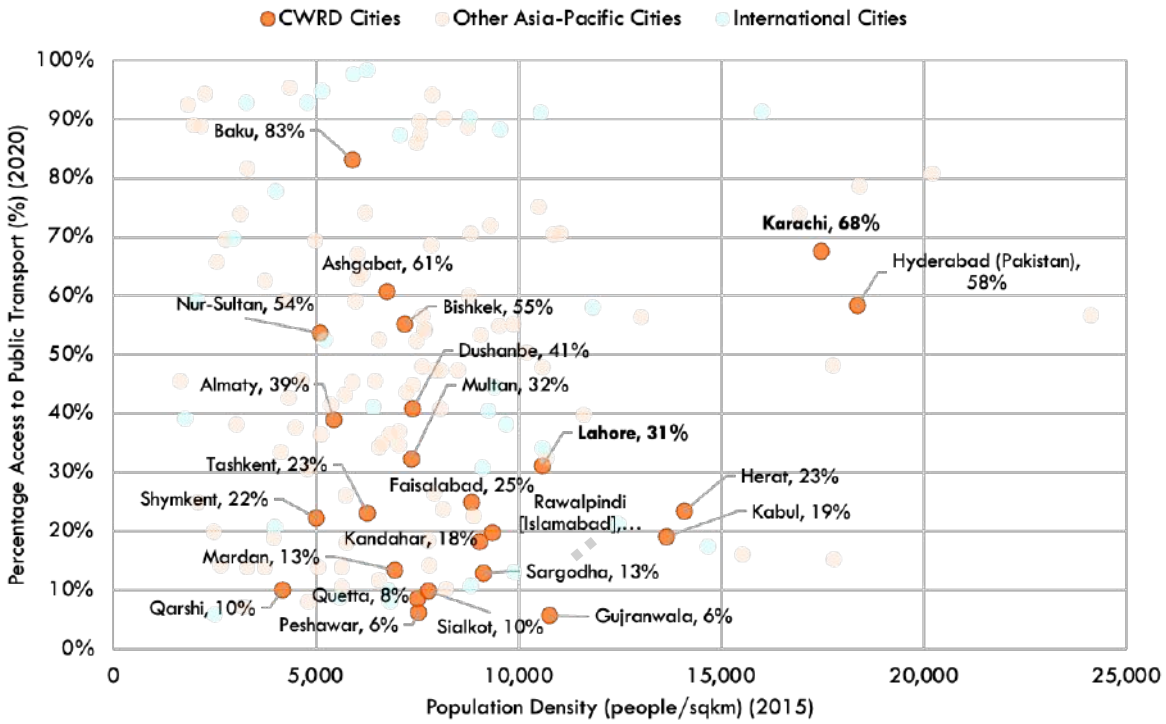

Figure 13: Percentage Access to Public Transport

2.3.2. Light Duty Vehicles Motorization:

In 2015, the LDV (light-duty vehicle) motorization rate in the Lahore district was recorded at 160 vehicles per 1,000 inhabitants (data source: Additional Director General, Excise & Taxation, Punjab, Lahore, Pakistan). According to projections outlined in the Lahore Urban Transport Master Plan (2012), car ownership is expected to increase to 45% of households by 2030, up from 18% in 2012 (Figure 14). This indicates a substantial upward trend in private vehicle ownership, which is anticipated to continue over the coming years.

It is noteworthy that the current LDV motorization rate in Lahore is significantly higher than Karachi, which stands at 76 vehicles per 1,000 inhabitants, as well as the average for the Central and West Asia region, which is 34 vehicles per 1,000 inhabitants as of 2022. This higher motorization rate in Lahore underscores the city's rapid urbanization and increasing reliance on private vehicle use, necessitating a strategic focus on sustainable urban mobility solutions and infrastructure planning to accommodate future growth.

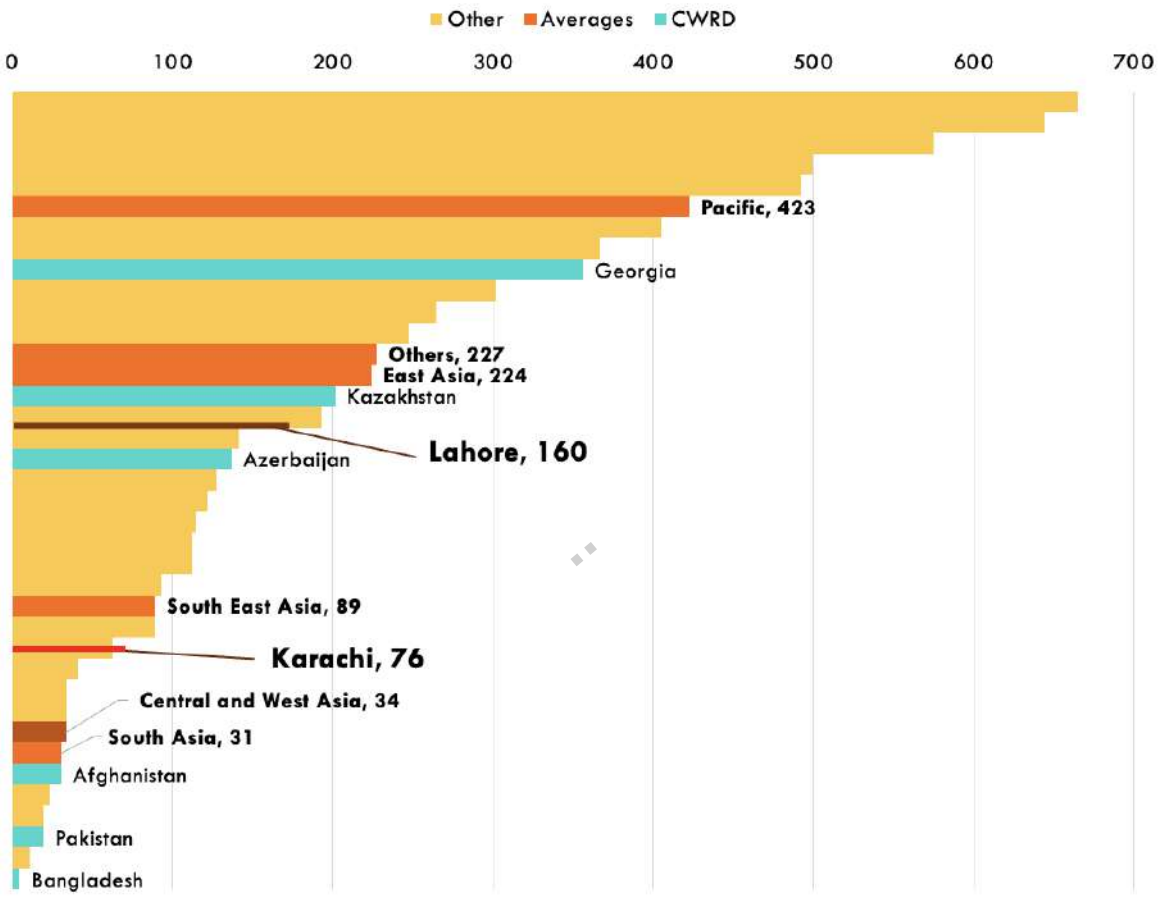

Figure 14: Light-duty Vehicle Motorization Rate/1,000 Persons

The rapid urbanization, commercial growth, and inadequate enforcement of motor vehicle regulations have significantly contributed to the surge in vehicular traffic on the roads of Lahore. The influx of various forms of local transport, including chingchis and wagons, particularly during peak hours, exacerbates congestion in the city's central areas. Even with the introduction of cost-effective and rapid public transportation options via overhead routes, traffic congestion remains a persistent challenge.

2.3.3. Transport PM2.5 Emissions

Lahore ranks among the highest Pakistani cities for transport-related PM2.5 emissions[30] per capita, placing it within the top five cities surveyed (Figure 15). With a per capita emission level of 122 grams per year, Lahore's transport sector significantly contributes to the urban air pollution burden, underscoring the need for targeted interventions to improve air quality and promote sustainable transport solutions. Lahore and Karachi, both with high population densities, demonstrate different transport dynamics influencing their PM2.5 emissions. Lahore, with a population density of about 12,000

[30] **European Commission, Joint Research Centre (JRC), Global Human Settlement (GHS) Dataset.** Available from: https://ghsl.jrc.ec.europa.eu/

people per square kilometer, has higher transport-related PM2.5 emissions per capita (122 g/year) compared to Karachi, which has a higher density of approximately 18,000 people per square kilometer but lower emissions (80 g/year). This difference can be attributed to Lahore's higher reliance on private vehicles, which leads to greater emissions per capita despite its lower overall density. Peshawar, with a density of around 10,000 people per square kilometer and emissions of 110 g/year, reflects a mix of both challenges seen in Lahore and Karachi. It requires strategic efforts to control emissions while managing population growth, such as upgrading to cleaner vehicle technologies and enhancing public transportation.

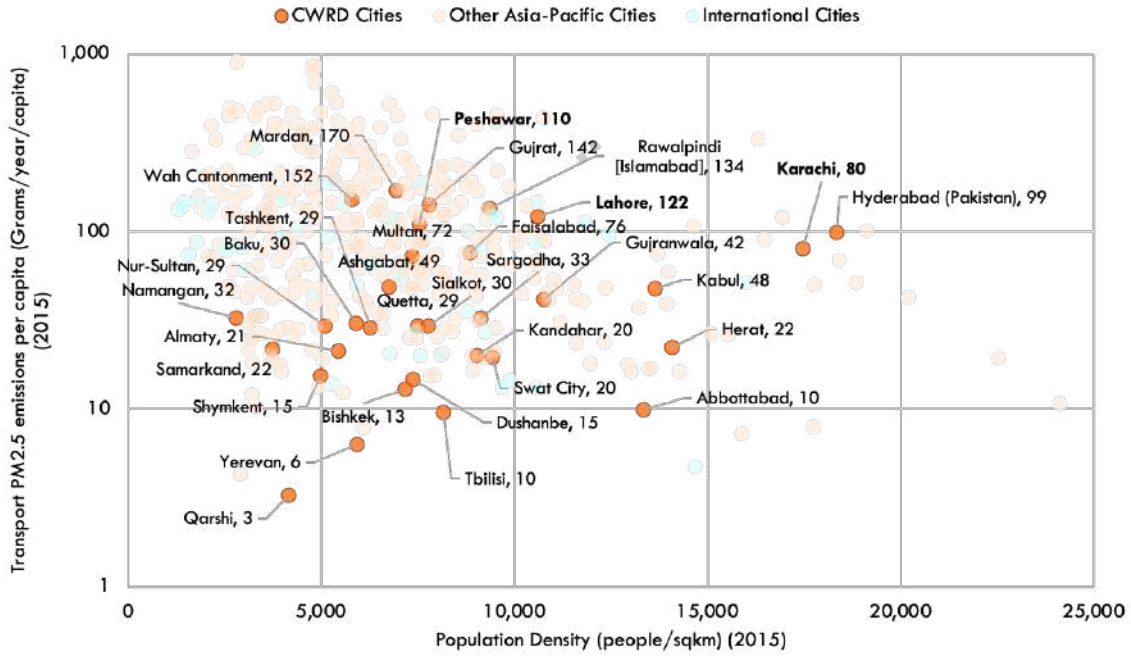

Figure 15: Transport PM2.5 Emissions per Capita (2015)

Lahore and Karachi exhibit distinct strategic challenges in managing road transport-related PM2.5 emissions, as seen in the data. Lahore's road traffic contributes 10% to its overall PM2.5 emissions, which is higher than Karachi's 7% (Figure 16). This suggests that Lahore is more dependent on road transport, likely due to a higher prevalence of private vehicle use and possibly less effective public transport options. To address this, Lahore should focus on reducing its reliance on private vehicles by investing in public transport infrastructure, encouraging the use of cleaner vehicles, and implementing stricter emission standards.

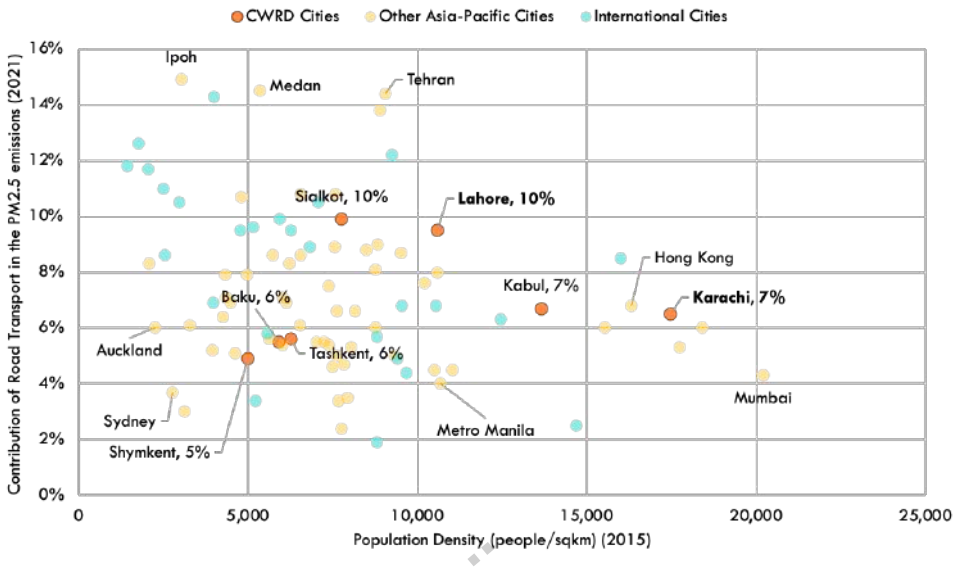

Figure 16: Contribution of Road Transport in the PM2.5 Emissions (2021)

Lahore and Karachi, as Pakistan's two primary urban centers, represent critical nodes for targeted interventions in reducing CO_2 emissions from the transport sector. Both cities are characterized by rapid urbanization, high population density, and substantial economic activity, which drive significant transportation demand and, consequently, elevated CO_2 emissions. However, distinct urban transport dynamics shape the emissions profiles of these cities differently. Lahore exhibits a higher modal share of private vehicles, including cars and motorcycles, which results in elevated vehicle kilometers traveled (VKT) and contributes to high per capita emissions. In contrast, Karachi's transport emissions are heavily influenced by an aging vehicle fleet, particularly a substantial number of diesel-powered commercial vehicles and public transport buses, which are less fuel-efficient and lack modern emission control technologies. Addressing these diverse challenges in Lahore and Karachi is essential to curbing Pakistan's overall transport sector emissions, making them strategic priorities for policy and technical interventions.

