COMCEC

COMCEC COORDINATION OFFICE

October 2023

MEASURING THE ENVIRONMENTAL IMPACTS OF TRANSPORT INFRASTRUCTURE IN OIC MEMBER COUNTRIES

2023

MEASURING THE ENVIRONMENTAL IMPACTS OF TRANSPORT INFRASTRUCTURE IN OIC MEMBER COUNTRIES

COMCEC COORDINATION OFFICE
October 2023

Cooperation for Development
COMCEC

For further information please contact:
COMCEC Coordination Office
Necatibey Caddesi No: 110/A
06100 Yücetepe
Ankara/TÜRKIYE
Phone: 90 312 294 57 10
Fax: 90 312 294 57 77
Web: www.comcec.org
*E-book: http://ebook.comcec.org
ISBN: 978-625-7621-12-0

CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Alternative Fuels (AF)
Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET)
Area License Scheme (ALS)
IPCC's Sixth Assessment Report (AR6)
ASEAN Regional Strategy on Sustainable Land Transport (ARSSLT)
Association of Southeast Asian Nations (ASEAN)
Adaptive Traffic Control Systems (ATCS)
Aviation Environmental Design Tool (AEDT)
Benefit-Cost Analysis (BCA)
Battery Electric Vehicles (BEVs)
Bureau of Transportation Statistics (BTS)
Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)
Clean Air Act (CAA)
Corporate Average Fuel Economy (CAFE)
Carbon Fibre Reinforced Polymer (CFRP)
Methane (CH4)
Congestion Mitigation and Air Quality Improvement (CMAQ)
Compressed Natural Gas (CNG)
Carbon Monoxide (CO)
Carbon Dioxide (CO2)
Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC)
Chronic Obstructive Pulmonary Disease (COPD)
Diesel Emissions Quantifier (DEQ)
Decibels (dB)
Day-Night Average Sound Level (Ldn)
Department of Transportation (DOT)
European Alternative Fuels Observatory (EAFO)
European Commission (EC)
European Environment Agency (EEA)
Energy and Emissions Reduction Policy Analysis Tool (EERPAT)
Environmental Impact Assessment (EIA)
Energy Independence and Security Act (EISA)
End of Life Vehicles (ELV)

Electronic Open-Road Tolling (EORT)
Environmental Protection Agency (EPA)
European Union (EU)
Electric Vehicles (EVs)
Federal Aviation Administration (FAA)
Federal Highway Administration (FHA)
Greenhouse Gas Assessment Spreadsheet for Capital Projects (GASCAP)
Greenhouse Gases (GHG)
Heavy-Duty Vehicle Emissions Calculator (HDVEC)
High Occupancy Vehicles (HOV)
Inventory of Carbon and Energy (ICE)
Integrated Noise Model (INM)
International Energy Agency (IEA)
International Convention for the Prevention of Pollution from Ships (MARPOL)
International Maritime Organization (IMO)
Institute of Noise Control Engineering of the USA (INCEUSA)
United Nations (UN)
International Civil Aviation Organization (ICAO)
Intergovernmental Panel on Climate Change (IPCC)
Low Emission Zones (LEZs)
Liquefied Natural Gas (LNG)
Master Plan on ASEAN Connectivity (MPAC)
Nitrous Oxide (N2O)
National Ambient Air Quality Standards (NAAQS)
National Environmental Policy Act (NEPA)
Natural Fibre-Reinforced Plastics (NFRP)
National Highway Traffic Safety Administration (NHTSA)
Noise Measurement Handbook (NMH)
Non-Motorized Transportation (NMT)
Non-Methane Volatile Organic Compounds (NMVOC)
Nitrogen Oxides (NOX)
New Plate Quota (NPQ)
Ozone (O3)
Organization for Economic Cooperation and Development (OECD)
Organization of Islamic Cooperation (OIC)
Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE)
Plug-in Hybrid Electric Vehicles (PHEV)
Particulate Matter (PM)
Rapid Policy Analysis Tool (RPAT)
National Medium-Term Development Plan (RPJMN)
Regional Strategic Planning Model (RSPM)
Sustainable Aviation Fuels (SAF)
Sustainable Development Goals (SDGs)
Strategic Environmental Assessment (SEA)

Sulphur Hexafluoride (SF6)
Strategic Highway Research Program (SHRP)
Sulphur Oxide (SOX)
Sustainable Urban Mobility (SUM)
Sustainable Urban Mobility Plans (SUMP)
Transportation Alternatives Program (TAP)
Traffic Noise Model (TNM)
United Kingdom (UK)
Urban Mobility Plan (UMP)
United Nations (UN)
United Nations Environment Programme (UNEP)
Unification of Accounts and Marginal Costs for Transport Efficiency (UNITE)
United States (US)
United States of America (USA)
U.S. Environmentally Extended Input-Output Model (USEEIO)
Volatile Organic Compounds (VOC)
Waste Reduction Model (WARM)
Water Framework Directive (WFD)
World Health Organization (WHO)

CHAPTER 1

EXECUTIVE SUMMARY

1. INTRODUCTION

Transportation infrastructure is irreplaceable in daily mobility, supply chain systems, and socioeconomic development. It is anticipated that by 2040, investments in transportation infrastructure will reach a staggering USD 97 trillion. This significant growth is driven by urbanization, population growth, and the expanding scope international trade.

Countries worldwide are committed to implementing effective and low-emission transport modes, given that transportation accounts for 37% of greenhouse gas (GHG) emissions. The ultimate goal is to achieve the Net Zero Goal. To attain this ambitious target, several key strategies must be embraced. These include the rapid adoption of electric vehicles, energy-saving technologies and operational practices, the increased utilization of low-carbon fuels, and the enactment policies that encourage the adoption of transportation modes with reduced carbon emission.

The development of new transportation infrastructure often necessitates the incorporation of sustainable transportation systems. This entails not only the creation of environmentally friendly infrastructure but also the integration of innovative micro-mobility solutions.

Connecting environmental factors is essential for comprehending the environment impact of transportation. Environmental issues span from local concerns like noise pollution and CO_2 emissions to global problems like climate change. These effects manifest at various geographic scales, including continental, national, and regional levels. It is of utmost importance to establish design guidelines for transportation infrastructure that prioritize minimizing harmful environmental effects and protecting ecosystems. The transport sector ranks third, following power generation and industrial activities regarding its contribution to climate change. This contribution is primarily due to air pollution and GHG emissions. Effective GHG mitigation initiatives in many countries depend on addressing these emissions.

Transportation policies and regulations are enacted by societies to address environmental impacts. Government agencies are responsible for enforcing these standards, while advocacy groups promote and defend environmental concerns. The extent and effects of these policies vary significantly depending on their level of implementation and geographic scope.

The **European Green Deal** sets a bold target of reducing GHG emissions from the transportation sector by 90% by 2050. Achieving this goal necessitates substantial investments in low-emission transportation modes. Across the globe, regulatory laws and measures are being implemented to address the environmental impacts of transport infrastructure and services.

The Strategic Environmental Assessment (SEA) play a central role. SEA is a systematic approach designed to evaluate the potential impacts of draft laws, public plans, and programs across various sectors, including transportation, infrastructure, energy, private sector development, agriculture, rural development, water, and sanitation. The European Union (EU) Directive (2001/42/EC) underscores the importance of developing sustainable plans that consider a multitude of many factors, including biodiversity, water, air, soil, climate age, human health, population, migration, and economic impacts. SEA offers the potential to significantly enhance transport planning by integrating these critical environmental factors into the decision-making process.

Additionally, the EU Environmental Impact Assessment (EIA) Directive plays a key role in evaluating the potential environmental impacts of significant infrastructure projects. This directive is integral to the project appraisal process and involves a comprehensive assessment of the project and its environmental implications. It encompasses the identification of anticipated impacts, the proposal of mitigation measures, and the implementation of monitoring procedures. EIA is mandatory for listed projects expected to have significant environmental effects.

This document serves as a comprehensive guidebook designed to fulfil a systematic roadmap for OIC member countries to effectively identify and evaluate the environmental impacts associated with transportation infrastructure projects. The methodology employed herein encompasses a multifaceted approach, combining desk-based case studies with informative field trips, enabling a deep exploration of best practices, challenges, and sustainable development pathways. The study's scope encompasses five countries that have garnered recognition for their advanced environmental awareness and expertise in environmental impact measurement.

The study focuses primarily on reviews by known countries on the "effective measurement of environmental impacts" that lies behind their success in reducing the environmental impacts of transport. Specific, the United States, the United Kingdom, and Singapore have been selected due to their unique and effective strategies. These encompass the adoption of electric and hybrid vehicles, the establishment of robust public transportation systems, and the utilization of sustainable fuel technologies.

The study also includes field visits to Malaysia and Jordan to gain a deeper understanding of the environmental impacts of transportation infrastructure within the context of OIC member countries. These visits serve as invaluable opportunities to engage directly with local transport systems, interact with stakeholders, and observe sustainable practices in action. These countries are not only known for their achievements in reducing the environmental impacts of transportation but also for the factors behind these achievements. This hands-on approach enables a more precise assessment of environmental impacts and a comprehensive examination of the intricate interplay between transport, social behaviour, and environmental considerations within these countries. Factors contributing to their success include stringent emissions regulations, widespread public awareness campaigns, robust public transportation infrastructure, and incentives for adopting eco-friendly transportation options.

The case studies provide a detailed overview of each country's transport sector, encompassing a detailed examination of legal regulations, assessment methodologies, programs, guidelines, data collection mechanisms, and efforts to mitigate and adapt to environmental impacts. By delving into the experiences of these five countries, the study aims to facilitate a common understanding among OIC member countries regarding project assessment procedures and the significance of prioritizing environmentally responsible transportation infrastructure.

A web-based questionnaire was designed to measure the impacts of transport infrastructure investments and services in OIC countries. This questionnaire systematically collected information from various stakeholders, including government officials, experts, practitioners, and communities. It consisted of twenty questions prepared to obtain measurable data on key metrics, crucial, including project management, policy framework, assessed environmental impacts, energy consumption, emission reduction, emerging technologies, standardized indicators, investment allocation, and modal split.

The questionnaire was widely disseminated through multiple communication channels, engaging key stakeholders with expertise in transport and environment topics. Participants were given a specific deadline to complete the questionnaire. The outcomes of this data-driven approach are detailed in the Survey Results section. This data-driven approach ensures guidelines are based on reliable insights, enabling OIC countries to make well-informed and sustainable transport decisions.