3. BAU Scenario until 2040 in the Absence of New Interventions

Figure 17 shows the historical emissions trajectory for Pakistan from 1990 to 2021, with a specific focus on two key metrics: "Total Including LUCF" (Land Use Change and Forestry) and "Transportation" emissions[31,32]. The data highlights both the magnitude and the growth trends of greenhouse gas emissions in these categories over the three-decade period. The "Total Including LUCF" series, marked by the orange line, demonstrates a pronounced and steady increase in emissions, beginning at approximately 168.24 $MtCO_2e$ in 1990 and reaching 488.02 $MtCO_2e$ by 2021. This reflects a compounded growth rate driven by multiple factors including increased fossil fuel consumption, urbanization, industrial activities, and land use changes. Notably, the rate of increase accelerates post-2000, indicating a potential shift towards more carbon-intensive development pathways. This escalation is particularly steep from 2010 onwards, where emissions grow from around 285.59 $MtCO_2e$ to 488.02 $MtCO_2e$ in 2021. The sharp upward trend suggests significant reliance on carbon-heavy sectors such as energy and industry, underscoring the urgent need for structural reforms and green transitions.

In contrast, the red line representing "Transportation" emissions also shows an upward trend, but at a more gradual pace compared to the total emissions. Starting at 14.15 $MtCO_2e$ in 1990, transportation emissions increase to 57.54 $MtCO_2e$ by 2021.

Kaya Identity Analysis Results (1990–2021): The fourfold increase in transportation emissions (14.15 $MtCO_2e$ to 57.54 $MtCO_2e$) can be decomposed as follows:

- Population Growth: 40.4% contribution
    - Population growth has played a substantial role in driving transportation emissions due to increased mobility demand.
- GDP per Capita Growth: 56.1% contribution
    - Rising income levels and increased economic activity have driven higher ownership and usage of private vehicles.
- Energy Intensity (Energy per GDP Unit): 20.2% contribution
    - Despite minor improvements in energy efficiency, the overall energy demand per GDP unit remains significant in the transport sector.
- Carbon Intensity (CO_2 per Energy Unit): 24.7% contribution
    - Limited progress in shifting to low-carbon fuels and technologies has sustained high carbon emissions per unit of energy consumed.

[31] https://www.gcisc.org.pk/GHGINVENTORY2011-2012_FINAL_GCISCRR19.pdf
[32] https://www.globalcarbonproject.org/

This consistent rise points to an expanding vehicle fleet, increased mobility demands, and a lack of substantial shifts towards low-emission transport modes. Although the growth rate of transportation emissions is less steep than the total emissions, the four-fold increase over the period underscores a persistent dependence on fossil fuel-powered vehicles, reflecting limited progress in transitioning to alternative fuels or enhancing public transport systems. The data underscores the sector's limited progress in adopting low-carbon technologies such as electric vehicles (EVs), alternative fuels, or enhancements in public transport systems, which are essential for curbing future emissions. The steady rise in emissions also indicates a lack of comprehensive policy interventions targeting vehicle emissions standards, fuel quality improvements, or infrastructure for sustainable transportation modes. As such, the transport sector remains a critical area for policy reform and investment to achieve meaningful reductions in Pakistan's overall emissions profile.

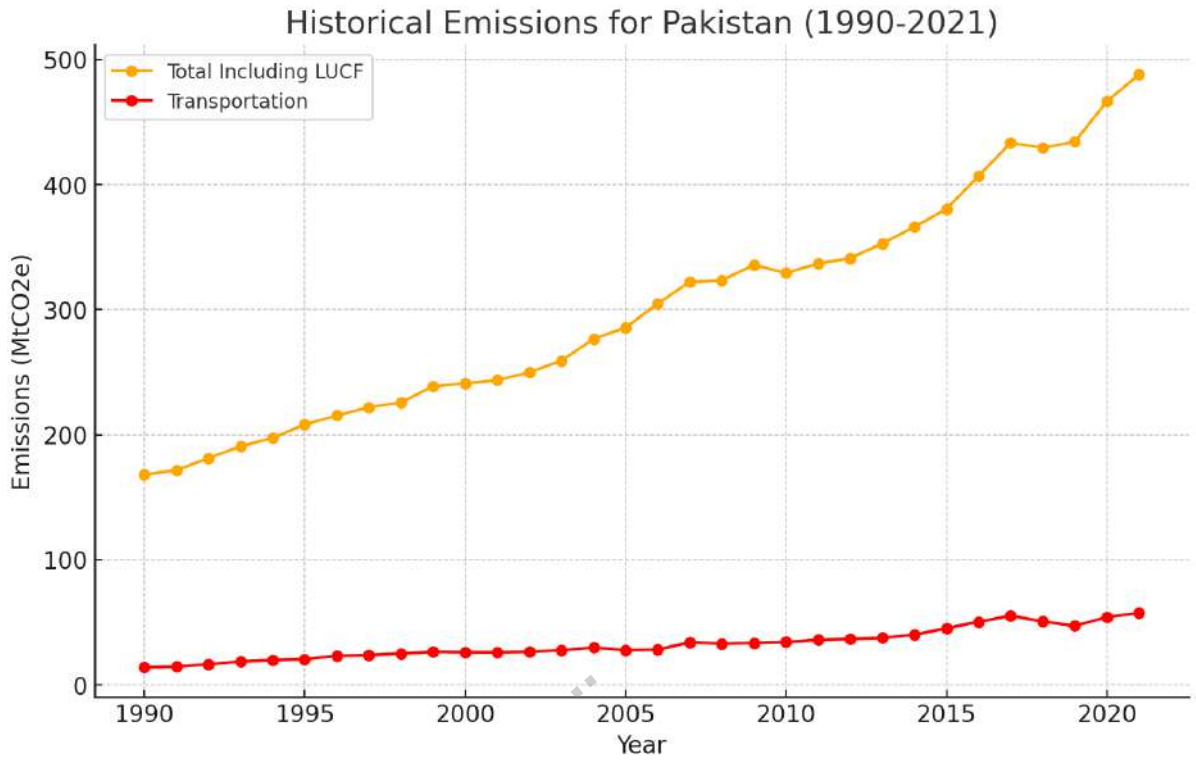

Figure 17: Historical GHG Emissions for Pakistan (1990 – 2021)

To calculate the BAU scenario for Pakistan's emissions up to 2040, a linear regression model was applied based on historical emission data from 1990 to 2021. The linear regression model used to project transportation emissions in Pakistan relies on a set of key explanatory variables derived from historical trends observed between 1990 and 2021. These variables include population growth, which serves as a fundamental driver of mobility demand, directly influencing transportation activity and emissions. Additionally, GDP per capita acts as a proxy for economic growth and income elasticity, reflecting the correlation between rising disposable incomes and increased vehicle

ownership rates. The model incorporates energy intensity (energy consumed per unit of GDP) to account for the efficiency of the transport sector in utilizing energy resources, highlighting whether the sector is becoming more or less energy-intensive over time. Similarly, carbon intensity (CO_2 emissions per unit of energy consumed) captures the emissions profile of the energy sources used in transportation, reflecting reliance on fossil fuels versus cleaner alternatives. Beyond these macroeconomic and sectoral indicators, the model considers vehicle fleet growth, capturing trends in the expansion of both light-duty and heavy-duty vehicles, which have distinct emissions profiles. The modal share variable differentiates between emissions arising from private vehicles, public transport systems, and freight logistics, reflecting variations in their respective contributions to the overall emissions profile. Additionally, fuel mix composition is integrated into the model to represent the proportion of traditional fossil fuels (e.g., diesel and petrol) versus cleaner alternatives (e.g., electricity and biofuels).

The BAU scenario assumes that current trends continue without additional interventions or policy changes. Using Python's library[33], two separate linear regression models were constructed: one for total emissions including Land Use Change and Forestry (LUCF) and another for transportation emissions. These models utilized historical data to estimate the intercept and slope, effectively capturing the trends in emissions over time. The fitted models were then used to forecast future emissions from 2022 to 2040 by extrapolating the linear trend observed in the historical data. This approach provides an estimate of future emissions levels under the assumption of unchanged conditions and growth patterns, serving as a baseline scenario for understanding potential future outcomes and the need for mitigation strategies.

3.1. BAU Scenario and Underlying Drivers of Land Transport Emissions in Pakistan

The BAU scenario for Pakistan's land transport emissions forecasts a continued increase in GHG emissions due to the lack of significant policy intervention or technological advancement. This scenario is driven by several technical and structural factors that characterize the current transport ecosystem in Pakistan:

3.1.1. Predominance of Road Transport and Vehicle Mix:

Road transport dominates Pakistan's transport emissions, accounting for 88% of the total emissions in the sector[34]. Within this, light-duty trucks are the largest contributors, responsible for 41% of road transport emissions. Heavy-duty trucks and buses add another 8%, while cars contribute 30%, and motorcycles account for 9%. The heavy reliance on road transport, particularly for freight and passenger movement, combined

[33] https://scikit-learn.org/
[34] https://unfccc.int/documents/470405

with an aging fleet that often lacks modern emission control technologies, is a significant driver of emissions. The data reflects the extensive use of older, diesel-powered vehicles and inefficient two-stroke engines in motorcycles, both of which have high emissions factors for carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter (PM).

3.1.2. Urbanization and Increased Vehicle Ownership:

Pakistan's urbanization rate is approximately 3% per annum, one of the highest in South Asia[35], with the urban population expected to nearly double by 2050. This rapid urban expansion has significantly increased the demand for both private and public transportation. However, insufficient development of integrated, efficient public transport systems has led to a sharp increase in private vehicle ownership. The significant share of emissions from cars (30%) and motorcycles (9%) highlights the impact of this trend, particularly in urban areas where traffic congestion and inefficient driving conditions prevail, leading to increased vehicle kilometers traveled (VKT) and higher emissions per capita.

3.1.3. Fuel Quality and Energy Dependence:

The transport sector's heavy reliance on petroleum-based fuels, such as diesel and gasoline, accounts for over 90% of total transport energy consumption. Poor fuel quality, particularly high sulfur content in diesel fuel (often exceeding 500 ppm in some regions, far above the 50 ppm limit set by Euro IV standards), contributes significantly to emissions. High sulfur levels not only increase sulfur dioxide (SO2) emissions but also impair the function of catalytic converters, resulting in higher emissions of NOx and PM. The slow adoption of cleaner fuels and the lack of electrification in the transport sector continue to hinder the transition to a low-carbon pathway.

3.1.4. Transport Infrastructure Deficiencies and Traffic Congestion:

Inadequate transport infrastructure and a lack of advanced traffic management systems have resulted in significant inefficiencies within urban traffic flows. The road network, while extensive, is not optimized for efficient travel, particularly in high-density urban areas like Karachi, Lahore, and Islamabad. Chronic underinvestment in road maintenance and the absence of intelligent transport systems (ITS) lead to frequent traffic congestion and extended vehicle idling times. This congestion exacerbates fuel consumption due to low-speed driving and idling, contributing to higher emissions of CO_2, NOx, and black carbon per kilometer traveled.

[35] https://www.undp.org/pakistan/urbanisation-pakistan#:~:text=Pakistan%20has%20the%20highest%20rate,will%20be%20living%20in%20cities.

3.1.5. Economic Growth and Freight Transport Demand:

Economic expansion in key sectors such as textiles, agriculture, and manufacturing has driven a substantial increase in freight transport demand. The reliance on road-based freight transport, which accounts for over 90% of domestic freight movement, is a major contributor to emissions. Light-duty trucks, which represent 41% of road transport emissions, are extensively used for both urban and intercity freight. Heavy-duty trucks and buses, contributing an additional 8%, further underscore the emissions challenge posed by the aging fleet and lack of efficient logistics. The absence of intermodal freight systems, such as rail or inland waterways, limits opportunities for more energy-efficient freight movement and exacerbates the carbon intensity of Pakistan's transport sector.

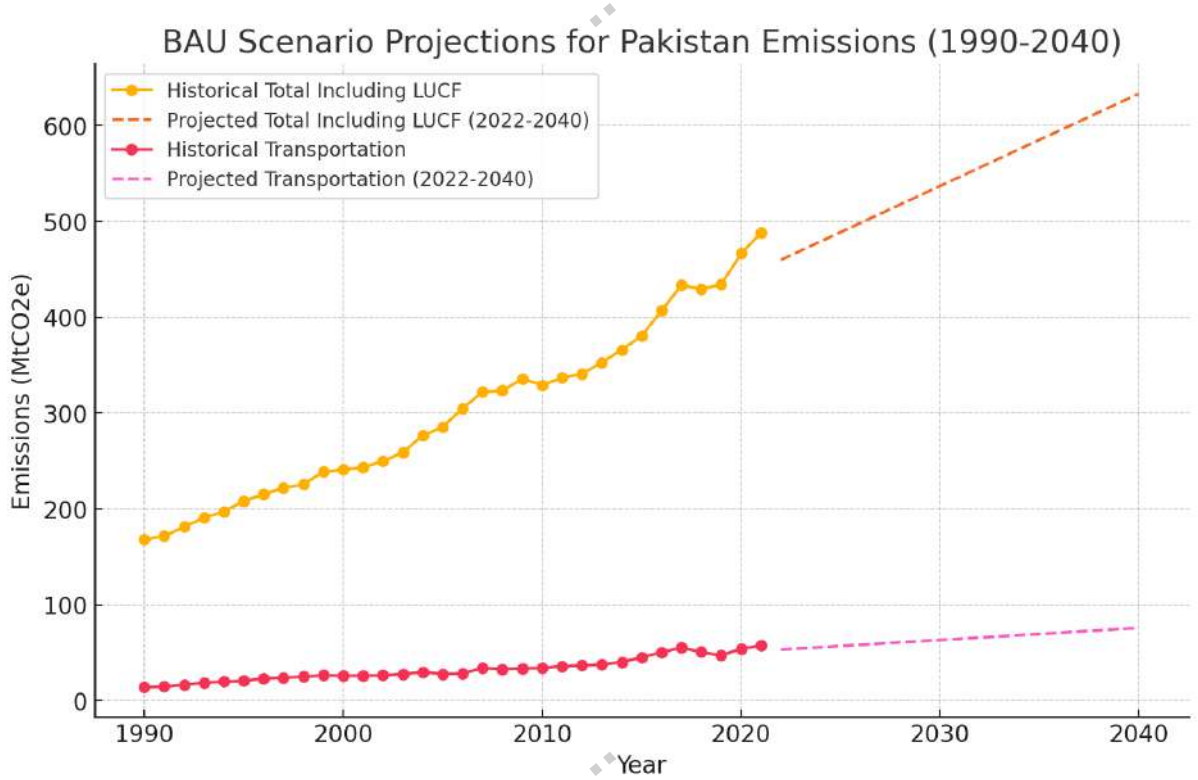

Figure 18: BAU Scenario for Pakistan GHG Emissions (2040)

The BAU scenario for Pakistan's transport sector indicates a persistent increase in emissions, driven by a heavy reliance on road transport, rapid urbanization, an aging and inefficient vehicle fleet, poor fuel quality, and inadequate infrastructure. The BAU scenario integrates key drivers based on robust macroeconomic and sector-specific assumptions. In Pakistan's transport sector, emissions are primarily shaped by demographic trends, including population growth and urbanization, which continue to drive increasing demand for both passenger and freight transport. Economic growth projections also play a significant role, as rising GDP correlates with greater demand for logistics and mobility services. The sector remains heavily reliant on road transport, with

limited modal shifts towards more sustainable alternatives such as rail or public transit systems. Additionally, the aging vehicle fleet, poor fuel efficiency, and the slow adoption of cleaner technologies contribute significantly to rising emissions. Infrastructure development remains constrained by limited investments in sustainable transport systems, further amplifying the sector's carbon footprint. Finally, the policy and regulatory environment, while evolving, has yet to create sufficient incentives for transitioning to low-carbon transport technologies or fostering behavioral change among transport users. These drivers are modeled using sector-specific elasticity assumptions derived from historical data, combined with projections informed by national development plans and sectoral studies. The resulting transport emissions trajectory reflects both historical inertia and anticipated future trends under a 'no-policy-change' scenario.

Figure 18 shows the BAU scenario projections for Pakistan's emissions from 1990 to 2040. It includes both the historical and projected data for total emissions including LUCF and transportation emissions. The solid lines represent historical data from 1990 to 2021, while the dashed lines indicate projected emissions from 2022 to 2040. This visualization illustrates the continuation of current emission trends under the BAU scenario, highlighting the potential future increases in emissions if no additional mitigation measures are implemented.

3.2. Land Transport Change Levers

Achieving a zero-carbon pathway in land transport is both feasible and essential for meeting global climate targets, including the 1.5°C goal outlined in the Paris Agreement. The International Council on Clean Transport's Vision 2050 report[36] estimates that approximately 85% of the CO_2 emissions reductions required to meet this target can be achieved through existing and emerging policies and technologies. These include electrification of vehicles, enhancing fuel efficiency, and adopting alternative fuels. The remaining 15% of emissions reductions will depend on changes in travel behavior and demand management strategies, such as reducing travel distances through teleworking, promoting integrated land-use and transport planning, and encouraging shifts to more sustainable modes like walking, cycling, and public transit.

Further supporting this approach, the International Transport Forum's analysis indicates that in urban settings, up to 70% of CO_2 emissions can be cut through technological advancements[37], such as the deployment of electric vehicles and improvements in public transport systems. The remaining 30% will require behavioral changes facilitated by supportive policies, including incentives for car-sharing, dynamic pricing mechanisms, and promoting non-motorized transport options. To achieve a zero-car-

[36] https://theicct.org/wp-content/uploads/2023/11/ID-22-%E2%80%93-1.5-C-strategies-report-A4-65005-v8.pdf
[37] https://www.itf-oecd.org/sites/default/files/transport-outlook-executive-summary-2021-english.pdf

bon future for the transport sector, a multi-faceted strategy is needed—one that effectively integrates technology adoption with policy measures aimed at influencing travel behavior. This integrated approach will not only reduce emissions but also enhance urban mobility, improve air quality, and support broader economic and social objectives. To deviate from BAU trajectory and achieve emissions reduction targets, Pakistan must implement comprehensive policies and strategic investments focused on fleet modernization, improved fuel standards, infrastructure development, and the promotion of alternative, lower-carbon transport modes. These measures are essential for reducing emissions, improving urban air quality, and advancing sustainable transport solutions.

The highlighted points in Figure 19 for 2030 show the target emissions levels after applying Pakistan's 50% reduction commitment compared to the BAU scenario, split into 15% unconditional and 35% conditional reductions. The reductions demonstrate a significant deviation from the BAU trajectory, underscoring the importance of achieving both unconditional and conditional targets to meet climate commitments.

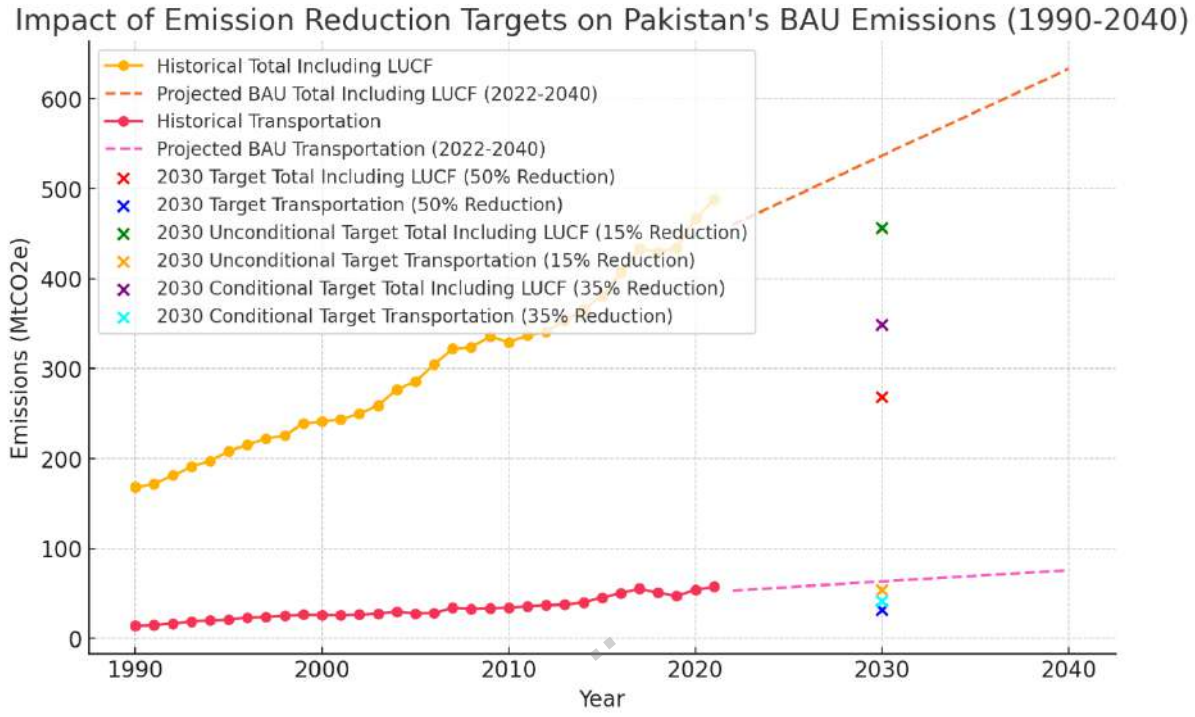

Figure 19: Emission Reduction Targets Scenario for Pakistan GHG Emissions (2030 - 2040)

4. Decarbonization Technologies and their Applications in Pakistan and Abroad

Decarbonization technologies in the transport sector offer a significant opportunity for Pakistan to reduce emissions and align with global sustainability targets. Key strategies include the adoption of electric mobility (e-mobility), such as electric buses and two-wheelers, which can be particularly effective in densely populated urban centers like Karachi and Lahore. Additionally, green hydrogen presents a viable solution for decarbonizing heavy transport and industrial vehicles, especially in logistics and public transport fleets. LRT systems, already being considered in cities such as Lahore, provide a scalable model for reducing reliance on carbon-intensive road traffic. These initiatives are complemented by international examples, such as India's aggressive expansion of electric buses and China's investment in hydrogen fuel technology, which demonstrate the feasibility and impact of these technologies in emerging markets. For Pakistan, integrating these solutions will require strategic policy frameworks, investment in infrastructure, and fostering public-private partnerships to support technology adoption and capacity building.

4.1. International Projects using Mitigation Technology

4.1.1. Transit-Oriented Development (TOD), Colombia

Background: The transport sector represents the most rapidly expanding source of GHG emissions in Colombia. Urban centers are increasingly plagued by traffic congestion, deteriorating air quality, and significant road safety challenges. The Colombian government recognizes the need for a comprehensive and integrated approach to transport planning and development, which necessitates improved alignment between land use, transportation systems, and social housing policies.

Approach to Transformational Change: The initiative "Colombia – TOD[38]" aims to catalyze a paradigm shift in urban development across Colombia by showcasing the effectiveness of transit-oriented development strategies. The project is projected to mitigate the increase in automobile traffic by 25 to 36 percent, while concurrently enhancing air quality metrics. To achieve this, both public and private sector investments—facilitated through Public-Private Partnerships (PPPs)—will be directed towards a diverse array of demonstration projects. These projects will span various geographical locations and types of interventions. The initiative is designed to foster the development of well-planned, pedestrian-friendly, and transit-oriented communities, thereby lowering household transportation expenditures, improving access to employment and essential services, and enhancing social inclusion in targeted areas.

[38] https://unfccc.int/files/focus/mitigation/application/pdf/ccap-colombia-tod-nama-for-cali.pdf

A critical component of the project's financial architecture involves empowering Findeter, a key national development bank, to extend loans with enhanced funding volumes and favorable terms to local entities. These loans are intended to finance transit-oriented development initiatives. The project anticipates mobilizing over EUR 60 million through these financial instruments.

Mitigation Potential: It is projected that the initiative could achieve a reduction in annual GHG emissions of between 3.6 million to 5.5 million tons of CO_2 equivalent (CO_2 e) by the year 2040.

Image Source: Transmilenio BRT in Bogotá, Colombia (MAF)

4.1.2. Green Hydrogen, Costa Rica

Background: Costa Rica is committed to achieving carbon neutrality by 2050. A critical challenge in realizing its decarbonization targets lies in transitioning away from reliance on fossil fuels and their derivatives in pivotal sectors such as industry, transport, and agriculture. Given Costa Rica's substantial potential for renewable energy—evidenced by the country's production of over 98% of its electricity from renewable sources over the past six years—there is a significant opportunity to leverage green hydrogen production to expedite the country's path toward net-zero emissions, particularly in sectors that are difficult to decarbonize.

Approach to Transformational Change: The project titled "Green Hydrogen for a Decarbonised Economy" (referred to as "Costa Rica – Green Hydrogen[39]") seeks to catalyze a transformative shift towards the adoption of hydrogen as an energy carrier and a chemical feedstock. The project is designed to ensure that hydrogen production is sourced exclusively from renewable energy within Costa Rica, aligning with the country's sustainability goals.

[39] https://hypat.de/hypat-wAssets/docs/new/publications/hypat-wp_02-2024-costa-rica-country-report_03.07.2024.pdf

The project's financial cooperation (FC) component is anticipated to incorporate targeted incentive mechanisms for hydrogen production facilities and end-users in the industrial, agricultural, and transportation sectors. This will involve blending commercial financing with concessional funds and grants to support the development of a green hydrogen market. Additionally, the technical cooperation (TC) component will assist the national government in establishing the necessary enabling conditions for the production and consumption of green hydrogen. This includes developing and implementing viable business models for the deployment of hydrogen across various sectors, alongside piloting projects to demonstrate its practical applications. The introduction of green hydrogen, supported by financial instruments and a conducive policy framework, is expected to facilitate its utilization across a range of domestic applications, particularly in industries such as metallurgy, cement, and glass, as well as in agricultural activities like sugar and coffee production. This approach will contribute significantly to the decarbonization of Costa Rica's economy.

Mitigation Potential: The initiative is estimated to directly reduce approximately 30,000 tons of CO_2 equivalent (tCO_2 e) during the implementation phase, with a total reduction of over 128,000 tCO_2 e over the operational lifespan of the supported technologies.

Picture Source: (TicoTimes[40])

4.1.3. Small Vehicles E-Mobility, Kenya

Background: Emissions from the transport sector in Kenya are experiencing rapid growth and are projected to surpass 20 million tons of CO_2 equivalent (tCO_2 e) by 2030[41]. Currently, the transport sector is the second-largest contributor to greenhouse gas (GHG) emissions in Kenya, accounting for approximately 13% of the nation's total

[40] https://ticotimes.net/2018/04/18/central-americas-first-hydrogen-fueled-bus-hits-the-road-in-costa-rica
[41] http://documents1.worldbank.org/curated/en/099110923174539500/pdf/P17979202d856600d09d1a099885ec86d8a.pdf

emissions. The sector has been identified as a key area for intervention in Kenya's enhanced Nationally Determined Contribution (NDC) commitments and the National Climate Change Action Plan. With 72% of the population residing in rural areas and a low vehicle ownership rate of 28 vehicles per 1,000 persons, Kenya presents a significant opportunity to leapfrog traditional motorization pathways through the development of e-mobility solutions.

Approach to Transformational Change: The project "Kenya — Small Vehicles E-Mobility[42]" is designed to expedite the shift towards e-mobility to achieve substantial reductions in transport sector emissions, while also fostering green job creation and industrial growth in the assembly and manufacturing of electric vehicles (e-vehicles). The project aims to accelerate the market uptake of electric two-wheelers (e-2Ws) and electric three-wheelers (e-3Ws) in peri-urban and rural areas, facilitating a market transformation towards sustainable e-mobility.

To stimulate both supply and demand for e-2Ws and e-3Ws, the project will deploy a series of strategic instruments. To address the barrier of high upfront costs, the initiative will allocate EUR 7.5 million in subsidies to support the purchase of approximately 65,000 e-vehicles (60,000 e-2Ws and 5,000 e-3Ws), with a specific focus on peri-urban and rural markets. To further mitigate the challenge of limited access to asset financing, particularly for commercial fleet operators, the project will establish a second-loss partial credit guarantee mechanism valued at EUR 3.5 million. On the supply side, the project seeks to unlock private sector debt financing through a first-loss credit guarantee fund of EUR 5.5 million, designed to cover losses of up to the first 10%, thereby enhancing local manufacturing and assembly capacities for e-vehicles.

Mitigation Potential: The project is expected to deliver GHG emission reductions exceeding 1 million tCO_2 e over a ten-year period post-implementation. Additionally, the initiative will support the development of local assembly capacity for more than 100,000 e-2Ws and e-3Ws, contributing to the creation of approximately 3,500 direct green jobs.

Picture Source: (WEF[43])

[42] https://mitigation-action.org/projects/kenya-small-vehicles-e-mobility/

4.1.4. Sustainable Urban Transport Program (SUTRI NAMA), Indonesia

Background: In Indonesia, the transport sector ranks as the third largest contributor to energy-related GHG emissions[44]. In 2005, the transport sector was responsible for approximately 23% of the nation's total energy-related CO_2 emissions, amounting to 67.68 million tons of CO_2 equivalent (tCO_2e) emissions. Among the various transport subsectors, road transport is the predominant emitter, accounting for around 89% of CO_2 emissions and 91% of energy consumption within the sector. Indonesia's updated NDC[45] encompasses strategies such as the development of urban mobility plans, the establishment of urban mass transit systems, the provision of national government support for integrated intermodal facilities, and the implementation of urban transport services through a "Buy the Service (BTS)" scheme.