In conclusion, this guidebook is an extensive source of knowledge and insights dedicated to decision-makers from OIC member countries. It offers a deep understanding of the environmental impacts of transportation infrastructure and serves as a valuable resource for navigating the complexities of sustainable and responsible transportation development. By drawing from global best practices, case studies, regulatory frameworks, and data-driven approaches, this guidebook equips leaders with the necessary tools and knowledge to make informed decisions that prioritize environmental stewardship and promote sustainable development in transportation infrastructure. These strategies and principles will help guide the path towards a more sustainable, eco-friendly, and resilient future for OIC member countries, ensuring the well-being of ecosystems and communities for generations to come.

1.1. Background

The Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC) has commissioned a study entitled "Measuring Environmental Impacts of Transport Infrastructures in Organization of Islamic Cooperation (OIC) Member Countries". This chapter summarizes the objectives of the research and the structure of this report.

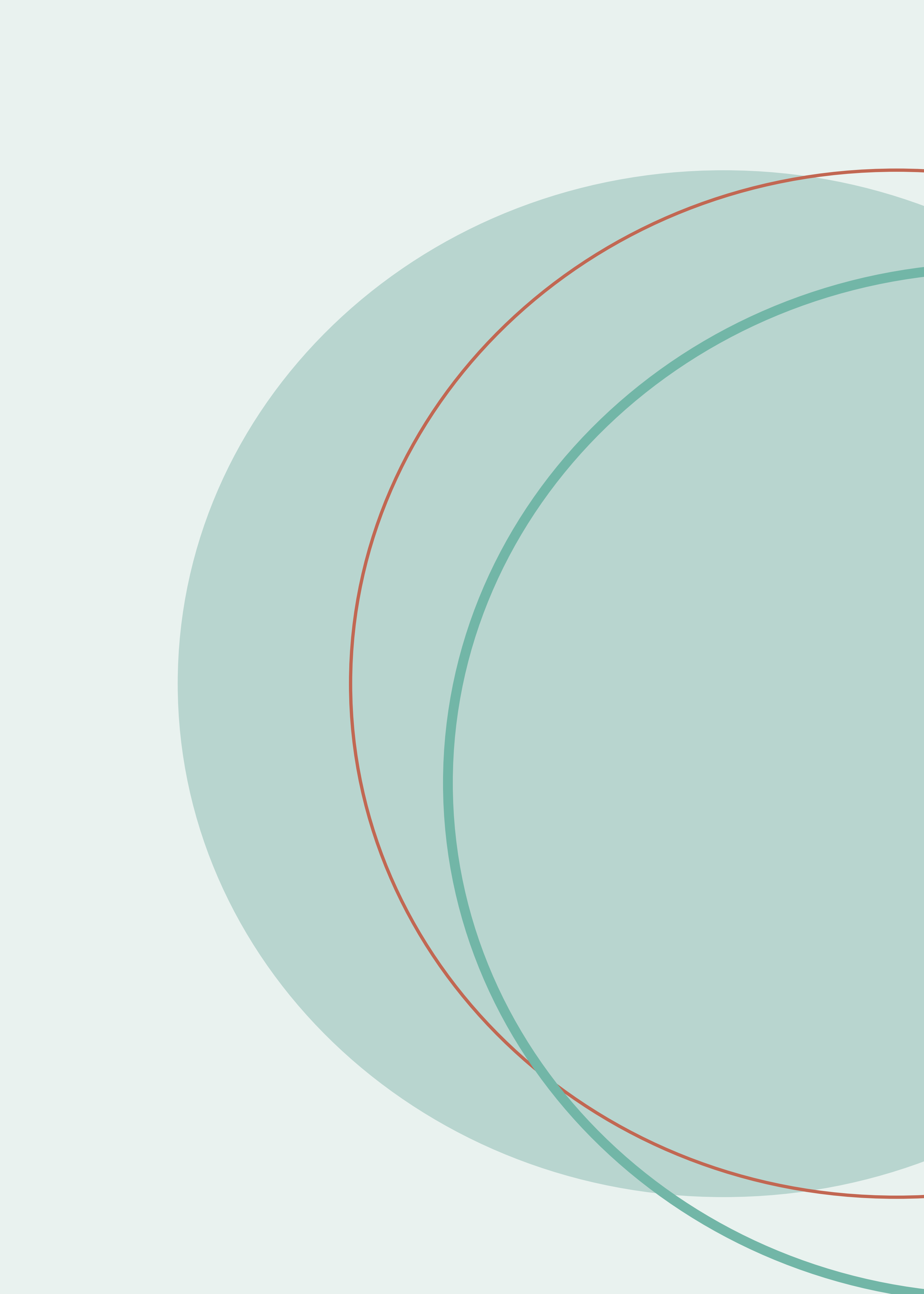
1.2. Objective of the Study

The main objectives of the study are outlined in the respective terms of reference as follows:

- To examine the methods and models that are well applied in the world for measuring the environmental impacts of transportation infrastructures.
- To prepare a handbook describing the steps for the OIC member countries to that end.
- To examine best practices, innovative approaches and successful initiatives in measuring the environmental impacts of transport infrastructures in OIC member countries or outside.
- To produce a handbook that can guide countries in this regard.
- To prepare a guiding document for decision-makers in terms of calculating the environmental impacts of transportation infrastructures from the planning stage to the implementation and post-implementation period and providing evidence-based input in their policy designs.

1.3. Contents of This Report

Chapter 2 and 3 of this report summarizes the conceptual framework, methodology and outlines the relevant literature on how transport infrastructure and services create environmental impacts. Chapter 4 presents the findings of the three good practice case studies outside the OIC geography. The case study countries which have been selected from North America, Europe and Asia are The United States (USA), The United Kingdom (UK), and Singapore, respectively. Chapter 5 outlines the general situation in OIC member countries and gives a comprehensive evaluation of selected countries: Malaysia and Jordan. Chapter 6 examines the responses to an OIC-wide questionnaire. Chapter 7 determines a unique model and methodology for OIC Member Countries for the measurement of environmental impacts of transport infrastructures and defines a step-by-step. Chapter **Hata! Başvuru kaynağı bulunamadı.** outlines the conclusion and discusses the policy implications.



CHAPTER 2

2. Conceptual Framework and Literature Review

2.1. Global Transport Infrastructure and the Path to Sustainability

Efficient transport infrastructure is vital for a well-functioning, interconnected world, supporting daily mobility, supply chains, and socio-economic development. With increasing global investment in transport infrastructure, projected to reach $97 trillion USD by 2040, driven by factors like population growth, urbanization, and global trade expansion, it plays a pivotal role in meeting the needs of a growing population and economic activities (Heathcote, 2017).

In response to global environmental concerns and commitments to the Paris Agreement and United Nations Sustainable Development Goals (SDGs), countries worldwide are striving for a Net Zero future, aiming to limit global warming and address various social, economic, and environmental challenges. The transportation sector, a major contributor to greenhouse gas (GHG) emissions, must reduce its emissions by nearly 20% to less than 6 Gt by 2030 (International Energy Agency [IEA], 2022). Achieving this entails transitioning to electric vehicles, energy-efficient operations and technology, increased use of low-carbon fuels (particularly in maritime and aviation sectors), and policy shifts toward lower carbon-emitting travel options (COMCEC, 2023).

While transport infrastructure primarily serves mobility, embracing sustainability often involves establishing new, environmentally friendly transportation options, systems, and infrastructure. This includes sustainable transport systems, infrastructure development, and micro-mobility solutions. Combining infrastructure improvements and intelligent transport technologies can even reduce vehicle travel demand by 10–15%, as suggested by the Intergovernmental Panel on Climate Change (IPCC) in a report by (Ribeiro & Kobayashi, 2007).

In an ever-evolving world, the expansion of passenger and freight mobility has resulted in increased environmental impacts from the transportation sector. Environmental impacts are influenced by the level of activity, emission factors, pollution load and mode-specific parameters. These environmental impacts can be categorized into three distinct groups are Direct, Indirect and Cumulative, as explained below:

- Direct impacts: These immediate negative influences on the environment arise directly from transportation activities and are often well-recognized with evident cause-and-effect relationships. Examples include noise pollution from motor vehicles, visual pollution such as heavy roadside parking, and carbon monoxide (CO) emissions (Cahill, 2010). Freight mobility can contribute to direct impacts through the emission of nitrate and sulphate aerosols, organic and black carbon, which affect climate and visibility by scattering/absorbing radiation and influencing radiative balance (OECD, 2010). Diesel-powered cars, in particular, emit black carbon, estimated at around 1.8 Tag carbon per year, contributing significantly to direct impacts (Hester & Harrison, 2004).
- Indirect impacts: These secondary or tertiary effects of transportation-related activities on environmental systems can accumulate over time and have potentially greater consequences than direct impacts. For instance, PM generated from motor activities can lead to various health problems. Air transportation, specifically, produces particles that generate indirect effects by initiating other physical or chemical processes at higher altitudes, where pollution is more damaging. This results in radiative forcing, enhanced ozone (O_3) in the troposphere, destruction of methane (CH_4), and increased production of greenhouse gases (GHG) (Daley, 2010). Freight transportation contributes to indirect effects through aerosols that lead to an increased number of cloud drops, increased reflected solar radiation, and subsequent cooling effects (OECD, 2010).
- Cumulative impacts: These refer to the combined and multiplying impacts of transportation activities on ecosystems, such as climate change, and consider the complex causes and effects resulting from both direct and indirect impacts. Transportation affects various natural and human-made elements, leading to intricate and sometimes unforeseen (Rodrigue, 2020).