Approach to Transformational Change: The project "Implementation of the Sustainable Urban Transport Programme Indonesia (SUTRI NAMA)[46]" aims to facilitate a transformational shift in urban transport practices in Indonesia through a series of capacity-building measures, with a particular focus on five pilot cities. The project will deliver technical assistance to local governments via a dedicated Technical Support Unit (TSU). The initiative seeks to foster a comprehensive change in urban transport policy in Indonesia by establishing framework conditions that are conducive to attracting public and private investment. The technical guidance provided by the TSU will facilitate the development and implementation of a bottom-up urban transport Measurement, Reporting, and Verification (MRV) system, which will support systematic monitoring and data-driven decision-making processes. The project will also strengthen local governance through targeted policy guidance. Under the INDOBUS component, the project will enhance conditions for private investments by improving infrastructure for parking management, ticketing systems, Non-Motorised Transport (NMT) facilities, and advertising.

Mitigation Potential: The project's indirect mitigation impact will be realized through enhanced urban transport services and policies that encourage a modal shift from private vehicles to buses and non-motorized transport modes. The estimation of this indirect CO_2 mitigation potential is based on a bottom-up methodology, utilizing data on transport demand, specific energy consumption, and emission factors. The average indirect mitigation impact is projected to be 24,500 tCO_2e by 2032, with a cumulative reduction of 222,600 tCO_2e from 2022 to 2032.

[43] https://www.weforum.org/agenda/2022/09/kenya-electric-mobility-transformation-model-worldwide/
[44] https://www.climate-transparency.org/wp-content/uploads/2022/10/CT2022-Indonesia-Web.pdf
[45] https://unfccc.int/sites/default/files/NDC/2022-06/Updated%20NDC%20Indonesia%202021%20-%20corrected%20version.pdf
[46] https://www.giz.de/en/worldwide/42943.html

Picture Source: (GIZ[47])

4.1.5. India E-Mobility Financing Program

Background: India's transport sector is the third-largest source of GHG emissions, accounting for approximately 13% of the nation's total CO_2 output[48]. The Government of India has prioritized a transition to e-mobility as a key component of its strategy to reduce emissions and enhance energy security. The "India E-Mobility Financing Program"[49] aims to accelerate the adoption of EVs by addressing financial barriers and supporting the development of a sustainable e-mobility ecosystem.

Approach to Transformational Change: The project aims to mobilize private sector investment in e-mobility by deploying innovative financing instruments designed to reduce the perceived risk and attract commercial financing. It will facilitate access to affordable financing for the purchase of EVs, particularly for two-wheelers, three-wheelers, and electric buses, which constitute the majority of the urban fleet. The program aims to introduce innovative financing solutions, such as operating leases, finance leases, and structured credit options, to catalyze the growth of one of the world's largest potential EV markets. By increasing credit availability and mitigating risks, the program seeks to enhance the appeal of EV ownership, accelerate capital turnover for OEMs, and establish EVs as the preferred choice for fleet operators. The financing program will employ a blended finance approach, combining concessional funding from the GCF with commercial capital to reduce the cost of financing for end-users and incentivize the market uptake of EVs. It will also provide technical assistance to financial institutions and local stakeholders to build capacity in assessing and managing risks associated with e-mobility investments.

[47] https://www.giz.de/en/worldwide/42943.html
[48] https://climateactiontracker.org/documents/832/CAT_2020-12-09_Report_DecarbonisingIndianTransportSector_Dec2020.pdf
[49] https://www.greenclimate.fund/document/india-e-mobility-financing-program

Mitigation Potential: The project is expected to significantly reduce GHG emissions by promoting a shift from fossil-fuel-powered vehicles to electric mobility solutions. During its implementation period, the program aims to mobilize up to USD 2.1 billion in capital investment for the electric vehicle sector and is projected to achieve a cumulative reduction of approximately 9.5 million tons of CO_2 equivalent emissions over its lifespan.

Picture Source: (EnergyMonitor[50])

4.1.6. Light Rail Transit for the Greater Metropolitan Area (GAM), Costa Rica

Background: In Costa Rica, the transport sector is a major source of GHG emissions, accounting for 51% of total emissions in 2015[51]. Emissions are projected to increase by 44% by 2050 without intervention, driven by declining public transport use, growing private vehicle ownership, and an inefficient public transit system. The current transport infrastructure contributes to air pollution, congestion, and accidents, with traffic congestion alone costing 4% of GDP in 2018. Costa Rica's lack of cycling infrastructure and insufficient last-mile connectivity further limit non-motorized transport options.

Approach to Transformational Change: The project[52] involves the development of a modern, electric LRT system in San José, extending 85 km with five lines and integrating with existing public transport, NMT options, and improved last-mile connectivity. The LRT will replace the old diesel train line with an environmentally sustainable, high-capacity system, designed to reduce travel times by 66% for bus passengers and support urban regeneration. The project includes 16 km of new segregated cycle lanes, enhancing connectivity and encouraging a shift from private vehicles to public and non-motorized transport.

Mitigation Potential: The LRT project is expected to directly reduce 7.62 million tons of CO_2 emissions over its lifespan by promoting a modal shift to sustainable transport.

[50] https://www.energymonitor.ai/news/signal-indias-plan-for-50000-electric-buses-gets-us-support/
[51] https://www.oecd-ilibrary.org/sites/ec94fd4e-en/1/3/2/index.html?itemId=/content/publication/ec94fd4e-en&_csp_=6c6671514db424ac0919ce9c979c1eec&itemIGO=oecd&itemContentType=book
[52] https://www.greenclimate.fund/document/light-rail-transit-greater-metropolitan-area-gam

It aims to decrease reliance on private vehicles, improve urban air quality, reduce traffic accidents, and shorten travel times by up to 60%. By integrating NMT and enhancing public transit options, the project supports Costa Rica's broader goal of achieving a net-zero emission transport sector by 2050.

Picture Source: (GCF[53])

4.1.7. E-Mobility and Low Carbon Transportation in Latin America

Background: The transport sector is the largest and fastest-growing source of GHG emissions in Latin America, driven by car-centric urban development and limited electric and public transit options[54]. Although there are a few EV pilot projects, large-scale adoption is hindered by high capital costs, private sector risk perceptions, and inadequate policy frameworks. Despite these challenges, the region's relatively clean electricity generation presents a significant opportunity for transitioning to clean transportation.

Approach to Transformational Change: The project[55] seeks to mitigate investment risks for both public and private sectors in the e-mobility market by providing technical support to develop and test innovative business models and enhance the enabling environment for electric mobility. This includes promoting large-scale investments in EV infrastructure and public transport fleets. The initiative focuses on improving access to affordable, low-carbon urban transport, especially for vulnerable populations reliant on public transit for essential services and economic opportunities.

Mitigation Potential: The program is expected to avoid 4.3 million tons of CO_2 emissions through enhanced urban transport systems and increased adoption of electric vehicles across seven countries: Argentina, Brazil, Colombia, Costa Rica, the Dominican

[53] https://www.greenclimate.fund/project/fp166
[54] https://climatepromise.undp.org/news-and-stories/why-low-emissions-transport-key-latin-america-and-caribbean
[55] https://www.greenclimate.fund/project/fp237#documents

Republic, Mexico, and Peru. The total project value is USD 335 million, emphasizing the role of sustainable mobility in regional climate mitigation strategies.

Picture Source: (IaDB[56])

4.2. Ongoing Projects in Pakistan

Pakistan's introduction of EVs into mass transit systems is gaining momentum, with significant initiatives underway across various regions. Sindh province has taken the lead by incorporating 30 hybrid and 50 fully electric buses into its public transport network, setting a precedent for sustainable urban mobility. In the federal capital, Islamabad, efforts are being made to acquire 160 EV buses to enhance the city's public transportation fleet, signaling a strong commitment to reducing emissions and promoting cleaner transit solutions. Punjab is ambitiously planning to deploy over 20,000 e-bikes and more than 650 EV buses, demonstrating a comprehensive strategy to electrify its transport sector. Meanwhile, Khyber Pakhtunkhwa has introduced diesel-hybrid buses in Peshawar, reflecting a diverse approach to integrating greener technologies within its mass transit system. These initiatives underscore a broader national strategy to transition towards low-emission, energy-efficient transportation, aligning with global sustainability goals and improving urban air quality.

4.2.1. Karachi Bus Rapid Transit Project

The Karachi Bus Rapid Transit (BRT) Red Line Project[57] is designed to develop a state-of-the-art, zero-emission mass transit system that is sustainable, accessible, and efficient. The project encompasses two core components: (i) the construction of a 26.5-

[56] https://www.iadb.org/en/news/idb-green-climate-fund-endorse-program-promote-e-mobility-latin-america-caribbean#:~:text=The%20E%2Dmobility%20Program%20for,by%20accelerating%20the%20use%20of

[57] https://www.adb.org/projects/47279-002/main

kilometer BRT corridor with associated facilities, and (ii) the establishment of sustainable BRT operations through institutional enhancements. The economic viability of the project is underscored by several key benefits, including significant time savings for future BRT passengers, reductions in vehicle operating costs, and improvements in air quality due to reduced carbon emissions. These advantages are anticipated to enhance public health in Karachi and contribute to global climate change mitigation efforts. The project is financially supported by a consortium of international and local funding partners. The Asian Development Bank (ADB) will provide $235 million, the Asian Infrastructure Investment Bank (AIIB)[58] will contribute $71.81 million, and the French Development Agency (AFD) will offer an additional $71.81 million. The Green Climate Fund (GCF)[59] will provide $49 million, comprising an $11.8 million grant and a $37.2 million loan. The Government of Sindh will also contribute to the funding of this initiative.

Figure 20: Features of BRT Karachi Project

The BRT will use 0-GHG emission biomethane hybrid buses. The project will produce its own biogas from cattle waste available within the larger urban zone of Karachi sufficient to cover 100% of the methane demand from BRT buses. The project also includes restructuring of the public transport network, the facilitation of a bus industry transition program, a fleet scrapping program and compensation mechanism for non-participating operators and organizational and institutional development. The project has a direct GHG reduction impact of 2.6 $MtCO_2e$ over 30 years[60]. The BRT infrastructure is adapted to increase climate resilience. It has a high replication for other BRT projects in Karachi as well as other cities of Pakistan.

[58] https://www.aiib.org/en/projects/details/2019/approved/Pakistan-Karachi-Bus-Rapid-Transit.html
[59] https://www.greenclimate.fund/project/fp085
[60] https://www.greenclimate.fund/document/green-brt-karachi

4.2.2. Peshawar Sustainable Bus Rapid Transit Corridor Project

The Peshawar Sustainable BRT Corridor Project in Pakistan is a critical initiative aimed at modernizing urban transport infrastructure to reduce congestion, lower greenhouse gas (GHG) emissions, and provide efficient and sustainable mobility options for the growing urban population. In 2017, the Asian Development Bank's (ADB) Board of Directors approved a $335 million loan to help the Government of Pakistan and the provincial Government of Khyber Pakhtunkhwa develop a sustainable urban transport system in Peshawar through the creation of the city's first integrated BRT corridor. Agence Française de Développement (AFD) and the European Investment Bank also provided support to the project through $75 million each in cofinancing. ADB will administer the loan from AFD.

The Peshawar BRT system is recognized as a "third-generation" BRT model, characterized by its innovative design that integrates on-corridor and off-corridor operations. The shift to a modern BRT system is projected to reduce CO2 emissions by approximately 31,000 tons per year. This reduction is achieved through improved fuel efficiency of the new bus fleet, lower per capita fuel consumption due to increased ridership, and reduced congestion.

4.2.3. Punjab Green Development Program

The Punjab Green Development Program (PGDP), backed by a $200 million loan from the World Bank, is designed to enhance environmental sustainability in Punjab, Pakistan. The transport sector component focuses on reducing emissions, improving air quality, and promoting sustainable mobility through innovative and regulatory interventions.

Key transport-related outputs and initiatives under the PGDP include:

1. **Introduction of Eco-Friendly Bus Service in Lahore:** The program will launch a new bus service comprising at least 100 eco-friendly buses operating on compressed natural gas (CNG), CNG hybrid (electric), and battery-electric technologies. This initiative aims to provide a cleaner public transport option, reducing vehicular emissions and contributing to better urban air quality.

2. **Pilot Program for E-Vehicles:** The PGDP will initiate a pilot program to test the feasibility of battery-electric buses and battery-electric rickshaws in urban areas. The goal is to evaluate the operational benefits and environmental impact of transitioning to electric mobility solutions.

[61] https://www.adb.org/projects/48289-002/main
[62] https://projects.worldbank.org/en/projects-operations/project-detail/P165388

3. **Vehicle Inspection and Certification System (VCIS)**: The program includes the establishment of a comprehensive VCIS to ensure compliance with stricter vehicle emission standards. This system will facilitate regular inspections and certifications, effectively reducing the number of high-emission vehicles on the road and ensuring adherence to environmental regulations.

4.2.4. Rail Rapid Transit System

Pakistan is expanding its urban mobility infrastructure with rail rapid transit projects aimed at reducing congestion and enhancing sustainability.

Ongoing Projects:

- **Karachi Circular Railway**: Focuses on revamping Karachi's urban transit with a modernized rail system.
- **Lahore Metro Orange Line**: Fully electric rail line achieving zero pollution and zero emissions, with an estimated annual reduction of 30,000 tons of fuel emissions.

Proposed Projects:

- **Peshawar Circular Railway**: Planned to improve connectivity and reduce traffic congestion in Peshawar.
- **Quetta Mass Transit**: Aimed at developing a mass transit solution for Quetta to enhance urban mobility.
- **Rawalpindi-Islamabad Circular Railway**: Proposed to strengthen regional connectivity and reduce travel time between the twin cities.

4.2.5. Non-motorized Transport

The "Cycling as an Alternative Transport" initiative in Islamabad reflects a strategic effort to promote non-motorized transport options within the federal capital. As part of this project, over 146 kilometers of dedicated cycling lanes are being developed, with a completion target set for February 2025. This initiative aims to enhance urban mobility, reduce traffic congestion, and promote healthier lifestyles while contributing to the reduction of greenhouse gas emissions. The development of cycling infrastructure is a key component of broader sustainable urban transport strategies, aligning with global best practices to foster resilient and low-carbon cities.