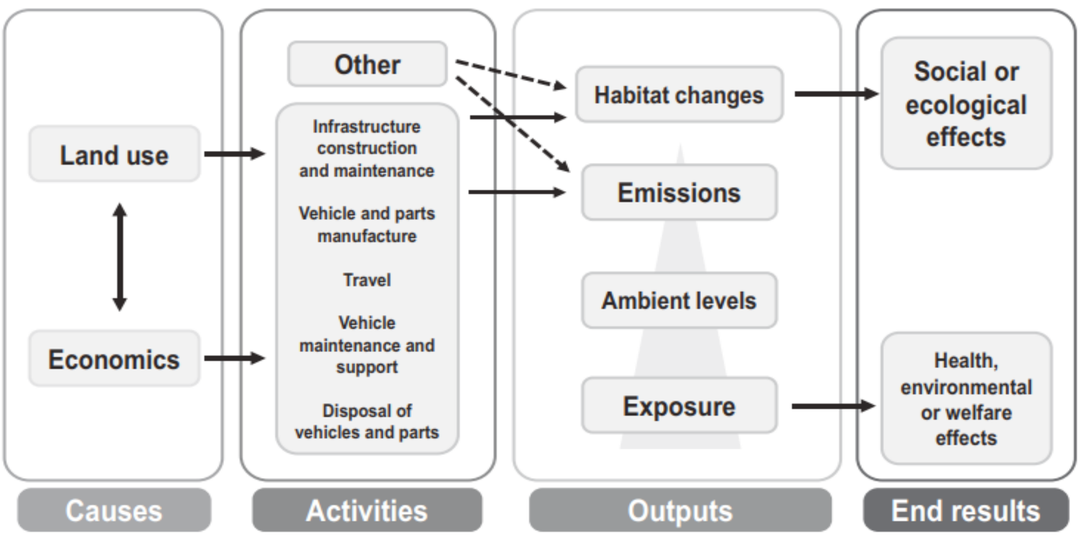
The connection between transportation and the environment is complex and intertwined. The factors that drive transportation, the actions involved, the results produced, and the ultimate consequences are all interconnected with the environmental effects they create. The Environmental Protection Agency (EPA) provides a visual representation, shown in the Figure 2.1, that illustrates the environmental dimensions of transportation (EPA, 2000).

- Causes: The level of transportation activity can be attributed to two main factors as economic aspects and land use. The economic aspect relates to income levels, development, and the availability of transportation services. Generally, industrialized economies have higher per capita transportation activities compared to developing economies. The spatial organization and distribution of transportation demand is referred to as land use, which indirectly impacts travel times and transportation modes needed to sustain economic activities.
- Activities: These encompass various elements that signify the utilization of transportation infrastructure and related services to facilitate the functioning of

the transportation system, particularly operational activities. Environmental impacts arise from each of these activities.

- Outputs: The primary outcome of transportation activity is the emission of various pollutants. The levels of pollution generated are influenced by the geographical characteristics of the regions where emissions occur. The degree of exposure to dangerous pollutants can be assessed once these levels are linked with population density and activity levels. Consequences are probably in place for such exposure.
- End results: This refers to the overall and often challenging-to-quantify consequences on human health, the environment, and well-being resulting from exposure to pollutants emitted by transportation activities.

Figure 2.1: Environmental Dimensions of Transportation *(EPA, 2000)*



Understanding the impacts requires creating connections between environmental dimensions. Two further observations add to the complexity of the connections between transportation and the impact on the environment (Rodrigue, 2020):

- Level of Contribution: Transportation activities, along with other human-made and natural sources, make significant contributions to environmental issues. Their influence can vary depending on the context, sometimes being readily evident while in other cases, more challenging to ascertain.
- Scale of Impact: The environmental impacts stemming from transportation activities can be observed at various geographical scales. These impacts range from local concerns such as noise pollution and CO emissions, to global issues like climate change. Additionally, transportation activities can contribute to con-

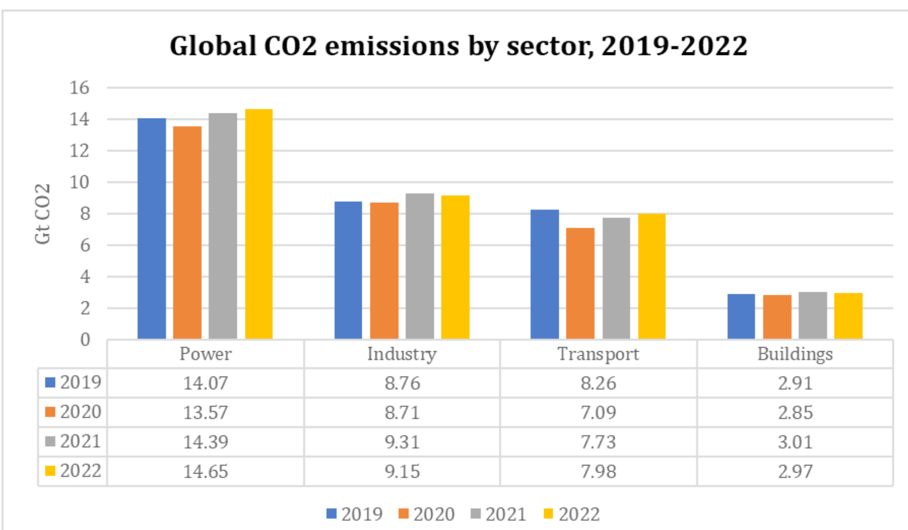
tinental, national, and regional environmental challenges, such as smog formation and acid rain.

Therefore, the contribution level and scale of impact dimensions should also be considered when measuring the environmental impacts of transportation and formulating regulatory measures; otherwise, environmental impacts may be transported elsewhere, creating unintended consequences in different geographies and contributing to climate change.

It is essential to establish design standards for transportation infrastructure that prioritize the reduction of negative environmental impacts and the preservation of ecosystems. To achieve this overarching goal, it is crucial to have a comprehensive understanding of the environmental effects associated with transport infrastructure and the specific activities that contribute to these impacts. Therefore, all phases of the infrastructure's life cycle, including construction, operation, and end-of-life, should be thoroughly analysed in terms of their environmental implications.

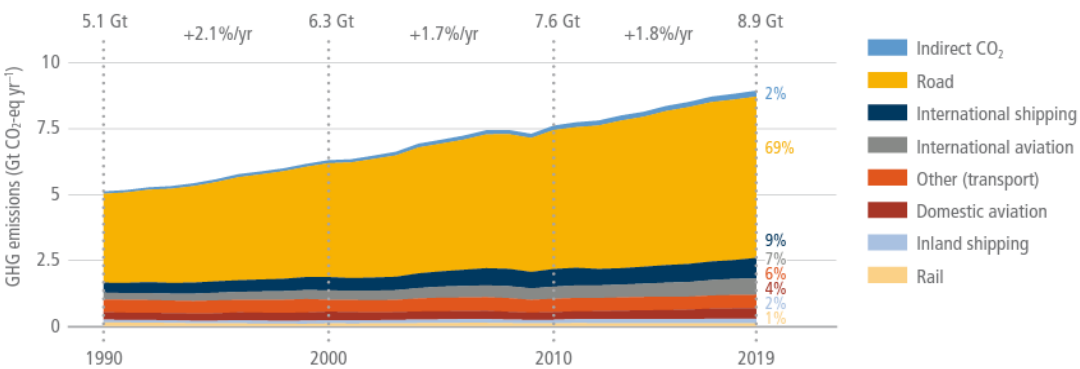
Among the significant consequences of transportation systems, two standout as fundamental climate change impacts: air pollution and GHG emissions. These topics garner considerable attention worldwide and are often the first environmental concerns associated with transportation. Analysing the distribution of global CO_2 emissions by sectors, the transport sector ranks third after power and industry sectors. Considering the last 3 years of data in Figure 2.2, it is seen that there is a decrease in 2020 due to the Covid-19 outbreak, however then the upward trend has continued (IEA, 2023). Given that the transportation sector accounts for 40% of total energy consumption globally and reflecting variations in land use, urbanization, population growth rates, and socio-economic development levels, addressing emissions from this sector is paramount for effective GHG mitigation strategies across many countries (Jaramillo, Ribeiro, & Newman, 2022).

Figure 2.2: Global CO_2 emissions by sector, 2019-2022 *(IEA, 2023)*



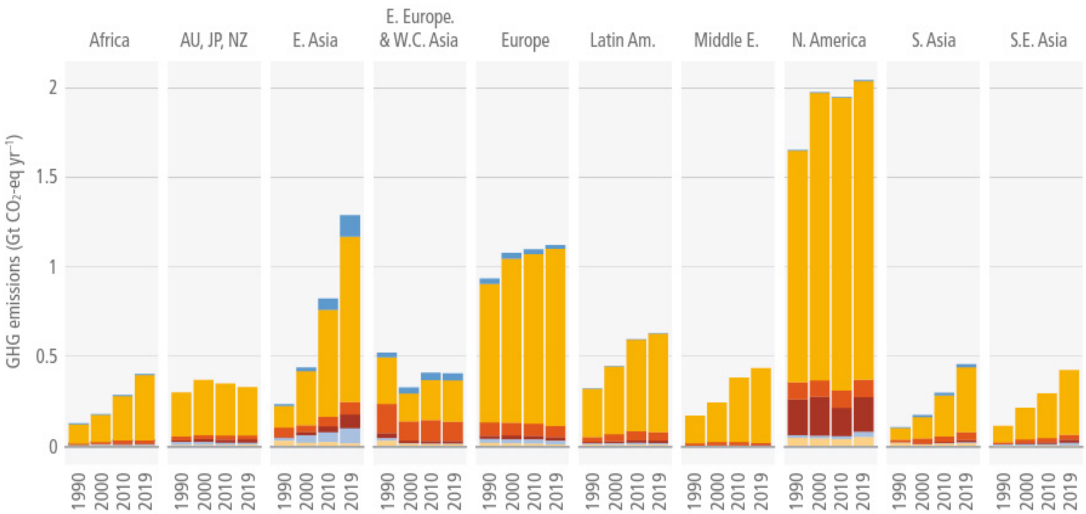
The global GHG emission trends of the transportation sector given in the IPCC's Sixth Assessment Report (AR6) shown in Figure 2.3 to examine the sector-wide pattern. Within the transportation sector, road vehicles are a significant contributor to emissions, particularly in terms of nitrogen oxide (NOx), CO_2, and CO. They are responsible for approximately 70% of the sector's emissions, with rail accounting for 1%, shipping for 11%, and aviation for 12%. The report highlights that passenger cars and light-duty trucks are the largest sources of emissions within the road transport sector, contributing to approximately 45% of the transportation sector's emissions. Additionally, heavy-duty vehicles such as trucks and buses account for approximately 20% of the sector's emissions. Apart from these emissions, road transport also plays a substantial role in generating primary particulate matter, predominantly resulting from tire and brake wear, as well as the suspension of road dust (Jaramillo, Ribeiro, & Newman, 2022).

Figure 2.3: Global GHG Emissions Trends of Transport Sector
(Jaramillo, Ribeiro, & Newman, 2022)



Another striking graph shared in the report (Figure 2.4) shows the regional GHG emissions trends of transport sector. Shared at 10-year intervals from 1990 to 2019, only Eastern Europe and West Central Asia have shown a downward trend in emissions regionally. Especially North America is seen as the main centre of emissions globally followed by Europe.

Figure 2.4: Regional GHG Emissions Trends of Transport Sector
(Jaramillo, Ribeiro, & Newman, 2022)



Despite ongoing technological advancements and the promotion of alternative fuels, fuel usage remains a significant contributor to the environmental impacts of various transportation modes. The IEA stated that for 2019, among all sectors, the share of road and aviation in final oil consumption ranks in the top two with 49.2% and 8.6%, respectively (IEA, 2021).

In the case of shipping, fuel consumption is a major source of global emissions of sulphur dioxide (SO_2) and CO_2, and it also emits SO_2 and NOx in coastal regions and port cities due to the combustion of heavy petroleum products. Additionally, shipping accidents pose further threats to the environment, including the release of toxic substances, the discharge of waste, and the introduction of invasive species. The aviation sector is responsible for approximately 2% of global CO_2 emissions resulting from fuel combustion. Apart from CO_2 emissions, aircraft also release water vapour, other gases, and aerosols at high altitudes. Moreover, the major contribute, road transportation is These emissions contribute to cloud formation and can influence the concentrations of O_3 and CH_4 in the upper troposphere and lower stratosphere. It is worth noting that while new technologies and alternative fuels are being developed, the information provided above underscores the ongoing significance of fuel usage as a key factor influencing the environmental effects of different modes of transport (Penner, Lister, & Griggs, 1999).

Proper management of vehicles at the end of their life cycle is of great importance in terms of environmental impacts. The transportation sector consumes a significant amount of materials each year for various purposes such as construction, operation, and maintenance. While materials like asphalt, concrete, plastics, and paint often end up in landfills after use, valuable materials such as steel, aluminium, copper, and other metals are partially recycled and reused in other applications. According to the End of Life Vehicles (ELV) directive, the European Union (EU) generates around 8-9 million tonnes of waste annually from vehicles, resulting in approximately 2-2.5 million tonnes of automotive shredder residue. The management of end-of-life tires also highlights the significance of waste management in the transportation sector. Improper disposal of tires can release harmful chemicals into the environment, contaminating soil, water, and air, posing risks to human health and the environment. Typically, tires are either burned for energy recovery or disposed of in landfills, both of which contribute to the emission of air pollutants such as CO, SO_2, NO_x, and volatile organic compounds (VOCs). These pollutants not only contribute to climate change but also negatively impact air quality. Globally, approximately 1 billion end-of-life tires are generated each year, with an estimated 4 billion currently in landfills and stockpiles, creating the potential for fires and infestations. However, these tires can be valuable energy input such as carbon black, oil, gas, and steel industry if properly utilized (EU, 2000).

Environmental impacts that are increasingly linked to the transportation sector are described below according to their impact areas.

2.2. The Environmental Impact of Transport Infrastructure and Services

Transportation is a domain where significant environmental impacts are generated by various factors. In this section, key environmental aspects, including land use, noise pollution, air pollution, water pollution, biodiversity loss, soil pollution, and climate change, will be explored, illuminating the intricate connection between the environment and transport infrastructure.

2.2.1. Land Use

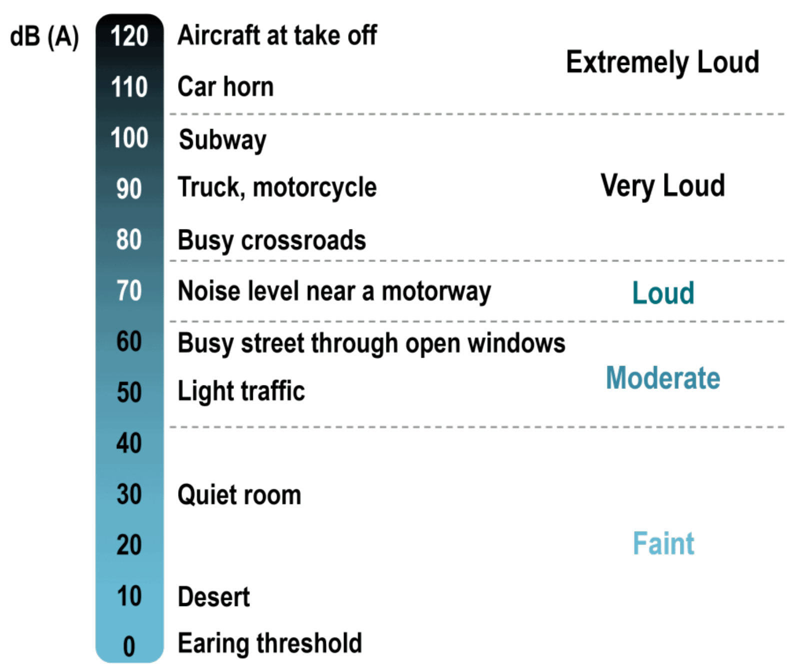
Land use and transportation are interconnected systems. Transportation infrastructures have the ability to both increase urban activity where it is present and to increase the business and economic attractiveness of a place (Morimoto, 2015). Therefore, transportation infrastructure has a footprint on the urban environment, both from its own development and from the structures it will develop within the framework of the land use. Although they meet the need for economic development, overbuilding of structures such as ports and airports can have negative impacts on natural resources and the environment (Wang, Xue, Zhao, & Wang, 2018). Major transportation hubs may detract from urban visual appeal, establish physical obstacles, increase noise pollution, emit odours, and have an influence on the built environment, every single one of which may negatively impact the quality of urban life. The expansion of logistical activities also has an indirect impact on the land take in suburban and peri-urban regions (Rodrigue, 2020). In the EU, a study by the European Environment Agency (EEA) (2016) found that the land taken by transport infrastructure, including roads, rail, and airports, increased by 6.7% between 2006 and 2012. Although the study notes that the rate of increase has slowed down since 2012, the land taken for the construction of new transport infrastructures results in fragmentation of ecosystems and land use changes.

2.2.2 Noise Pollution

According to the Institute of Noise Control Engineering of the USA (INCE-USA), noise is defined as any unwanted sound (The Institute of Noise Control Engineering of the USA, 2023). The acoustic measurement of noise intensity is expressed in decibels (dB), which vary from 1 to 120. Prolonged exposure to noise levels exceeding 75 dB impairs people's hearing and their physical and mental wellbeing. The quality of life is decreased by ambient noise, which is typically a result of traffic in urban areas and is the sum of all the noise that cars produce (which vary from 45 to 65 dB) (Rodrigue, 2020). According to the European Commission (EC), transportation is responsible for approximately 30% of urban noise pollution, and in the scope of Zero Pollution Action Plan, the number of people chronically disturbed by noise from transport is aimed to be reduced by 30% by 2030 (Zero Pollution Action Plan, 2021). In the EU, over 120 million individuals experience noise levels from road traffic exceeding 55 day-night average sound level (Ldn), which is considered detrimental (OECD, 2011). Also, according to studies, 10% of the European Union population is likely to experience significant annoyance due to noise from air transport (EEA, 2001). World Health Organization (WHO) (2022) stated that although the levels of noise produced by transportation sources are typically too low to cause biological harm, prolonged exposure to noise above a certain threshold can have negative effects on children's cognitive development, annoyance, sleep disturbance, and the cardiovascular and metabolic systems.

In Figure 2.5 below, noise levels from different sources are given. Noise levels may differ according to modes of transportation from moderate to extremely loud.

Figure 2.5: Noise Levels from Different Sources *(Rodrigue, 2020)*

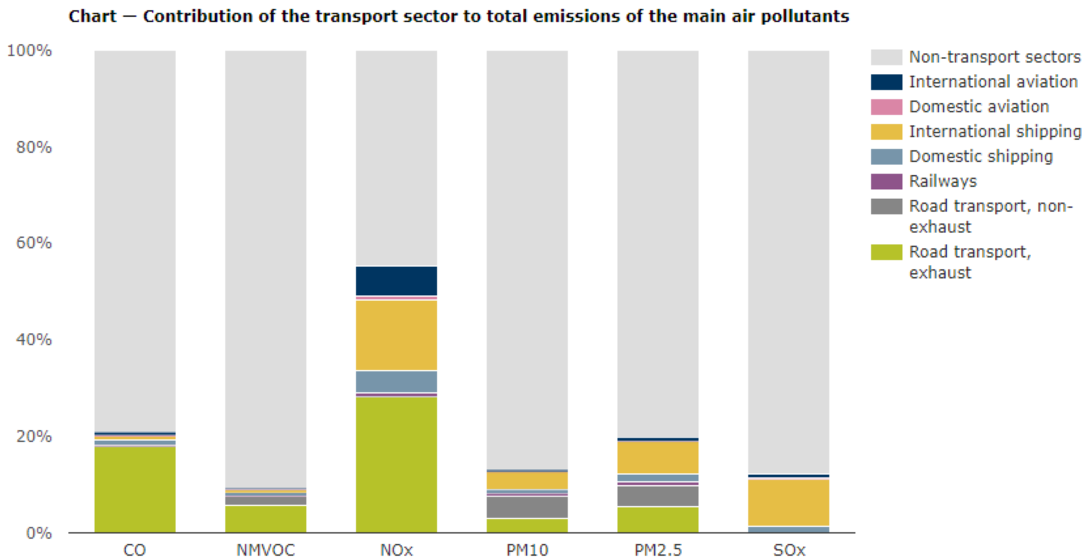


Transportation-related noise pollution can also have significant health impacts. Exposure to high levels of noise can cause stress, sleep disturbance, and cardiovascular disease (Babisch, 2014). In addition, noise pollution can also affect cognitive development and academic achievement in children (Clark & Stansfeld, 2016). Strategies to mitigate noise pollution include the use of quieter technologies, noise barriers, and land-use planning to separate residential areas from high-traffic areas (WHO, 2011). The health effects of noise on people based on evidences such as: impaired communication, disturbed sleep, and mental performance reduction in focus, attention and memory (Dora & Phillips, 2000).