[63] https://documents1.worldbank.org/curated/en/248411591967796014/pdf/Disclosable-Restructuring-Paper-Punjab-Green-Development-Program-P165388.pdf?_gl=1*1q67pa8*_gcl_au*MTgxMTUyMTk3MC4xNzIyOTM1MTc0

4.3. Indicating the Mitigation Costs of Different Technologies

Table 3 provides a comprehensive overview of strategies to mitigate emissions across different aspects of transport operations. The mitigation measures are categorized into three primary approaches: reduction of emissions per kilometer driven, reduction of emissions per unit transported (passenger-kilometers or ton-kilometers), and reduction of emissions through decreasing travel distance or trip numbers[64]. Each category incorporates various technologies, behavioral strategies, and infrastructural enhancements designed to lower carbon footprints within the transport sector. The measures range from transitioning to low-emission vehicles and fuels to optimizing traffic flow through advanced management systems and promoting urban development that integrates transit solutions, thereby enhancing overall transport sustainability. A holistic approach is crucial, integrating technological advancements with policy-driven initiatives to achieve effective emission reductions across diverse contexts. This strategy is particularly vital in developing countries, where the feasibility of implementation can vary significantly due to varying economic, infrastructural, and regulatory environments.

[64] These are suggestions for possible mitigation measures within the transport sectors. Not all of them are always feasible in different developing countries.

Table 3: Transport Sector Mitigation Measure

Mitigation Measures		
Emission reduction per kilometer driven	Emission reduction per unit transported (pkm or tkm)	Emission reduction through reducing distance driven or the number of trips
Transition from high-carbon to low-carbon fuels (e.g., biofuels, electricity).	Shift to low-emission vehicles for passengers and freight; transition from cars to public transit or from motorized vehicles to Non-Motorized Transport (NMT); shift freight from road to rail or ship, using larger units with similar occupation rates.	Encourage behavioral changes to reduce travel demand.
Deployment of advanced vehicle technologies (e.g., hybrids, hydrogen fuel cells, electric vehicles).	Enhance vehicle occupation rates through improved dispatch systems or by increasing the attractiveness of transport modes.	Implement advanced traffic management strategies, including congestion information systems and optimized parking solutions.
Adoption of best practices in vehicle operation (e.g., enhanced maintenance protocols, eco-driving techniques).	Promote increased ridership on public transportation systems.	Utilize Transit-Oriented Development or Transit-Enhanced Development (TED) measures: integrating urban development with public transport through the creation of dense, mixed-use, pedestrian-friendly urban nodes centered around transit stations.
Behavioral shifts, such as opting for more energy-efficient vehicles.		Implement road pricing strategies, such as toll roads.
Infrastructure enhancements to mitigate congestion (e.g., construction of flyovers, intelligent traffic signal systems).		Enforce restrictions on vehicle usage to manage demand.
Improved vehicle dispatch techniques to optimize routes and reduce unnecessary travel.		Infrastructure investments aimed at reducing travel distances (e.g., construction of shorter road connections, tunnels, bridges, etc.).

Following table 4 delineates a structured framework for advancing transport sector mitigation through targeted measures, instruments, and institutions, while also identifying critical barriers to implementation. Key measures include transitioning to low-carbon fuels, enhancing vehicle efficiency through ecological driving practices, adopting new vehicle technologies, improving urban public transit systems, and advancing urban planning initiatives. Instruments such as bio-fuel mandates, tax incentives, and voluntary agreements are pivotal in operationalizing these measures. Federal and provincial governments, alongside private sector stakeholders, are central to driving these initiatives. However, the sector faces substantial barriers, including technological development challenges, high implementation costs, resistance to change, and political obstacles, which require strategic management and policy coordination to overcome, particularly in the context of Pakistan where institutional capacity and infrastructure may be limited.

Table 4: Mitigation measures, instrument, entities and barriers

MEASURE / TECHNOLOGY	INSTRUMENT	INSTITUTIONS	BARRIERS
Fuel switch from high to low carbon fuels (bio-fuels, natural gas, electricity).	- Bio-fuel blending mandates. - Incentives on fuel prices.	- Federal and Provincial Governments - Fuel distributing companies	- Fuel availability - Infrastructure adaptations - Technological adjustments
Introducing best practices: improved maintenance, ecological driving.	- Voluntary Agreements between governments and private fleet companies. - Driver education and awareness.	- Federal and Provincial Governments - Transport companies - Private drivers	-Resistance to change
New vehicle technologies (such as hybrids, hydrogen in fuel cell vehicles, electric vehicles).	-Tax policies and incentives	- Federal and Provincial Governments - Fuel distributing companies - Technology suppliers	- Technological development - Implementation costs - Relative fuel prices
Improving urban public transit	- Implementation of Mass Transport Systems (BRT/LTR, Metros, Tram) - Reorganization of public transportation	- Federal and Provincial Governments - Transport companies	- Investment costs for infrastructure and rolling stock - Resistance from existing transport sector - Technological implementation challenges - Political resistance - Risk of incomplete implementation
Improved urban planning	Implementation of TOD	- Federal and Provincial government - Local government	- Resistance to implementation by public and community institutions - Lack of know-how and experience - Political resistance - Risk of incomplete implementation

Reducing emissions in Pakistan's transport sector involves a combination of strategies, each with its associated costs and benefits. A careful economic assessment is essential to identify the most cost-effective measures, optimize resource allocation, and align emission reduction efforts with broader economic and social objectives (Table 5).

Implementing bio-fuel blending mandates in Pakistan could provide direct emission reduction benefits. However, such mandates often lead to higher compliance costs due to the uniform application of requirements across diverse stakeholders and the need for technological adjustments in vehicles and fueling infrastructure. In Pakistan's context, where the technological landscape and fuel supply chains are still evolving, these costs could be disproportionately high, making it essential to evaluate the trade-offs carefully. Adjusting fuel prices to incentivize lower emissions can be a powerful tool to influence consumer behavior in Pakistan. However, these incentives must be carefully calibrated to avoid economic inefficiencies. For instance, while higher fuel taxes could reduce fuel consumption and emissions, they might also place a disproportionate burden on lower-income populations, highlighting the need for a balanced approach that considers social equity. Strategically designed tax policies and incentives could offer flexible pathways to lower emissions in Pakistan. For example, tax breaks for hybrid or electric vehicles could encourage their adoption. However, such policies may entail significant administrative costs, especially considering the varied institutional capacity across different regions in Pakistan. Investments in Mass Transport Systems and Transit-Oriented Development hold significant potential for long-term emission reductions in Pakistan. These high-cost interventions promise substantial benefits, including reduced congestion, lower emissions, and enhanced urban mobility. The Peshawar Sustainable BRT Corridor Project, with an estimated total cost of USD 587 million and a per-kilometer cost of USD 69.01 million in PPP terms, represents a significant financial commitment to mitigating both technological and environmental costs in Pakistan's rapidly urbanizing context. Beyond the high costs associated with integrating advanced technologies such as electric and hybrid buses, a substantial portion of the expenditure is allocated to land acquisition and infrastructure development. These costs are particularly pronounced in densely populated urban areas like Peshawar, where acquiring land for dedicated BRT lanes and constructing associated facilities requires extensive financial resources. The project involves compensating affected property owners and relocating displaced communities, which are necessary steps to align with Asian Development Bank (ADB) guidelines on social safeguards, yet add significantly to the overall project cost.

The high cost of electricity is a significant barrier to the establishment and profitability of EV charging stations in Pakistan, severely impacting the overall adoption of electric vehicles. Charging stations are currently forced to buy electricity at rates higher than what they can sell it for, with urban stations purchasing electricity between Rs90 and Rs105 per unit and selling it at Rs75 to Rs100 per unit, and motorway stations facing even greater losses. This pricing disparity is driven by the inefficiencies in the power sector and regulatory constraints set by NEPRA, which have not adequately accounted for the actual costs incurred by charging stations. As a result, these high costs deter investment in EV infrastructure, discourage potential investors, and undermine efforts to transition towards a sustainable, electric vehicle market.

Table 5: Instruments for implementation

INSTRUMENT		
Bio-fuel blending mandates	- Emission levels set directly, though subject to exceptions. - Depends on deferrals and compliance. - Preferable when other barriers prevent consumers from responding to price signals.	-Depends on design; uniform application often leads to higher overall compliance costs.
Incentives on fuel prices	-Depends on program design; generally less certain than regulations or standards	-Depends on the level and design of the program; can create market distortions.
Voluntary Agreements: between governments and private fleet companies	-Effectiveness depends on program design, including clear targets, a baseline scenario, and third-party involvement in design and monitoring.	-Depends on the flexibility and extent of government incentives, rewards, and penalties.
Driver education and awareness	-Depends on how effectively consumers use the information provided; most effective when combined with other policy measures.	-Potentially low-cost, but effectiveness depends on program design.
Tax policies and incentives	-Effectiveness depends on the ability to set tax levels that induce behavioral change; cannot guarantee specific emission reduction levels.	-More effective with broad application; higher administrative costs where institutional frameworks are weak.
Implementation of Mass Transport Systems (e.g., BRT, LTR, Metros, Tram)	-Potential for significant environmental benefits in the short, medium, and long term.	-High implementation costs.
Implementation of E-mobility Infrastructure	-Significant environmental benefits achievable in the short medium, and long-term	-High implementation costs.

[65] https://www.adb.org/sites/default/files/linked-documents/48289-002-efa.pdf
[66] https://www.brecorder.com/news/40277329

5. Carbon Market Opportunities and Challenges

Internationally Transferred Mitigation Outcomes are part of a new suite of market-based mechanisms introduced under Article 6 of the Paris Agreement. These mechanisms serve as a replacement for the earlier Clean Development Mechanism system, which was governed by the UNFCCC. Under these provisions, parties voluntarily engaging in cooperative approaches that involve ITMOs must ensure that the transfers contribute to nationally determined contributions, promote sustainable development, and maintain environmental integrity and transparency. This includes robust governance and adherence to rules that prevent double counting. The use of ITMOs must align with guidance provided by the COP. ITMOs arise from activities that lower greenhouse gas emissions and allow for the transfer of these reductions between participating nations. The rules established at the 26th COP26 in Glasgow dictate that when an ITMO is transferred, corresponding adjustments (CAs) must be made. A CA involves the host country (where the project is based) approving the transfer and adjusting its greenhouse gas inventory to reflect the emission reductions credited to the buying country, thus avoiding double counting. The purchasing nation then mirrors this adjustment in its own inventory.

As of 2021, ITMOs can be generated and are poised to replace the previous market mechanisms utilized for compliance purposes, such as the CDM. ITMO transactions can occur through bilateral agreements or multilateral platforms under the United Nations. Some bilateral deals have already taken place with countries such as Australia, Japan, Norway, Singapore, South Korea, Sweden, and Switzerland. However, the multilateral platform still requires further decisions, with the next major discussions scheduled for COP29, anticipated in November 2024 in Baku, Azerbaijan, and full operationalization expected before 2025. Notably, the first ITMO transaction occurred between Thailand and Switzerland in January 2024, centered on an electric bus program managed by Energy Absolute[67].

ITMO prices generally surpass those in the voluntary market, typically ranging from 15-40 USD per tCO_2 , contingent on the purchasing country, project, and conditions. Registration criteria are similar to other markets, though with additional complexities. For example, Singapore mandates a VCS project approach, along with prior approval and registration, often involving a designated host country entity. This process, along with a list of eligible activities pre-approved by the government, introduces additional layers of complexity, distinguishing ITMOs from voluntary or domestic market projects. Projects under ITMOs may need to exceed the minimum targets set by the nationally determined contributions (NDCs) under the Paris Agreement. In practice, this requires close collaboration with the host government to verify that the activities generating

[67] https://www.klik.ch/en/news/news-article/first-ever-itmos-for-ndc-use

ITMOs can be traded. The table below summarises the three categories of carbon markets.

Table 6: Categories of Carbon Markets

Carbon Markets	Registration and Issuance Process	Buyer	Corresponding Adjustment to National Carbon Registry	Current Prices (USD per tCO_2)	Recommended Project Size (tCO_2 p.a.)
Voluntary Carbon Markets	Certification through recognized standard: Verra/VCS, Gold Standard, GCC, etc.	Any private company or individual (typically large corporate entity)	Not required (may change in the near future)	4 to 10	> 100,000
National (and Regional) Offset Markets	Based on local legislation (typically cap-and-trade scheme applicable for a particular industry)	Any private company subject to local carbon scheme or tax	Not required (intranational transaction)	5 to 200+	Depends on local price
ITMO Market	Issuance by government of host country The project must meet requirements of buyer	Any government of a Paris Agreement participating country or entity appointed by such a government (in practice only a handful of buyers) Some governments (e.g. in Asia) do not buy directly	Mandatory	15 to 40	> 25,000

		but instead grant access/equivalence to their national offset market, where the ITMOs can be sold to any private company subject to local carbon scheme or tax			

The table outlines the key principles that ensure the credibility and effectiveness of emission reduction projects within carbon markets. These principles—such as requiring reductions to be genuine and additional, and ensuring they are measurable, permanent, independently verified, and unique—are fundamental to maintaining the environmental integrity of carbon credits. They prevent issues like double-counting and ensure that each credit represents a true, quantifiable impact on reducing greenhouse gases. Adherence to these principles is critical for fostering trust among stakeholders, encouraging investment in decarbonization projects, and achieving meaningful climate action.

Table 7: Standards for Credible Emission Reductions

Principle	Description
Real	Emission reductions must represent genuine and tangible decreases in greenhouse gases.
Measurable	The amount of reduced emissions must be quantifiable using reliable and transparent methods.
Permanent	Emission reductions should be long-lasting and not subject to reversal.
Additional	Reductions must be above and beyond what would have happened without the project, ensuring they are extra.
Independently Verified	Projects must undergo third-party verification to confirm the legitimacy and accuracy of emission reductions.
Unique	Each reduction credit should only be counted once and not double-counted across different schemes.

5.1. E-Mobility Opportunities

E-mobility offers a strategic pathway for monetizing emission reductions through carbon markets. Key players, including vehicle owners, operators, manufacturers, and financiers, can benefit from carbon credits by transitioning to EVs and supporting infrastructure such as charging stations (Table 8). E-mobility assets span a wide range, from

two-wheelers and cars to buses, trucks, and specialized equipment used in construction, ports, and airports. By capturing the emission reductions from these electrified assets, stakeholders can generate tradable carbon credits, providing a financial incentive for further investments in e-mobility. Accurate MRV processes are essential to ensure these credits are credible and align with international standards, thereby enhancing participation in global carbon markets and accelerating the shift towards low-carbon transport systems.

Table 8: E-mobility Players and Assets

E-mobility Players	E-mobility Assets
Owners	Charge points
Operators	2/3-wheelers
Manufacturers	Cars
Importers	Buses
Dealers	Delivery vans
Financiers	Trucks
Leasing companies	Construction and mining equipment
Etc.	Port and airport equipment
	Rail rolling stock
	Vessels
	Etc.