2.2.3. Air Pollution

Pollution is generated by the emissions of gases and particulates from automobiles, locomotives, marine engines, and aircraft. They affect human health and impair the quality of the air. lead (Pb), CO, NOx, VOCs, sulphur hexafluoride (SF_6), benzene, heavy metals (chromium, copper, cadmium and zinc), and particulate matter (ash, dust) are the most common. The report published by OECD (2014) on air pollution and transport states that there are two risk factors under the air pollution that are associated with transportation: ambient particulate matter (PM) pollution and ambient ozone pollution. Transportation contributes significantly to NO_X emissions and PM pollution. As seen in the Figure 2.6 below, it is responsible for nearly 60% of all NO_X emissions and a considerable part of overall pollutant emissions. Road transport emissions are largely driven by emissions from gasoline combustion; however, non-exhaust emissions contribute to both non-methane volatile organic compounds (NMVOC) and primary PM emissions (EEA, 2016). Emissions of air pollutants have increased for all modes of transportation during the previous 30 years. The growth in the shipping and aviation sectors is particularly noteworthy. Since 1990, GHG emissions from international aviation in the EU have more than doubled. If no additional action is taken, CO_2 emissions from worldwide shipping might account for 17% of total CO_2 emissions by 2050. Figure 2.6 shows the contribution of the transport sector to the total emissions of the main air pollutants across the EU in 2015. It can be seen that land transport causes most of the air pollution in terms of CO, NMVOCs and NO_X, followed by international shipping, which is a significant contributor in terms of NO_X, PMs and SO_X (EEA, 2021).

Figure 2.6: Contribution of The Transport Sector to Total Emissions of The Main Air Pollutants in the EU-28 in 2015 *(EEA, 2021)*



In Zero Pollution Action Plan adopted by the EC in 2021, several actions have been highlighted related to the transportation sector in the light of 2030 targets (European Commission Joint Research Centre, 2022).

- Reducing air pollution from transport by setting ambitious air quality standards, improving the emissions performance of vehicles, and promoting cleaner fuels, including renewable and low-carbon alternatives.
- Reducing the environmental impact of shipping, including through the use of cleaner fuels and technologies, improving port operations, and promoting sustainable shipping practices.
- Promoting the uptake of zero-emission vehicles and vessels, including by supporting the deployment of infrastructure such as charging and refuelling stations and promoting the use of clean electricity and hydrogen.
- Speeding up the tendency towards sustainable and smart mobility, including zero-emission vehicles, public and active transport, and new mobility services, while ensuring that the transition is just and leaves no one behind.

Moreover, the reliance on fossil fuel-powered transportation contributes to air pollution, resulting in detrimental health effects, including respiratory and cardiovascular diseases and premature deaths (Pope & Dockery, 2006). Fine particulate matter is a particularly significant source of health worries because it can go into the organs, bloodstream, and tissues. Children and vulnerable groups, such as the elderly, pregnant women, and those with pre-existing medical conditions are more exposed to the detrimental impacts of air pollution (WHO, 2016). According to the WHO (2022), outdoor air pollution result in 4.2 million premature deaths globally each year. In accordance to an OECD report (2014), the health effects of transportation-related air pollution include respiratory conditions incşuding but not limited to obstructive pulmonary disease (COPD), lung cancer, and asthma.

2.2.4. Water Pollution

Transportation operations have an influence on water quality and hydrological conditions (Rodrigue, 2020). The direct channels to sewers that are provided by pavement, roadways, and parking lots allow pollutants such leak oil, chemical gases, brake fluid and etc. to drain unfiltered into water bodies (Clean Water Action Council, 2023). Regarding transportation-related issues, point and non-point sources are equally responsible for water contamination (Trumbull & Bae, 2000). For point sources, the following can be examples. Impervious surfaces created on the earth's surface during road construction processes cause increased runoff rates, reduce groundwater discharge levels, and affect water quality due to increased erosion. Pollutants from vehicles meet with water bodies and pollute them. Pollutants entering groundwater adversely affect groundwater quality. Moreover, oil spills, especially from the shipping sector, cause serious problems in the marine environment (Akhtar, Syakir Ishak, Bhawani, & Umar, 2021). The most notable non-point source is the impact of air pollution on water resources (Trumbull & Bae, 2000). The primary sources of maritime transport activities' detrimental effects on water quality include dredging, rubbish, ballast waters, and oil spills. Also, environmental issues arise from waste produced by ship operations at sea or at ports since it may include a significant number of bacteria that, when released into water, could be harmful to both human health and marine ecosystems (Rodrigue, 2020).

2.2.5. Biodiversity Loss

Deforestation is caused by the increased use of building materials and the expansion of transportation actvities. Many transportation routes required land drainage, which diminished wetland habitats and pushed out aquatic plant species (Rodrigue, 2020). Moreover, natural habitats and landscapes are divided up by roads, which makes it difficult for animals to navigate between the resulting habitat patches. Road traffic generates both animal aversion and animal-vehicle accidents, which are one of the primary causes of animal death in human-dominated environments (Saxena & Habib, 2022). Fragmentation and land use changes cause disturbance of wildlife and ecosystems thus leading to biodiversity loss. The inability of the EU to fulfil its aim of preventing biodiversity loss by 2010 has been connected in part to the establishment and operation of transport infrastructure, which is considered as an obstacle to meeting the goals of the EU Biodiversity Strategy to 2020 (EC, 2020).

2.2.6. Soil Pollution

Soil pollution and erosion are the two issues that the environmental impact of transportation brings (Rodrigue, 2020). In indirect manner, soil pollution starts when chemicals and PM in the air which released by vehicles and fall onto the streets and soil. In addition, various pollutants such as oils, fuels, anti-freeze fluids, engine coolants, etc. leaking from vehicles can directly meet the soil. Zinc eroded from car tires and salt added to prevent slipping on the roads in winter are also examples of direct pollutants (Clean Water Action Council, 2023). For soil erosion, the main impact is on the coastal transportation infrastructure. A considerable loss of productive land has resulted from the construction of highways or from lowering surface grades for port and airport developments (Rodrigue, 2020).

2.2.7. Climate Change

Transportation infrastructure plays a significant role in climate change through various mechanisms. The Figure 2.7 below summarizes the potential impacts of climate change on transportation operations and infrastructures. The combustion of fossil fuels releases GHGs, such as CO_2, CH_4, N_2O, and halocarbons. Rodrigue (2020) stated that differences in the atmospheric lifetime (or residence period) of GHG further complicate their unique impacts. It can range between 5 and 200 years for CO_2, 12 years or so for CH_4, and 114 years or so for NO_2. Halocarbons such as chlorofluorocarbons have a half-life of at least 45 years. According to Jaramillo et al. (2022), the transportation sector accounts for a substantial portion of the global CO_2 emissions, with road transportation being the largest contributor. In addition, as stated above, the expansion of transportation networks, including roads, harbours, and airports, often leads to deforestation, habitat destruction, and increased GHG emissions associated with the construction process. This finding is supported by Pucher & Buehler (Pucher & Buehler, 2017), who highlighted the correlation between urban sprawl, automobile dependence, and higher transportation-related emissions. Along with its emissions, increased air traffic has resulted in a rise of contrails, which are mostly ice crystals formed by condensation surrounding aircraft flying at high altitudes. They paradoxically have the ability to both reflect solar energy and retain heat, which can contribute to climate change. In addition to being a contributing factor, transportation is also affected by climate change, notably in terms of operations (more weather disruptions) and infrastructure (e.g., increased flooding due to rising sea levels) (Rodrigue, 2020).

Figure 2.7: Climate Change and Its Potential Impacts on Transportation
(Rodrigue, 2020)

	Operations	Infrastructures
Heat waves	• Limits on periods of construction activity. • More energy for reefer transportation and storage.	• Thermal expansion of piers. • Pavement integrity and softening. • Deformation of rail tracks.
Rising sea levels	• Frequent interruptions of coastal low-lying road and rail due to storm surges. • Flooding of terminal areas.	• More frequent flooding of infrastructure (and potential damage) in low lying areas. • Erosion of infrastructure support. • Changes in harbor facilities to accommodate higher tides and surges.
Intensity of precipitation	• Increase in weather related delays and disruptions.	
Increasing hurricane intensity	• Frequent interruptions of air services. • Frequent and extensive evacuations of coastal areas. • Debris on road and rail infrastructures.	• Greater probability of infrastructure failure. • Greater damage to port infrastructures. • More significant flooding on hinterland infrastructures.
Increase in arctic temperatures	• Longer shipping season. • More ice-free ports in northern regions. • Availability of trans-arctic shipping routes.	• Damage to infrastructure because of the thawing of the permafrost. © GTS

2.3. Policies and Initiatives to Deal with the Environmental Impacts of Transport Infrastructure and Services

Societies often address the environmental impacts of transportation by implementing policies and regulations that set standards for emissions, operating conditions, and other related aspects. When creating legislation pertaining to the environment for transportation, the level of contribution and geographic extent must be considered. Otherwise, certain policies might just reposition the issues and produce unintended results. In recent years, there has been a growing emphasis on the environmental impact of transport infrastructure. Reducing this adverse effect of the transportation sector has been an important goal. This aim led to higher number of regulations and policies aiming to mitigate the adverse impacts of constructing transport infrastructures.

Regulatory laws and measures are being implemented worldwide to address the environmental impacts of transport infrastructure and services. In line with the European Green Deal, European countries have set a target to reduce GHG emissions from the transportation sector by 90% by 2050 (EEA, 2023). Achieving this target will require substantial investments in low-emission transportation modes, such as EV, public transport, cycling, walking, alternative fuels, carpooling and ridesharing. Various policies and initiatives are already in place to establish a framework for these investments, address challenges, and ensure widespread adoption among the public.

Since the mid-20th century, the aim of meeting the needs of the increasing population has led to more consumption of natural resources. As humanity began to face the consequences of using natural resources unnecessarily, and only for the purpose of gaining profit, the damage to the environment was realized. In order for future generations to continue their life activities, all countries of the world have agreed on the concept of sustainable development. The concept of impact assessment has emerged within the scope of environmental management.

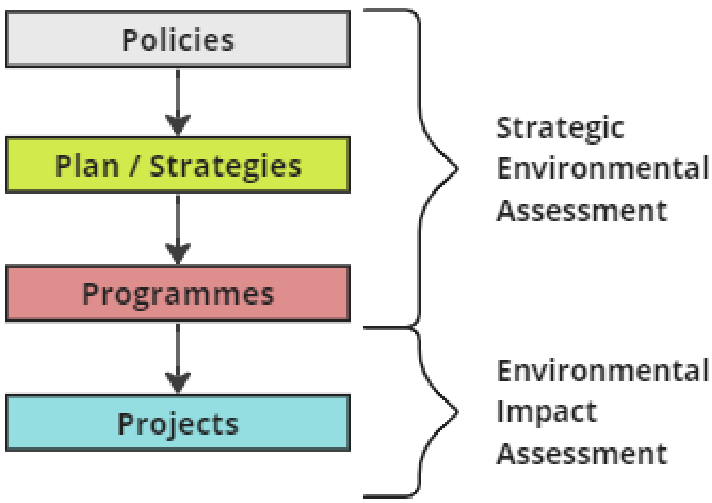
Before the development of the environmental impact assessment approach, methods for evaluating investment projects were based solely on financial criteria. For instance, the cost and benefit calculations of a project to be invested in are made and compared in financial terms. The environmental impact assessment approach was first considered as an additional dimension to this economic analysis method and was developed to consider some potential impacts that are difficult to handle in this analysis. Different countries have different environmental impact assessment regulations.

The **Strategic Environmental Assessment (SEA)** process, which includes the impact assessment approach in its broadest scope, is already practiced in many countries, including the most developed countries of the world. It is defined as a systematic process of assessing the potential impacts of draft laws, specific public plans or programs prepared by governmental organizations that are expected to have substantial environmental impacts in sectors including transportation, infrastructure, energy, private sector development, agriculture and rural development, as well as water and sanitation. In countries implementing SEA, strategic decisions and assessments are a must prior to the construction of transport infrastructure (Lee & Walsh, 1992). The main objective of this EU Directive (**2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment)** is to develop sustainable plans considering biodiversity, water, air, soil, climate factors, cultural heritage, human health, population, migration and economic impacts. It will be ensured that risk areas, natural disasters, vulnerability to risks and energy efficiency issues are considered in the preparation processes of spatial and sectoral plans where SEA is applied and measures will be developed accordingly (EU, 2001).

The EU SEA Directive states that the process required by the directive should be implemented in the preparation of a transport infrastructure plan and program by evaluating both the proposed plan and the feasible alternatives. By abandoning the "list of projects" approach, the SEA has the potential to significantly enhance transport planning at the strategic level. Some transport plans have a broad geographic and temporal scope, which presents additional complexity and uncertainty difficulties for the SEAs for those plans. In these circumstances, more adaptable methods, such qualitative analyses, may be required when evaluating environmental effects (EU, 2001).

Transportation infrastructure investments such as construction of railway lines, airports, roads, and motorways are referred to by different thresholds under the EIA process applied in many countries. The EU EIA Directive pertains to evaluating the potential environmental impacts of significant infrastructure projects as part of the project appraisal process. It serves as a fundamental element that establishes a structure for assessing the project before the approval stage. This involves describing both the project and the environment, assessing the anticipated direct and indirect impacts. The directive also encompasses evaluating alternative options, proposing mitigation measures, and implementing monitoring procedures. EIA is held obligatory for the listed projects in the Annex I of the Directive, which causes significant effects on the environment (EU, 2011). The scopes of EIA and SEA are described in Figure 2.8.

Figure 2.8: SEA and EIA in Project Planning Processes *(EEA, 2013)*



SEA and EIA are the most comprehensive and detailed impact assessment methodologies. as defined in the relevant regulations, where they are applied to transport infrastructures, all possible environmental impacts should be considered and mitigation methods should also be defined. There are also different framework regulations that allow for a stand-alone evaluation of the environmental impacts of transport infrastructures.

EIA and SEA are mentioned above as they are the two main regulations that are applied in many countries around the world and are the two most widely used regulations/approaches for the respective evaluation. The regulations/approaches listed in the Table 2 below are evaluated by giving their relations with the transportation sector and examples of their application. These regulations, which are framework documents defined in the table, are published by the European Parliament and have been adopted in many countries in alliance with the EU.

Table 2-1: Applied Framework Regulations in Transportation Sector

Regulation/ Approach	Purpose	Relevance with the Transportation Infrastructures	Implementation Example
Green Infrastructure Strategy, (COM/2013/0249 final (EU, 2013).	To preserve, restore and enhance green infrastructure to halt biodiversity loss caused by infrastructure projects.	The strategy defines green infrastructure as *"a network of natural and semi-natural areas, designed and managed to deliver multiple ecosystem services"*, such as climate regulation, water management, biodiversity conservation, and recreational opportunities. It includes specific recommendations such as green corridors along roads and railways, on promoting the integration of green infrastructure into transport planning.	- Reconnection in an existing road network - Holstein Habitat Corridors (Northern Germany) (EU, 2023): The Hamburg metropolitan region in Northern Germany is experiencing habitat fragmentation and species extinction due to extensive trans-European traffic and urban development. To restore biodiversity, the Federal Agency for Nature Conservation is funding a project that aims to reconnect fragmented habitats. The project's goals include reducing conflicts between infrastructure and the habitat network, restoring wildlife connectivity to Scandinavia via a land bridge, and supporting species and habitat adaptation to climate change. Fauna passages crossing a federal motorway have been linked to nearby nature protection areas, including Natura 2000 sites, through the installation of the country's pioneering "ecological hinterland connections" of fauna passages. Additionally, ecological corridors have been established between multiple fauna passages crossing other motorways (Reck & Schulz, 2011) .

Regulation/ Approach	Purpose	Relevance with the Transportation Infrastructures	Implementation Example
EU Nature Directive/ Natura 2000	To safeguard Europe's natural heritage by ensuring the long-term protection of habitats and species.	The directive mandates that EU member states implement measures for the conservation and restoration of habitats and species, as well as establish a network of protected areas. It also requires member states to regularly monitor the status of habitats and species to ensure the achievement of conservation objectives. It includes provisions to ensure that the planning and operation of transportation infrastructure projects account for their potential environmental impacts. Specifically, the directive necessitates the completion of a SEA prior to commencing any major transportation infrastructure project (EU, 2008).	- Efforts to restore and conserve wetlands, such as the Oostvaardersplassen, have been successful in protecting important habitats and increasing biodiversity. By supporting endangered species of nesting birds, the site has global significance for the ecological richness of the Atlantic biogeographic region. Also, site plays a vital role to avoid floods by water management. (Netherlands) (Ramsar Site Information Service, 2022). - Conservation measures for species like the Iberian Lynx have helped stabilize populations and promote their recovery (Spain and Portugal). - The sustainable management of habitats, such as the Białowieża Forest, has resulted in the preservation of old-growth forests and the protection of numerous species (Poland and Belarus).
Water Framework Directive (WFD)	To protect all EU surface waters and groundwater by preventing further degradation, protecting and improving water quality, and promoting sustainable water resource management.	It requires EU member states to identify and address any significant pressures that transport infrastructure projects may have on water bodies. This includes measures to prevent or reduce pollution from construction activities, runoff from roads and other transport facilities and discharges from ports and harbours. It requires assessing the potential impacts of transport infrastructure projects on water resources and to take steps to mitigate any negative effects (EU, 2000).	- When building bridges over water bodies, the WFD requires measures to be taken to prevent or minimize sedimentation, pollution from construction activities, and disruption to aquatic habitats. - Transport projects need to incorporate effective drainage systems and pollution control. WFD requires measures to reduce the impact of road runoff on water bodies. - WFD applies to the development of ports and harbours, ensuring that activities such as dredging, construction, and shipping operations are carried out in an environmentally sustainable manner. Several Water Framework Directive Assessment reports were published by the United Kingdom government, including Aberdeen Harbour (Intertek, 2015), Port of Southampton, and Port of Dundee (Fairhurst, 2022). Reports included screening, scoping and further assessment of the project to estimate the risks of impacting on WFD objectives.

Regulation/ Approach	Purpose	Relevance with the Transportation Infrastructures	Implementation Example
Eurovignette Directive	To ensure equitable cost sharing among road users, including transport infrastructure operators, for the use of road networks, including costs associated with congestion, pollution, and other negative externalities.	The Directive states that the revenue generated from tolls and user fees will be used to fund investments in transport infrastructure, including projects aimed at reducing the environmental impact of transport. This can include the development of alternative transportation modes, such as public transit and cycling infrastructure, as well as the implementation of measures to reduce congestion, air pollution, and GHG emissions (European Parliament, 2022).	- Adjusting the truck toll to the climate: It involves creating favourable conditions, including a CO_2 toll, to operate zero-emission trucks economically and boost the market (Germany). - Heavy Vehicle Toll Implementation: Belgium introduced a km-based road charging for trucks, which account for 25% of road transport's GHG emissions (despite their low share in overall number of vehicles). This charging system includes allowing tolls to be differentiated according to the fuel efficiency or carbon emissions of trucks, thereby increasing the CO_2 reduction rate by the means of behavioural changes among truck operators and shippers, or renewed truck fleet. The toll has multiple benefits such as improved logistics efficiency, and acceleration of the purchase and use of cleaner trucks (Belgium) (Transport & Environment, 2016).

Regulation/ Approach	Purpose	Relevance with the Transportation Infrastructures	Implementation Example
Sustainable Urban Mobility Plans (SUMPs)	To mitigate the environmental effects of urban transportation, enhance accessibility. To encourage sustainable modes of transport such as walking, cycling, electric scooters, and public transportation, while also fostering the use of low-emission vehicles.	The SUMP framework provides guidance on the development of transport policies and measures that support sustainable mobility, including infrastructure development, mobility management, and innovative transport solutions. It also emphasizes the importance of stakeholder engagement and collaboration in the planning and implementation of sustainable mobility policies.	- The Barcelona Urban Mobility Plan (UMP) serves as a planning tool to establish the guiding principles for urban mobility in the upcoming years. The Plan includes a set of actions designed to prioritize pedestrians and cyclists, stimulate public transportation, and decrease reliance on private vehicles. Its goal is to enhance the city's mobility, road safety, and overall efficiency of the transportation system. The goal is to increase the share of sustainable to 80% by 2024. The proposed adjustments for various modes of transportation include enhancing traffic light signalling, parking strategies, intermunicipal public transport services, complementary services and bus network routes (Eltis, 2022). In 62 action lines with more than 300 initiatives, five key topics are outlined: *"safe mobility, sustainable mobility, healthy mobility, equal mobility and smart mobility"* (Barcelona) (Köllinger, 2022). - Türkiye's SUMP focuses on increasing the share of sustainable modes of transport (pedestrian, bicycle and public transport), reducing the share of private vehicles, reducing air/noise pollution and energy consumption, ensuring an accessible transport system for all citizens, and reducing the number of accidents and improving safety in transport (Türkiye).
Clean Vehicle Directive	To promote the eco-friendly and energy-efficient vehicles.	The Clean Vehicle Directive is implemented through a three-step process, including setting procurement targets, implementation of targets, and reporting and monitoring. It has been successful in promoting clean and energy-efficient vehicles. The EU provides guidance and support for the implementation of the directive, through its Clean Vehicles Portal and other initiatives (EU).	- 45% of buses will be green vehicles and half of these will be zero emission (Ireland). - In 2021, Finland enacted the Act on Environmental and Energy Efficiency Requirements for Vehicle and Transport Service Procurements. In Finland, 38.5% of new public sector passenger car and van acquisitions will have emissions. In addition to these obligations, a vehicle fleet emission management tool has been established that is based on the directive as well (Finland) (Gyllenbögel, 2021).