The following table shows the estimates of the potential revenue from carbon credits for fully electric urban or inter-urban buses, as presented in the table, has been calculated using the Zeroca Estimator[68] for several of the e-mobility assets[69].

[68] https://zeroca.world/#

[69] These examples serve as a 'worked' illustration of potential ITMO carbon credit net revenue only and is provided "as is." It is based on assumptions concerning average technical and operational characteristics of different vehicles, energy systems, macroeconomic environments, and market circumstances. Author assumes no responsibility or liability for any error or omission herein, and actual parameters and outcomes may differ from case to case. As such, no rights, claims, or liabilities can be derived from this example. No representations to third parties should be made based on this example.

Table 9: Monetizing emission reductions from e-mobility through international carbon markets

	Category	Description	Potential Revenue from Carbon Credits
Urban or Inter-Urban Buses		Buses of all sizes, fully electric (no hybrids).	Up to $3,000 USD per year per bus (up to $30,000 USD over the lifespan for 100 buses: $3M).
Delivery Trucks and Long-Haul Trucks		Battery-electric trucks of all sizes.	Up to $2,000 USD per year per truck (up to $20,000 USD over the lifespan for 200 trucks: $4M).
Motorcycles and 3-Wheelers		Electric motorcycles or 3-wheelers for ride-hailing, rent, or delivery.	Up to $50,000 USD per year per 1,000 vehicles (up to $500,000 USD over the lifespan).
Public and Fleet Chargers		Public chargers for passenger cars, chargers for captive fleets (buses, trucks, taxis, delivery vehicles).	1.5-2.0 USD cents per kWh of electricity sold.

Urban Trains, LRTs, Trams, Metros		Electric urban trains, light rail transit (LRTs), trams, and metros.	Several million USD of extra revenue based on observed modal shift from non-electric modes.
Heavy Equipment and Vehicles		Trucks, dumpers, mobile machinery, pick-ups, buses for staff transport.	Revenue depends on type/size of equipment and usage rates.
Port Operations Equipment		Reachstackers, tractor-trailers, straddle carriers, cranes.	Revenue depends on equipment type/size and usage; sufficient credits can make electrification profitable.
Airport Ground Support Equipment		Pushback tractors, boarding stairs, belt loaders, luggage tugs, lavatory, water and fuel trucks, ground power units.	Revenue depends on equipment type/size and usage; facilitates transition to green airports.
Electric Vessels		Electric vessels for public transport, electric barges, tug boats, ferries.	Up to $50,000 USD per year per 200-passenger electric ferry (up to $500,000 USD over the lifespan).

5.1.1. Example of Article 6 Transaction: The Bangkok E-bus Program

The Bangkok E-Bus Programme marks the first transaction approved under the bilateral cooperation agreement between Switzerland and Thailand, aligned with Article 6 of the Paris Agreement, with support from the KliK Foundation. Energy Absolute, a Thai renewable energy company, is generating credits by converting thousands of petrol-fueled private buses in Bangkok to electric vehicles. Switzerland's Klik Foundation, which represents fossil fuel importers in the country, is funding the programme through the purchase of credits. Swiss law requires fuel importers to compensate for part of their carbon dioxide emissions. The Klik Foundation buys credits on the companies' behalf and finally transfers them to the federal government, which will count them towards its emission reduction targets. To ensure financial viability, a purchase agreement between Energy Absolute and the KliK Foundation regarding greenhouse gas emission reductions (ITMOs) generated by this programme was finalized on June 24, 2022.

The ITMOs generated with financial backing from the KliK Foundation are transferred according to the terms of this agreement and are utilized by Switzerland to fulfill its emission reduction commitments under the Paris Agreement. The agreement guarantees that these ITMOs are additional to Thailand's unconditional NDCs and comply with rigorous standards for quality, environmental integrity, SDGs, and human rights. To prevent double counting, Thailand agrees to adjust its emissions balance by the amount of ITMOs transferred to Switzerland. The project aims to deploy up to 4,000 electric buses in Bangkok, with an initial purchase of 1,916 carbon offset credits completed by the KliK Foundation in December 2023.

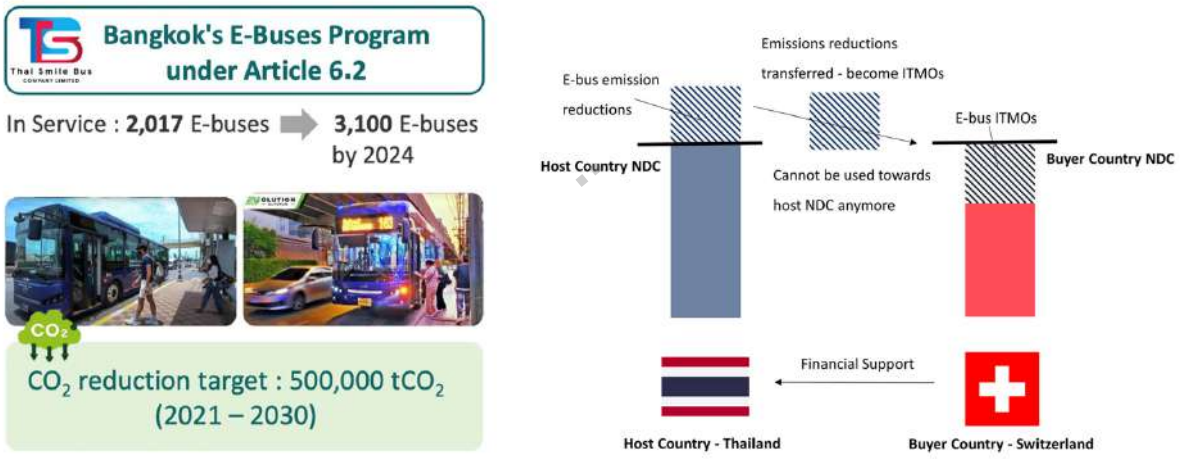

Figure 21: ITMOs facilitate credible and transparent climate cooperation between governments and the private sector.

By aligning the project with Switzerland's emissions reduction goals, the Bangkok E-Bus Programme highlights how international cooperation can mobilize finance, accelerate the deployment of clean technologies, and contribute to the global effort to combat climate change. Moreover, this program serves as a model for future public-private partnerships aimed at reducing carbon footprints while promoting sustainable urban development.

5.2. Rail Sector Opportunities

Potential projects for the rail sector could include:

- Enhancing Efficiency: This might involve upgrades like improved air conditioning or heating systems, implementation of ecodriving techniques for locomotives, efforts to increase load factors, and advancements in (diesel) engine efficiency, among other measures.
- Modernizing Rolling Stock: Acquisition of new, more energy-efficient rolling stock is another viable project type.
- Electrification and Alternative Technologies: Projects may also focus on electrifying rail tracks, and incorporating hybrid trains, hydrogen trains, or battery-electric trains.
- Infrastructure Development: Investments aimed at expanding the capacity of passenger and/or freight rail systems could include the construction of new rail lines, duplicating existing tracks, and implementing new signaling systems.
- High-Speed Rail (HSR): Establishing HSR networks that shift modal transport from road or air to rail could also be an effective strategy.

In summary, carbon offsets can be generated through either a modal shift, which results from increased rail capacity or the introduction of a new service such as HSR, or through initiatives that aim to boost energy efficiency and decrease the carbon emission factor per ton-kilometer (tkm) or passenger-kilometer (pkm), either by improving efficiency or by switching to a lower-carbon energy source.

5.2.1. Available Methodologies

The following table shows internationally approved carbon credit methodologies applicable to the rail sector.

[70] As of January 2024, the following rail projects were listed: CDM: Metro Delhi, Mumbai Metro One, Metro Gurgaon, Mexico Line 12 Metro, LRT Tunis, Guiyang Metro; VCS: Metro Lima, Metro Buenos Aires, Metro Line 9 Seoul, Bursa LRT; domestic standards: road-to-rail projects in Switzerland, high-speed rail project in South Korea.

[71] Reasons may be that the project did not eventually materialise and/or that the collapse of the CDM market after 2012 made it no longer viable to claim carbon credits for the project.

Table 10: Carbon Credit Methodologies Applicable for Rail

Methodology	Standard	Applicable Area	Registered Projects
ACM0016: Mass Rapid Transit Projects	CDM	Urban rail systems such as metro, LRT, tram, sub-urban rail	Various metros and LRTs, e.g., Delhi metro, Mexico City metro, Tunis LRT, or in the VCS Buenos Aires metro, Seoul metro
AM0090: Modal shift in transportation of cargo from road transportation to water or rail transportation	CDM	Modal shift cargo	One project registered in India, which however never generated carbon credits; one VCS project under development in the USA and one under validation in India
AM0101: High-speed passenger rail system	CDM	High-speed rail	Korail's KTX Honam high-speed rail, registered in the Korean domestic offset system

National carbon markets operate under their own specific regulations, often allowing significant flexibility in the methodologies they employ. For instance, several rail projects have been registered in the Swiss domestic carbon market by leveraging the shift of freight transport from road to rail. These projects partially align with CDM methodologies but also incorporate unique elements specific to local needs. However, the number of registered methodologies and projects in the rail sector, particularly outside of urban settings, remains quite limited. For various activities, such as the deployment of battery-electric trains, there is a need for the development of new methodologies or the adaptation of existing ones. Despite these challenges, carbon credits have the potential to play a crucial role in enhancing the financial viability of rail projects, particularly if these projects are integrated into the ITMO market.

[72] https://registry.verra.org/app/projectDetail/VCS/4530
[73] https://registry.verra.org/app/projectDetail/VCS/4862
[74]https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/verminderungsmassnahmen/kompensation/inland/registrierte-projekte/5-1.html

6. Policy Scenario for Decarbonization of the Transport Sector

6.1. National Roadmaps and Initiatives for Low-Carbon Transport in Pakistan

Pakistan has been proactive in implementing a series of policies and initiatives aimed at reducing carbon emissions from the transport sector, which is a significant contributor to the country's greenhouse gas emissions. The government has introduced several environmental protection legislations to establish a regulatory framework that supports the transition to a low-carbon transport system. These measures are aligned with global sustainability goals and the country's commitment to mitigating climate change impacts.

Key Legislative Measures:

1. **The National Transport Policy 2018**[75]: This policy provides a comprehensive framework for developing an efficient, safe, and sustainable transport sector in Pakistan. It emphasizes reducing emissions through modernizing the transport infrastructure, enhancing public transportation systems, and promoting non-motorized transport options.
2. **The National Electrical Vehicle Policy (NEVP) 2019**[76]: NEVP aims to accelerate the adoption of electric vehicles (EVs) in the country. The policy includes incentives for EV manufacturers and consumers, infrastructure development for EV charging, and a phased approach to increase the share of EVs in both private and public transport. This policy is crucial for reducing reliance on fossil fuels and cutting down carbon emissions.
3. **National Electricity Policy 2021**[77]: The policy lays the groundwork for integrating renewable energy into the national grid, thereby ensuring that the electricity used to power electric vehicles comes from sustainable sources. This integration is essential for maximizing the environmental benefits of transitioning to electric mobility.
4. **Draft**[78] **EV Charging Infrastructure Regulations 2023**[79]: To support the widespread adoption of electric vehicles, these regulations focus on the development and deployment of a robust EV charging network across the country. The policy provides guidelines for public and private sector investment in charging infrastructure, ensuring accessibility and convenience for EV users.

[75] https://www.pc.gov.pk/uploads/downloads/policy.pdf
[76] https://mocc.gov.pk/SiteImage/Policy/EV%20Policy%20Final.pdf
[77] https://power.gov.pk/SiteImage/Policy/1-NationalElectricityPolicy2021.pdf
[78] Not approved yet
[79] https://neeca.gov.pk/SiteImage/Downloads/Draft%20EV%20Charging%20Infrastructure%20Regulations%202023%20(1).pdf

5. **National Clean Air Policy 2023**[80]: The National Clean Air Policy (NCAP) 2023 in Pakistan emphasizes reducing air pollution through comprehensive interventions in the transport sector. It promotes the adoption of cleaner fuel standards and encourages mass transit systems to reduce emissions from road transport. The policy aims to improve urban air quality by reducing reliance on private vehicles, enhancing public transport options, and implementing stricter emissions regulations. By targeting the transport sector, NCAP 2023 seeks to address one of the largest sources of urban pollution, contributing to healthier cities and compliance with international environmental standards.

Overall, Pakistan's climate change mitigation targets are aligned with the broader goal of transitioning to sustainable, low-emission mobility solutions. By 2025, the Alternative and Renewable Energy Policy[81] mandates that at least 10% of diesel fuel comprises bio-diesel (B10), reducing reliance on fossil fuels. The National Electric Vehicle Policy[82] aims for a significant market shift, targeting 30% and 90% shares in electric passenger vehicles and heavy-duty trucks by 2030 and 2040, respectively. Similarly, the updated NDC[83] commit to a 30% shift to electric passenger vehicles and a 50% shift to electric two/three-wheelers and buses by 2030, with ambitions to increase this to 90% by 2040. According to National Clean Air Policy (NCAP), Pakistan's strategy to mitigate transport emissions includes a phased transition to Euro-5 fuel standards by 2025 and Euro-6 by 2030, aiming to reduce vehicular emissions significantly and align with international best practices. Additionally, the NCAP mandates the development of mass transit systems in at least 10 major cities by 2030, promoting multi-modal transport solutions to decrease reliance on personal vehicles. These measures require substantial investments in infrastructure, regulatory enforcement for fuel quality, and incentives to facilitate the shift towards cleaner technologies and more efficient public transportation networks.

6.1.1. National Transport Policy 2018

The National Transport Policy 2018, approved by the Government of Pakistan, provides a strategic roadmap for transforming the country's transport sector to align with sustainable development goals and international climate commitments. The policy aims to establish an integrated, multi-modal transport system that improves connectivity and reduces reliance on high-emission vehicles.