Regulation/ Approach	Purpose	Relevance with the Transportation Infrastructures	Implementation Example
Euro 6 Emission Standards	To regulate the exhaust emissions of cars and light commercial vehicles.	These standards impose limits on the release of harmful pollutants, including nitrogen oxides, particulate matter, and carbon monoxide, with the goal of minimizing the environmental impact of transportation. The implementation of Euro 6 standards has successfully led to a reduction in the emissions of harmful pollutants, contributing to improved air quality in Europe (ICCT, 2016).	- Specific emissions limits on the emissions of pollutants from vehicles, including nitrogen oxides and particulate matter, promoting the use of cleaner and more fuel-efficient vehicles
Alternative Fuel Infrastructure Directive	To promote the development and deployment of alternative fuels and the corresponding infrastructure (EU, 2014)	In the context of transportation, the EU Alternative Fuel Infrastructure Directive aims to address the challenge of limited refuelling and recharging infrastructure, which has been considered a barrier to the widespread adoption of alternative fuel vehicles. By expanding the infrastructure network, the directive seeks to promote the use of electric vehicles, hydrogen-powered vehicles, natural gas vehicles, and other low-emission vehicles. This contributes to reducing GHG emissions, improving air quality, and fostering the transition towards a more sustainable and environmentally friendly transportation sector (EU, 2023).	- In line with its low-carbon economy goals, the UK government recognizes the Southampton Port as a major contributor to the country's renewable energy targets. The port's strategic location makes it an ideal partner for power generation companies in developing biomass-based power generation. It provides essential facilities for the import and storage of raw materials used in power generation. Furthermore, the port's advantageous position enables the establishment of a robust supply chain for the offshore wind industry. It offers strategic land reserves within the port for preassembly, manufacturing, and construction of wind turbines. Due to grid and power availability, one terminal will be operational at any given time. The implementation of a 16MVA system began in March 2022 at the Horizon Cruise Terminal and Mayflower Cruise Terminal in the Western Docks of the Southampton Port (United Kingdom) (Associated British Ports, 2022).

2.3.1. Alternative Fuels and New Vehicle Technologies

Customer preferences shift towards sustainability in recent years. Factors such as health products, organic practices, environmental consciousness, brand reliability, and fair working conditions have gained prominence among customer priorities. Moreover, customers increasingly tend to pay more for the sake of sustainability. Consequently, companies are expected to adopt sustainable practices and produce environmentally friendly products to meet customer demands. The sales of sustainable products have been steadily rising in response to changing customer preferences. Consumers also value the integration of sustainability into a company's core business processes (Deloitte, 2022). This signifies that changing customer preferences have become a necessity across all sectors.

While consumer preferences are not the sole driver of technological advancements in the transportation industry, it is clear that technology, regulations, and consumer demands are converging. As highlighted in Chapter 2.3 above, seeking alternative fuels in the transportation sector, where fossil fuel consumption remains significant, is deemed essential, and policymakers are encouraged to develop specific approaches to address this issue. Technological advancements play a central role in translating regulations and policies into action within the transportation and infrastructure sector.

Significant progress has been made in battery technology for EVs, exemplifying how technological improvements facilitate the implementation of regulations. Advancements have led to cheaper, lighter, and more energy-dense batteries, resulting in reduced charging times and extended driving ranges. These developments drive market penetration, support policies incentivizing EV adoption, and prompt governments to invest in charging infrastructure and supportive policies for its expansion. Additionally, the use of new advanced materials like Carbon Fibre Reinforced Polymer (CFRP) and natural fibre-reinforced plastics (NFRP) enables the automotive sector to manufacture lighter vehicles, improving fuel efficiency and reducing emissions. These materials also contribute to extending the range of EVs, aligning with policies that promote their adoption.

The relationship between new vehicle technologies and regulations forms a mutually reinforcing cycle, wherein technology advancements drive and enable regulatory changes, while regulations foster an environment conducive to the creation and adoption of innovative vehicle technologies. At the forefront of transportation and infrastructure regulations, which progress in tandem with technological advancements, are measures related to low-emission alternative fuels and the development of supporting infrastructure.

Below are primary examples of such regulations, policies, and initiatives:

European Union Clean Vehicles Directive

According to the EU Clean Vehicles Directive, public entities must support and acquire alternatives to traditional diesel or gasoline cars, such as those that operate on electricity, natural gas, or hydrogen (H). Greater public demand will stimulate the market and increase the affordability of these cars for all operators. Particularly in the bus category, where public procurement accounts for over 70% of the market, the Directive is anticipated to speed the broad market adoption of greener road transport. Sales growth will enable cost savings via economies of scale, which will gradually enhance the energy and environmental efficiency of the entire fleet of vehicles (European Commission, 2019).

Alternative Fuels and Electric Vehicles Regulation of Türkiye

To mitigate the environmental impact of transportation, the Turkish government has adopted programs to promote the use of alternative fuels and electric cars. Various incentives have been introduced to encourage the adoption of alternative fuel vehicles and the development of charging infrastructure. To support these efforts, the Alternative Fuels and Electric Vehicles Regulation was enacted in 2017, aiming to promote the use of alternative fuels in public transportation and establish a robust fuel supply infrastructure (Ministry of Energy and Natural Resources, 2017).

As of 2023, approximately 26% of Türkiye's vehicle fleet consists of vehicles using alternative fuels, with a notable increase in the number of Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). This shift towards alternative fuel vehicles has led to a corresponding increase in the development of infrastructure for charging points. Currently, Türkiye boasts around 3,000 charging points throughout the country (European Commission, 2023). Türkiye has taken significant steps to promote the use of alternative fuels and EVs as part of its efforts to reduce the environmental impact of transportation. The implementation of the Alternative Fuels and Electric Vehicles Regulation and the expansion of charging infrastructure demonstrate the government's commitment to fostering sustainable and low-emission transportation systems in the country.

National Platform Future of Mobility in Germany

The National Platform Future of Mobility in Germany is a government initiative that aims to shape the future of transportation in the country that was initiated in 2018. The platform brings together representatives from various parties, including industry, academia, civil society, and government, to develop strategies and recommendations for sustainable and innovative mobility.

The platform focuses on addressing key challenges in transportation, such as reducing GHG emissions, promoting electric mobility, advancing digitalization and connectivity, and enhancing the efficiency and accessibility of transport systems. It aims to foster collaboration and dialogue among stakeholders to develop comprehensive and integrated solutions.

In the context of transportation, the National Platform Future of Mobility plays a key role in shaping policies, strategies, and initiatives that promote sustainable and future-oriented mobility. It seeks to accelerate the transition to low-emission and environmentally friendly transportation modes, including EVs and alternative fuels. The platform also emphasizes the importance of digitalization and connectivity in enhancing mobility services, optimizing traffic flows, and improving the overall efficiency of transport systems.

One of the six focus areas of the platform, the Working Group 2, is devoted to alternative drive technologies and fuels for sustainable mobility. This Working Group formulates recommendations for action to be taken by politicians, businesses and society to promote particularly effective technology-neutral alternative drive technologies and fuels for all modes of transport. These actions include design of framework conditions and funding programmes, research & development (R&D) measures and investments. The Working Group also divides into three focus groups: Technological Electromobility Concepts, Water and Fuel Cells and Alternative Fuels for Internal Combustion Engines. Preliminary results of the working group indicate that the transition will not take a linear path taking advantage of one technology rather will provide a blend of different measures and technological solutions to reduce CO_2 emissions in mobility (National Platform for Future of Mobility, 2019).

Through its recommendations and insights, the National Platform Future of Mobility contributes to the development of a holistic and forward-looking transportation sector in Germany, aligning with national and international sustainability goals (National Platform Future of Mobility, 2021).

Electric Mobility Act in Germany

The Electric Mobility Act, also known as the Emobility Act, is a legislation adopted by the German government to promote the use and expansion of electric mobility in the country. The act focuses on creating favourable conditions for EVs and establishing the necessary infrastructure to support their widespread use.

The main objective of the Electric Mobility Act is to accelerate the transition to electric transportation and reduce GHG emissions in the transportation sector. It encompasses various measures to incentivize the purchase and use of EVs, support the development of charging infrastructure, and facilitate research and development in the field of electric mobility.

One key aspect of the act is the provision of financial incentives for EV buyers, such as purchase premiums and tax benefits. It also aims to increase the number of charging stations by setting binding targets for public and private charging infrastructure deployment. Furthermore, the act promotes the integration of EVs into the energy system, facilitating the use of renewable energy sources for charging.

The Electric Mobility Act plays an important role in fostering the growth of electric mobility in Germany. By providing a comprehensive legal framework and support measures, the act aims to encourage consumers to switch to electric vehicles, expand the charging infrastructure network, and contribute to achieving the country's climate and sustainability goals (Federal Ministry of Transport and Digital Infrastructure, 2019).

Corporate Average Fuel Economy (CAFE) Standards in USA

The Corporate Average Fuel Economy (CAFE) Standards in the USA are regulations established by the government to improve the fuel efficiency of vehicles and reduce GHG emissions from the transportation sector. These standards require automobile manufacturers to meet certain fuel economy targets for their fleet of vehicles. The main objective of the CAFE Standards is to enhance energy security, reduce dependence on foreign oil, and mitigate the environmental impact of transportation. The standards apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, and they are set by the National Highway Traffic Safety Administration (NHTSA) and the EPA (Sen, Noori, & Tatari, 2017).