[80] https://mocc.gov.pk/SiteImage/Misc/files/NCAP%20(28-02-2023)%20v1.pdf
[81] https://power.gov.pk/PolicyDetail/ZmNkNjE3MzgtZWE0Ni00N2E0LTk2OTktMzdjNTg4ZGMxNTNh
[82] https://mocc.gov.pk/SiteImage/Policy/EV%20Policy%20Final.pdf
[83] https://unfccc.int/sites/default/files/NDC/2022-06/Pakistan%20Updated%20NDC%202021.pdf

Key Focus Areas:

1. **Multi-Modal Transport Integration**: The policy promotes the development of a cohesive network incorporating road, rail, air, maritime, pipeline, and inland waterways. This approach aims to optimize resource use, improve efficiency, and reduce environmental impacts by encouraging a modal shift from road to more sustainable modes such as rail and inland waterways.
2. **Transition to Sustainable Fuels**: A significant focus is placed on reducing dependence on fossil fuels by promoting the use of sustainable alternatives, including electric and biofuels. This shift is crucial for decreasing carbon emissions and enhancing energy security.
3. **Promotion of Public and Non-Motorized Transport**: The policy encourages the enhancement of public transport systems and non-motorized transport (NMT) options like walking and cycling, particularly in urban areas, to reduce congestion and improve air quality.
4. **Environmental Safeguards**: Strengthening emission standards and adopting cleaner technologies are prioritized to minimize the transport sector's adverse environmental impacts. The policy sets specific targets for reducing vehicular emissions and noise pollution through improved standards and regulatory compliance.

The National Transport Policy 2018 serves as a foundational framework for guiding Pakistan's efforts in achieving a sustainable, low-carbon transport future. It aligns with global best practices and supports Pakistan's broader objectives under the Paris Agreement and SDGs.

6.1.2. National Electrical Vehicle Policy 2019

To effectively introduce and sustain EVs and the necessary supporting infrastructure, it is crucial for a country to establish clear and achievable penetration targets. In Pakistan, the Prime Minister's Committee on Climate Change recognized this need and, during its meeting on May 17, 2019, approved a set of minimum mandated targets to guide EV adoption across the country. These targets provide a structured approach for integrating EVs into the national fleet and aim to ensure a steady and strategic expansion of electric mobility. Table 1 outlines these targets, specifying the anticipated timelines for different categories of EV penetration, thereby setting a roadmap for the transition towards sustainable transportation.

Table: Electric Vehicle Penetration Targets

EV Penetration Targets	Medium Term Targets (Five Years) Cumulative	Long Term Targets (2030)	Ultimate Targets (2040)
Cars (including Vans, Jeeps, and small Trucks)	100,000	30% of New Sales (Approximately 60,000)	90% of New Sales
Two and Three Wheelers Four Wheelers of UNECE 'L' Category	500,000	50% of New Sales (Approximately 900,000)	90% of New Sales
Buses	1,000	50% of New Sales	90% of New Sales
Trucks	1,000	30% of New Sales	90% of New Sales

In Table , the calculations for the impact of emissions consider the socio-economic cost of carbon, which varies between USD 15 and USD 100 per metric ton for developing countries. For this analysis, a value of USD 50 per metric ton is used as a standard for Pakistan. This is considered a conservative estimate, reflecting Pakistan's status as one of the countries most vulnerable to climate change. The introduction of electric vehicles (EVs) is expected to reduce effective tailpipe emissions by 65%, attributable to two main factors: first, the use of efficient electricity generation plants; and second, Pakistan's energy mix, which includes approximately 37% from renewable sources.

The cost of electricity for EV users is estimated at PKR 25 per kWh. Fuel prices have been updated to reflect current petrol pump prices, with gasoline at PKR 260 per liter and diesel at PKR 266 per liter. It is important to highlight that the reduction in fuel consumption stems not only from the energy efficiency of electric motors but also from more efficient electricity generation. Additionally, EVs reduce fuel use due to the elimination of idling losses, as electric motors provide instant torque without the need for engine idling. Furthermore, EVs do not incur the maintenance costs associated with traditional vehicles, such as those for changing lubricants and filters. Collectively, these factors contribute to an estimated annual savings and earnings of approximately PKR 210 billion, as outlined in the EV penetration targets in Table 1.

Table: Estimates of Yearly Income and Savings from EVs with Five Year Penetration

Category	Cars	2/3 Wheelers	Buses	Trucks	Total
Fuel Savings (PKR)	44,812 M	83,567 M	3,452 M	4,136M	**135.9 B**
Idle Vehicle Fuel Savings	10,758 M	16,732 M	1,535 M	1,450 M	**30.4 B**
Socio-Economic Cost of Emissions	3,096 M	8,960 M	235 M	281 M	**12.5 B**
Charging Revenue (@ Rs. 25/kWh)	8,754 M	7,293 M	1,875 M	1,875 M	**19.7 B**
Maintenance Cost (Lube, etc.)	3,000 M	7,222 M	280 M	280 M	**10.7 B**
Total (PKR)					**209.6 B**
Total (USD)					**1.55 B**

6.1.2.1.Charging Infrastructure:

To effectively promote the adoption of electric vehicles (EVs) in Pakistan, the development of a comprehensive charging infrastructure is essential. The Government of Pakistan, in collaboration with relevant stakeholders, will implement the following measures:

1. **Urban Charging Infrastructure**: Install charging stations in all major cities, with a focus on initial deployment. Each major city will have at least one DC fast charger per 3x3 km area. The network will then be expanded to cover all secondary cities.
2. **Highway Charging Network**: Deploy DC fast chargers along major motorways and highways, spaced every 15-30 km. Initially, chargers will be installed at each rest area along key routes, including highways N5 and motorways M1, M2, M3, M4, M5, and M9, with plans to extend coverage across the entire network.
3. **Battery Swapping Options**: Public charging stations may provide standardized swappable battery facilities as an alternative to traditional charging methods, catering to specific categories of vehicles.
4. **Priority Rollout Locations**: The initial phase of charging infrastructure deployment will prioritize Lahore, Islamabad, and motorway M2. Lahore will receive special attention due to its significant smog challenges, making it a priority for EV adoption and related services.
5. **Electricity Distribution Coordination**: Electric Distribution Companies (DISCOs) will be responsible for identifying appropriate feeders to manage electricity load for fast charging stations. DISCOs must address any system constraints to achieve the targeted infrastructure in each 3x3 km urban area.

6. **Integration with Existing Fuel Infrastructure**: Existing CNG and fuel stations are encouraged to participate actively in establishing EV charging infrastructure, leveraging their current networks.
7. **Smart Charging Solutions**: To minimize the impact on the national grid, smart charging solutions, such as smart metering and time-of-use pricing, will be employed at Level-2 and higher charging stations. This will optimize grid usage and enhance energy efficiency.

6.1.2.2. Incentives for New Cars:

To promote the adoption of electric vehicles (EVs) in Pakistan, particularly in the passenger and commercial sectors (UNECE Categories M1 and N1), the government plans several strategic interventions:

1. **Maintain Existing Auto Development Policy Incentives**: Retain incentives from the Auto Development Policy 2016-2021 while introducing additional measures specifically for local EV manufacturers.
2. **Tax and Duty Reductions**: Eliminate Additional Customs Duty and Additional Sales Tax on imported EVs to lower purchase costs. Import EV-specific parts and components not produced locally at 1% custom duty and 0% sales tax.
3. **Federal Excise and Sales Tax Relief**: Exempt 4-wheeler EVs from Federal Excise Duty (FED). Locally manufactured EVs up to 50KW and light commercial vehicles up to 150KW will be subject to only 1% sales tax.
4. **Registration Benefits**: Waive registration and annual renewal fees for EVs. Introduce distinct registration plates to create specific EV zones and provide targeted incentives in high-density areas.
5. **Green Financing Incentives**: Encourage EV financing under the State Bank of Pakistan's Green Banking Guidelines. Offer a special car financing window with a low interest rate of 1+4% to make EVs more affordable.
6. **Reduced Toll Taxes**: EVs will receive a 50% discount on toll taxes at all National Highway Authority (NHA) toll stations.

These measures aim to reduce the upfront costs of EVs, incentivize local manufacturing, and accelerate market penetration in Pakistan.

6.1.2.3. Incentives for Two and Three Wheelers/Low Speed Electric Cars

Pakistan's substantial market for two and three-wheelers, with over twenty million such vehicles currently on the roads, presents a significant opportunity for transitioning to electric mobility. With local production already achieving over 90% indigenization, there is a strong foundation to incentivize the conversion to electric bikes (e-bikes) and

e-rickshaws. Additionally, low-speed electric vehicles (L-category under UNECE classification) are emerging, which should be treated similarly to two and three-wheelers in terms of policy incentives.

To support this transition, the Government of Pakistan, in collaboration with relevant stakeholders, intends to implement the following measures:

1. **Customs and Sales Tax Reductions**: Import all completely knocked down (CKD) kits related to two and three-wheeler EVs at 1% customs duty and sell them at 0% sales tax. Locally manufactured two and three-wheeler EVs will be sold at 1% sales tax to reduce their purchase price.
2. **Exemption from Registration Fees and Taxes**: Waive registration fees and annual token taxes for two and three-wheeler EVs to encourage buyers. The Federal Board of Revenue (FBR) will also develop policies to offer additional tax incentives to prospective buyers.
3. **Import of EV-Specific Parts**: Allow the import of EV-specific parts and components not manufactured locally, at 1% customs duty and 0% sales tax.
4. **Distinct Registration Plates**: Introduce distinct colored or designed registration plates for EVs to create designated zones for electric vehicles in high-density areas and differentiate between two, three, and low-speed four-wheeler EVs and conventional vehicles.

6.1.2.4. Incentives for Buses

To support the adoption of electric bus technology, the Government of Pakistan, along with relevant stakeholders, intends to undertake the following measures:

1. **Support for Local Manufacturing**: Encourage the establishment of local assembly plants for electric buses. Given the low current volumes, the government may facilitate this through government-to-government agreements or commercial contracts.
2. **Reduced Import Duties**: Import of electric buses will be subject to only 1% customs duty. This rate also applies to the import of both localized and non-localized parts for buses manufactured locally, as well as for Complete Built Units (CBU) and Complete Knock Down (CKD) kits, until the new Auto Industry Development and Export Plan (AIDEP) is announced.
3. **Lower Sales Tax**: Locally assembled electric buses will be taxed at a reduced rate of 1% at the point of sale.
4. **Fee and Tax Exemptions**: Electric buses will be exempt from registration fees and annual token taxes. The State Bank of Pakistan may also offer favorable financing options under Green Banking Guidelines or similar schemes to lower the upfront costs.

5. **Reduced Toll Fees**: Electric buses will benefit from a 50% reduction in toll fees at National Highway Authority (NHA) toll stations.
6. **Electrification of Public Transit**: Prioritize the electrification of metro bus and Bus Rapid Transit (BRT) routes in major urban areas to enhance public transportation sustainability.

6.1.2.5.Incentives for Trucks:

The adoption of all-electric trucks in Pakistan presents unique challenges due to their high initial cost and the need for extensive charging infrastructure, particularly for long-haul routes. To facilitate the introduction of electric trucks, the Government of Pakistan, in collaboration with relevant stakeholders, intends to implement the following measures:

1. **Phased Implementation Strategy**: In the short term (1-2 years), focus on deploying electric trucks for intra-city hauling, where charging needs are more manageable. In the next five years, develop a robust charging infrastructure to support long-distance hauling.
2. **Support for Local Manufacturing**: Encourage manufacturers to establish local assembly plants for electric trucks. The government may facilitate this through government-to-government agreements or commercial contracts due to the currently low volume of trucks.
3. **Reduced Import Duties**: Electric trucks will be imported at a reduced customs duty of 1%. This duty rate also applies to EV-specific parts for locally manufactured trucks, particularly non-localized components, until the new Auto Industry Development and Export Plan (AIDEP) is announced.
4. **Lower Sales Tax**: Set the sales tax for locally assembled electric trucks and prime movers at 1% at the point of sale.
5. **Fee and Tax Exemptions**: Waive registration fees, annual token taxes, and permit costs for electric trucks to reduce operational costs. The State Bank of Pakistan may also extend favorable financing terms under Green Banking Guidelines or similar schemes until a focused EV incentive policy is developed.
6. **Reduced Toll Fees**: Electric trucks will benefit from a 50% reduction in toll fees at all National Highway Authority (NHA) toll stations.

6.1.2.6. Incentives for EV Assembly Plants:

1. **Maintain Existing Auto Policy Incentives**: Continue incentives from the Auto Development Policy 2016-21 to support automotive assembly plants and attract Greenfield investments.
2. **Duty and Tax Exemptions**: Import machinery, equipment, and parts for EV assembly and infrastructure development at 0% customs duty and 0% tax.

3. **Test Marketing Allowance**: Permit import of up to 100 Complete Built Units (CBUs) for each variant at 50% customs duty for test marketing purposes.
4. **Low-Cost Financing**: Enable lower financing rates for EV manufacturing plants under the State Bank's Long Term Financing Facility (LTFF).

6.1.2.7. Incentives for EV Components and Modules Manufacturing:

1. **Reduced Import Duties**: Allow import of motors, batteries, and electronics at 1% customs duty, with 0% sales tax, except for locally manufactured components.
2. **Income Tax Exemption**: Grant a five-year income tax exemption for auto part manufacturers setting up Greenfield facilities for EV components.
3. **Loans for Part Manufacturers**: Provide loans at 5% interest rate to certified manufacturers of EV-specific parts and infrastructure.

6.1.2.8. Incentives for Charging Infrastructure and Battery Swapping Stations:

1. **Tax Benefits for Charging Facilities**: Allow entities installing public Level-2 chargers to count installation costs as Corporate Social Responsibility (CSR) contributions.
2. **Import Duty Reduction**: Import charging equipment, including mobile chargers and battery swapping stations, at 1% customs duty.
3. **Support for Advanced Technologies**: Encourage investment in new charging technologies such as supercapacitors and wireless charging through tailored incentives.

These measures are designed to boost local EV manufacturing, reduce initial investment costs, and ensure a robust charging infrastructure, aligning with international standards for safety and efficiency.

6.1.3. Establishment of Inter-Ministerial Committee on Electric Vehicles

An inter-ministerial committee shall be formed to overlook all issues related to the entire EV value chain in order to smoothly introduce and coordinate efforts towards local manufacturing. The committee will also be responsible for overseeing standardization, regulation and compliance towards charging infrastructure. Periodic changes in the EV policy based on the changing technology and marketplace will also be the responsibility of this committee. The committee will also develop a blueprint for the National Center for Electric Vehicles in consultation with relevant departments and ministries.

The inter-ministerial committee; will comprise off:

- Ministry of Climate Change & Environmental Coordination (Chair)

- Ministry of Industries and Production (Co-Chair)
- Ministry of Foreign Affairs
- Ministry of Commerce
- Ministry of Communication
- Ministry of Energy (Power Division)
- Ministry of Energy (Petroleum Division)
- Ministry of Science and Technology
- Ministry of Finance
- Federal Board of Revenue
- Higher Education Commission (HEC)
- Pakistan Engineering Council (PEC)
- Provincial representatives from all 4 provinces, AJK and GB.
- Five Interested Representatives from transport and EV industry
- Two notable members and experts from academia

6.2. Implementing National EV Policy:

The National Electric Vehicle Policy in Pakistan lays a foundation for transitioning towards sustainable mobility, but several strategic challenges must be addressed to accelerate the uptake of EVs. Despite the clear policy targets for EV penetration across various vehicle categories, the adoption rates remain low due to a combination of financial, infrastructural, and regulatory barriers that require targeted solutions tailored to Pakistan's unique context.

Firstly, the high upfront cost of EVs remains a significant obstacle in a market where purchasing power is limited, and conventional vehicles are more affordable. Although the policy includes incentives such as reduced customs duties, tax exemptions, and lower registration fees, these measures may not be sufficient given the economic realities faced by consumers and fleet operators in Pakistan. Secondly, the development of a comprehensive charging infrastructure is essential but has lagged behind due to inadequate coordination and investment. The draft policy's vision for urban and highway charging networks and battery swapping stations is ambitious, yet its implementation requires a coordinated approach involving federal and provincial governments, private sector stakeholders, and utility companies. Prioritizing high-traffic corridors and urban centers like Lahore and Karachi, where air pollution levels are critical, would create early momentum for EV adoption. Public-private partnerships could accelerate the deployment of charging stations, and existing fuel stations could be incentivized to integrate EV charging facilities into their operations.

Furthermore, there is a critical need for a more nuanced approach to market segmentation. The significant penetration of two- and three-wheelers in Pakistan presents a substantial opportunity for electrification. Given the high levels of local manufacturing

for these vehicles, targeted incentives could accelerate their transition to electric models, especially in congested urban areas where they contribute significantly to air pollution. A focus on electrifying public transport, such as buses and rickshaws, could also deliver immediate environmental and economic benefits, particularly in cities grappling with severe air quality issues.

6.2.1. Role of Federal and Provincial Agencies in Implementing National EV policy

The National EV Policy in Pakistan requires a coordinated, multi-stakeholder approach to facilitate its successful implementation and drive the transition to sustainable transportation. Led by the Ministry of Climate Change, in partnership with the Ministry of Industries and Production, the policy mandates clear roles for federal and provincial ministries and agencies, each contributing to different facets of the EV ecosystem—from incentivizing local manufacturing and developing charging infrastructure to ensuring compliance with international standards and fostering industry-academia collaboration. Key actions include reducing taxes and duties on EV imports and components, formulating incentives for the establishment of EV assembly plants, and integrating green financing mechanisms to lower costs for EV buyers and manufacturers. The involvement of entities such as the Engineering Development Board (EDB), National Transmission and Dispatch Company (NTDC), NEPRA, and various provincial governments is critical to address infrastructure challenges, standardize regulations, and promote research and innovation in EV technologies. To enhance efficiency and mitigate the potential for regulatory overlap, a comprehensive governance structure, underpinned by inter-ministerial collaboration and strategic oversight, is essential to advance Pakistan's EV transition while aligning with broader environmental and economic goals.

The successful implementation of Pakistan's National EV Policy hinges on effective coordination across numerous federal and provincial stakeholders, with the Ministry of Climate Change playing a pivotal leadership role. Given the diverse range of stakeholders involved—including various ministries, provincial governments, and regulatory bodies—there is a critical need for a cohesive and integrated approach to policy execution. The Ministry of Climate Change must leverage its position to foster inter-agency collaboration, ensuring that each entity's efforts align with the overarching objectives of reducing emissions and promoting sustainable transport. However, the multiplicity of stakeholders presents challenges in terms of potential overlaps, conflicting priorities, and delays in decision-making. It is essential for the Ministry of Climate Change to anticipate these challenges and address them through proactive management and regular inter-ministerial meetings. This would help streamline efforts, avoid duplication of work, and ensure that all parties are moving in the same direction.

Also, the delay in finalizing a comprehensive policy on EV charging infrastructure has also been a major setback for EV manufacturers and potential investors[84]. Disagreements among stakeholders and a lack of coordination between various governmental bodies have created a policy vacuum, leading to uncertainty in the market. For instance, while NEPRA has drafted regulations for EV charging stations, they remain unfinalized, causing hesitation among investors and EV manufacturers about committing to the market. Standardization and compliance, particularly concerning charging infrastructure and vehicle specifications, require close cooperation between technical bodies like the Engineering Development Board (EDB), NEPRA, and the National Transmission and Dispatch Company (NTDC).

One of the most significant barriers to the establishment and profitability of EV charging stations in Pakistan is the high cost of electricity. As reported, urban EV charging stations purchase electricity at prices between Rs90 and Rs105 per unit but are only allowed to sell it at Rs75 to Rs100 per unit. On motorways, the situation is even worse, with the purchase price at Rs160-Rs170 per unit and a selling price capped around Rs150[85]. This pricing discrepancy results in negative margins, making the business model of EV charging stations unviable. This high cost can be attributed to several factors:

- **Inefficiencies in the Power Sector:** The power generation and distribution sector in Pakistan is plagued by inefficiencies, high losses, and an inability to produce affordable electricity. These inefficiencies result in high input costs for electricity, which are then passed on to end users, including EV charging stations.
- **Regulatory Constraints:** NEPRA regulates the pricing structure for electricity, which appears to have not fully accounted for the cost disparities between the electricity purchase and resale prices by charging stations. This regulatory framework has inadvertently created a disincentive for potential investors in EV infrastructure.

The Ministry of Climate Change should act as a facilitator, bringing together these technical agencies with industry representatives to develop harmonized standards that support both local manufacturing and international competitiveness. Overall, the Ministry of Climate Change must navigate a complex landscape of stakeholders and objectives, balancing the urgent need for environmental sustainability with the practical requirements of economic growth and energy security. By fostering collaboration, ensuring regulatory coherence, and maintaining a strategic focus on long-term goals, the ministry can lead the successful implementation of Pakistan's EV ambitions.

[84] As of August 27, 2024; https://humenglish.com/business/lack-of-ev-charging-network/
[85] https://www.brecorder.com/news/40277329

6.3. EV Adoption in Malaysia and Lessons for Pakistan

A policy shift toward EV adoption is crucial for Pakistan as it aims to modernize its transportation sector and reduce greenhouse gas emissions in line with its commitments to sustainable development and climate resilience. In 2024, several Asian countries have made significant progress in advancing e-mobility through robust policy frameworks that incentivize EV adoption, develop charging infrastructure, and promote domestic manufacturing.

Malaysia is witnessing a substantial increase in EV adoption, driven by global trends and bolstered by government incentives. These incentives include tax exemptions for imported EVs (valued at a minimum of RM100,000) until 2025 and for locally assembled EVs until 2027, alongside tax benefits for green investments in EVs and associated infrastructure. The nation's Low Carbon Mobility Blueprint (LCMB)[86] and National Energy Transition Roadmap (NETR)[87] aim for ambitious targets: reaching 20% of the Total Industry Volume (TIV) by 2030, with an interim goal of deploying 10,000 EV chargers by 2025 to address concerns around range anxiety and accessibility.

As the third-largest automotive producer in Southeast Asia[88], Malaysia is positioning itself as a regional hub for EV production, capitalizing on its robust automotive and electronics sectors. The New Industrial Master Plan 2030 (NIMP2030)[89] envisions Malaysia as a center for affordable EVs, partnering with local automakers like Proton and Perodua to drive this growth. To this end, the government has enacted strong policies, focusing on installing 3,000 public EV charging stations and fostering a local supply chain for critical components, including advanced batteries. The Malaysia Electric Vehicle Charging Network (MEVnet)[90] supports this initiative by providing a comprehensive dashboard that maps both existing and planned EV charging infrastructure, facilitating strategic planning and monitoring.

A notable effort is the GEF-backed[91] and UNIDO-supported project that promotes renewable energy-based smart charging solutions, vehicle-to-grid integration, and battery swapping, which collectively contribute to developing a robust EV economy. Malaysia's strategy highlights collaboration across government bodies, industry partners, and international stakeholders to ensure that policies are not only comprehensive but also pragmatic and context-specific. The National EV Steering Committee and Task Force[92] play crucial roles in fostering such partnerships, encouraging stakeholders to develop innovative solutions that promote the accelerated uptake of zero-emission trucks and other e-mobility technologies.

[86] https://www.mgtc.gov.my/what-we-do/low-carbon-mobility-2/low-carbon-mobility-blueprint/
[87] https://www.ekonomi.gov.my/sites/default/files/2023-09/National%20Energy%20Transition%20Roadmap_0.pdf
[88] https://www.mida.gov.my/wp-content/uploads/2024/01/1.-Automotive-SIB-2022-2023.pdf
[89] https://www.nimp2030.gov.my/
[90] https://www.planmalaysia.gov.my/mevnet/
[91] https://www.thegef.org/sites/default/files/documents/10270_CEO_Endorsement_Request_1.pdf
[92] https://paultan.org/2023/06/26/new-national-ev-steering-committee-formed-to-speed-up-infra-development-resolve-issues-tengku-zafrul/

To accelerate the development of EV public charging infrastructure, Pakistan's Inter-Ministerial Committee on Electric Vehicles, led by the Ministry of Climate Change and Environmental Coordination (MOCC&EC), needs to strategically leverage interministerial coordination, similar to the role played by Malaysia's National EV Steering Committee (NEVSC). The NEVSC has been instrumental in bringing together diverse government bodies, to align on EV policy, infrastructure deployment, and market development. By coordinating efforts across these ministries, Malaysia aims to expand its charging network from 1,000 to 10,000 stations by 2025 and achieve 38% EV sales by 2040. The committee should prioritize establishing public-private partnerships, incentivizing the installation of charging stations, and ensuring grid readiness for increased EV adoption. By setting clear infrastructure targets and fostering a synergistic approach among ministries, the committee can fast-track the development of a robust EV ecosystem in Pakistan, positioning it as a leader in sustainable transport within the region and effectively contributing to its climate mitigation objectives.

To reduce GHG emissions in Pakistan's transport sector, a comprehensive policy framework must be implemented that addresses local challenges and leverages specific opportunities. Beyond promoting EVs, Pakistan should focus on scaling up public transportation systems, particularly in congested urban centers like Karachi and Lahore, where the reliance on private vehicles exacerbates air pollution and GHG emissions. Expanding and modernizing the BRT networks and integrating them with emerging technologies, can significantly reduce emissions by shifting commuters away from private cars to efficient, low-emission public transport. Additionally, adopting Euro-5 and Euro-6 fuel standards is critical, especially given the current reliance on older, more polluting vehicle fleets. Improving fuel quality not only aligns Pakistan with international standards but also directly reduces particulate matter and NO_X emissions, which are severe in urban areas. Furthermore, there is a strategic opportunity for Pakistan to participate in international carbon markets by developing certified projects that demonstrate verifiable emission reductions. For instance, promoting biofuels, enhancing freight logistics, and incentivizing non-motorized transport can create carbon credits that generate revenue and attract international climate finance. To capitalize on these opportunities, Pakistan must strengthen its policy and regulatory frameworks, ensure robust interministerial coordination, and build capacity to engage effectively with global carbon markets. This integrated approach will not only help Pakistan meet its NDCs under the Paris Agreement but also support economic growth and improve urban air quality, enhancing the overall resilience of the transport sector to climate change.

7. Conclusion:

To effectively engage in carbon markets under Article 6 of the Paris Agreement, Pakistan must strategically address the existing challenges within its transport sector while positioning itself to capitalize on the financial and technical opportunities these markets offer. The transport sector in Pakistan is a significant contributor to greenhouse gas emissions, and while there is strong government commitment through policies like the National Transport Policy 2018 and the National Electric Vehicle Policy 2019, several barriers hinder progress. High upfront costs for electric vehicle adoption and lack of policy approval on charging infrastructure, coupled with a lack of technical expertise and fragmented regulatory frameworks, pose substantial challenges. These issues are exacerbated by limited coordination among federal, provincial, and local authorities, which leads to inefficiencies and delays in implementing sustainable transport projects.

Despite these challenges, there is a considerable opportunity for Pakistan to leverage carbon finance through Article 6, which allows for voluntary cooperation between countries to trade internationally transferable mitigation outcomes (ITMOs). For example, Pakistan can learn from Thailand's successful transaction with the Swiss Klik Foundation, which utilized carbon credits generated from the deployment of EV buses. This transaction demonstrates how targeted, low-carbon transport initiatives can generate ITMOs that are valuable in the global carbon market. By focusing on similar projects, such as expanding EV bus fleets and developing Bus Rapid Transit systems, Pakistan can create a pipeline of projects that generate significant emissions reductions and are eligible for carbon credit trading. As technical and jurisdictional challenges in the emissions trading market are addressed, it is anticipated that the ITMO market will expand rapidly, with projects like the Bangkok E-Bus Programme leading the way. The continued evolution of the Article 6 mechanisms will likely provide greater clarity and opportunities for similar initiatives, reinforcing the critical role of carbon markets in global climate strategies.

To address the multifaceted challenges posed by rapid urbanization, climate change, and sustainability in the transport sector, there is an urgent need to implement systemic transformations that integrate strategies across transport, sustainability, and climate action domains. The "Avoid-Shift-Improve" (ASI) framework provides a comprehensive approach to tackling these challenges by reducing the need for motorized travel ("Avoid"), promoting more sustainable modes of transport ("Shift"), and enhancing the efficiency and environmental performance of transportation systems ("Improve"). When applied effectively across both passenger and freight transport, this approach fosters integrated, inter-modal, and multi-dimensional solutions that are essential for achieving sustainable development goals. In a world of interconnected challenges, the opportunity lies in finding solutions for systemic transformation that cut across transport, sustainability and climate action. Applying "AvoidShift-Improve" measures

across passenger and freight transport through integrated, inter-modal and multi-dimensional approaches remains critical to deliver such cross-cutting solutions.

By addressing these structural challenges and strategically positioning its transport sector within the framework of Article 6, Pakistan can enhance its ability to meet its Nationally Determined Contributions, generate revenue through carbon credit sales, and attract international investment. Strategic policy measures are crucial to catalyze this transition. These include setting ambitious national, regional, and city-specific targets for the electrification of transport modes, establishing financial incentives to support the adoption of electric vehicles and other sustainable technologies, and creating zero-emission zones in urban and regional areas to reduce greenhouse gas emissions and improve air quality. Furthermore, policy strategies must also focus on encouraging behavioral changes, such as promoting public transit, cycling, and walking, and discouraging car dependency through pricing mechanisms and regulations.

A coordinated approach led by the Ministry of Climate Change & Environmental Coordination is essential to align efforts across ministries, streamline regulatory frameworks, and ensure robust monitoring and verification processes for carbon credit generation. By strategically positioning itself in the carbon markets, Pakistan can secure necessary funding, incentivize private sector participation, and accelerate the shift towards a low-carbon, sustainable transport system, enhancing its resilience to climate change and contributing to its global climate commitments.

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