The CAFE Standards are designed to gradually increase the fuel efficiency of vehicles over time. Automakers must meet specific miles per gallon (mpg) targets for or their new fleets of light vehicles sold in the USA. The standards are set based on vehicle size and weight classes, with more stringent requirements for larger vehicles. This encourages manufacturers to develop and produce vehicles that consume less fuel and emit fewer GHGs (Sen, Noori, & Tatari, 2017). Additionally, due in large part to the reaction of USA automakers, CAFE standards stimulate technological advancement in new passenger cars. To comply with the CAFE Standards, automobile manufacturers employ various strategies, including engine efficiency improvements, lightweight materials, aerodynamic design enhancements, reduced frictions, hybrid and electric vehicle technologies, and advanced transmission systems. These measures help handle fuel inefficiency and high emission levels (Wang & Miao, 2021).

The CAFE Standards have played a significant role in driving innovation and technological advancements in the automotive industry. They have spurred the development of hybrid and electric vehicles, as well as other fuel-efficient technologies. The standards also contribute to energy conservation, reduce air pollution, and promote a more sustainable transportation system in the USA (National Highway Traffic Safety Administration, 2022).

2.3.2. Pricing Mechanisms

Adjusting pricing mechanisms is a critical element in making transport systems more sustainable and efficient, striking a balance between societal benefits and the adverse consequences of the sector. These mechanisms help internalize the environmental costs associated with transportation activities by incorporating them into pricing structures. When establishing pricing regulations, factors such as affordability, proportionality, and the ability to manage external expenses should all be considered, while ensuring that vulnerable populations are not burdened excessively. Enhancing the fairness and acceptability of transportation pricing policies can be achieved by combining different pricing mechanisms. For example, integrating congestion fees and road tolls with complementary measures like investment in public transportation and incentives for sustainable modes can lead to improved outcomes (Schuitema, Steg, & Kruining, 2011).

Studies on pricing mechanisms for transportation systems have been ongoing for decades. One notable effort in this area is the EC-funded project called Unification of Accounts and Marginal Costs for Transport Efficiency (UNITE). The project utilized the Impact Pathway Approach, a bottom-up methodology, to estimate and value the marginal social and environmental costs of transport. This methodology considers various factors, such as time, vehicle type, and location, aiming to assess damages rather than focusing solely on emissions of fine particles (Bickel, Friedrich, Link, Stewart, & Nash, 2006).

Another relevant concept is Low Emission Zones (LEZs), which are designated areas where vehicle access is restricted or limited depending on the emissions of these vehicles. These restrictions are typically based on the vehicle's emissions standard and can involve complete prohibition or entry fees. Over the past two decades, several European cities, including Germany, the Netherlands, and Sweden, have implemented LEZs to improve air quality and reduce pollution. Studies conducted in Germany have shown a significant reduction in PM10 levels after the introduction of LEZs, indicating substantial health benefits from reduced air pollution (Malina & Scheffler, 2015).

Road user charging is another policy aimed at mitigating the negative impacts of driving, particularly congestion. The primary goal of road user charging is to make users aware of the costs imposed on other users when deciding to travel with an additional car. This mechanism aims to align private costs with social costs during traffic. It has been employed in major cities like London, Stockholm, and Singapore. Singapore's Area License Scheme (ALS), supported by strict auto ownership regulations and efficient public transportation systems, effectively manages traffic within its restricted zone. In contrast, London's congestion pricing scheme initially reduced congestion but faced challenges with increasing delays beyond the pricing zone. Efforts were made to address these issues by expanding the cordoned area, but the program had limited success in improving bus services and travel time reliability (Wang, 2010; Metz, 2018).

The New Plate Quota (NPQ) is an auto ownership control policy implemented in Shanghai to control the road traffic volume. Under this policy, new motor vehicle licenses are auctioned to manage traffic congestion and reduce air pollution. However, it has been observed that a large share of new vehicles in the city uses non-local plates to get rid of high license plate payments (Wang, 2010).

In conclusion, the integration of effective pricing mechanisms is vital for addressing the environmental impacts of transport infrastructure and services. These mechanisms play a significant role in internalizing environmental costs, promoting sustainability, and achieving a balance between societal benefits and negative consequences. By considering factors such as affordability, proportionality, and the capacity to manage external expenses, pricing regulations can be developed.

2.3.3. Shared Mobility

Many cities have laws governing ride-sharing services like Uber and Lyft, while places such as New York, San Francisco, and Washington, D.C. have bike-sharing schemes in place.

In addition to the District of Columbia, 47 states have at least one type of shared mobility scheme as of 2015. Shared mobility initiatives have existed in some capacity in the USA for a long time. Alternative modes are practical, affordable, and ecologically beneficial. Individual carpooling and neighbourhood bicycle cooperatives have developed into governmental and commercial programs and initiatives in recent years, serving the demands of several expanding metropolitan marketplaces. Although shared mobility programs are mostly found in cities and around transportation hubs, there is an increasing demand for them in university towns and other smaller metropolitan areas as well (Texas Department of Transportation-Shared Mobility Programs, 2016).The Shared Mobility Strategy of China calls for the creation of the finest public policies and pertinent planning to ensure sustainability. In general, these strategies call for increasing the use of bicycles, walking the proper distances to destinations, and use public transit, as well as creating incentives to discourage the use of private. The following goals are supported by shared mobility policies and services in China (Institute for Transportation & Developement Policy [ITDP], 2016):

1. Encourage and lower obstacles to shared mobility infrastructure and services that:
   - **a.** Increase environmental sustainability, equality, or accessibility
   - **b.** Support the practicality of public transportation, cycling, and walking
   - **c.** Fewer individuals own cars overall

2. Promote the integration of services via open data, coordinated infrastructure design, and unified payment system requirements.

3. Establishing a mobility vision for rewards and barriers, and enacting "real cost" per voyage pricing for non-sustainable means of transportation (Institute for Transportation & Developement Policy [ITDP]).

2.3.4. Non-motorized Modes

The transition to a sustainable urban transportation system must include Non-Motorized Transportation (NMT). NMT is another cost- and time-effective, environmentally friendly mobility choice, particularly in metropolitan settings where short- and medium-distance excursions are the most common. Below are a few instances of nations with non-motorized transportation systems:

Non-Motorized Transport Policy for Mid-Size Cities in Indonesia

The most popular non-motorized modes of transportation in Indonesia include walking, bicycling, pedicabs, and horse-drawn carriages, or "delmans." These non-motorized modes of transportation don't produce pollution and can improve an area's good air quality. In order to fulfil the National Medium-Term Development Plan (RPJMN) 2020-

2024's direction, mass transit systems must not only be connected to a good motorized road network system but also integrated with NMT infrastructure.

NMT may promote inclusivity in metropolitan areas if the proper infrastructure is put in place since it is accessible to all societal groups, regardless of ability, age, or wealth. Additionally, a recent research has demonstrated that providing adequately designed NMT can also boost road safety. RPJMN 2020-2024 includes enhancing road security and safety as one of its objectives, which emphasizes the need of creating NMT infrastructure in urban areas (ITDP, 2020).

NMT in Nairobi

The NMT policy is a joint initiative of United Nations Environment Program (UNEP) and the Nairobi City County, which aims at enhancing the non-motorized transport mode. The importance of NMT must be acknowledged and considered when making investments in public transportation and road infrastructure if we are to move toward a more sustainable mobility route. Most transportation services are dependent on roads. Only services between the central business district and the eastern and southern areas of the City can be reached by railroad during peak hours. Nairobi's primary modes of transportation are walking and public transportation; just 15% of journeys were made in a private vehicle (Nairobi City County Government, 2015).

National Cycling Strategy in Denmark

The National Cycling Strategy of Denmark is a comprehensive plan developed by the Danish government to promote and enhance cycling as a mode of transportation. The goal of the strategy is to ensure a safe, accessible, and efficient cycling infrastructure that encourages more people to choose cycling for their daily commute and other travel needs and to double the number of people cycling in Denmark. In terms of infrastructure development, the strategy emphasizes the creation of a well-connected and continuous cycling network that is integrated with other modes of transportation. This includes the construction of dedicated cycle paths, bike lanes on roads, bicycle parking facilities, and bike-sharing systems. In addition, the strategy emphasizes the improvement of cycling facilities at public transport hubs to facilitate multimodal journeys.

Safety is a key aspect of the strategy, and it includes measures to reduce accidents and conflicts between cyclists and other road users. This involves improving intersections, implementing traffic calming measures, increasing visibility, and promoting safe cycling practices through educational campaigns. The National Cycling Strategy also focuses on encouraging cycling use as a sustainable and health-conscious means of transportation. The strategy highlights the importance of collaboration between government agencies, local authorities, organizations, and the community to achieve its goals.

The implementation of the National Cycling Strategy in Denmark has led to a large increase in cycling rates and has contributed to a more sustainable and efficient transportation system. It has improved the accessibility and live ability of cities and towns, reduced congestion and air pollution, and promoted active and healthy lifestyles (Denmark Ministry of Transport, 2018).

2.3.5. Public Transit

Sustainable Transportation Action Plan of Türkiye

To promote sustainable mobility and lessen the environmental effects of transportation, the Turkish government created the Sustainable Transportation Action Plan, a comprehensive policy program. This plan encompasses various actions aimed at enhancing public transit infrastructure, improving pedestrian walkways, promoting bicycle usage, reducing reliance on private automobiles, mitigating air pollution, and lowering GHG emissions from transportation (Ministry of Environment and Urbanization, 2017). The plan also highlights the implementation of the Environmental Order Plan, which has led to a significant increase in walking trips, accounting for 48.6% of total trips in 2016. This achievement is attributed to the creation of local activity centers, where schools, shopping areas, entertainment venues, and workplaces are situated within walking distance of residential areas. Additionally, the plan emphasizes the importance of cycling by promoting bicycle sharing programs, integrating cycling infrastructure with public transport stations, commercial centers, city parks, and hospitals, and providing adequate bicycle parking facilities

Furthermore, the Istanbul Metropolitan Municipality Transportation Master Plan serves as a policy initiative to address transportation challenges in Istanbul and encourage sustainable mobility. The plan lines up with the goals of the Sustainable Transportation Action Plan and encompasses various measures to enhance public transit, promote bicycle usage, reduce private car dependency, mitigate air pollution, and decrease GHG emissions from transportation (Istanbul Metropolitan Municipality, 2017).

Transportation Alternatives Program (TAP) of USA

The Transportation Alternatives Program (TAP) is a federal funding program that aims to enhance transportation options and promote non-traditional projects that improve the quality of transportation infrastructure. TAP provides funding for projects that support active transportation, supports the cultural and environmental characteristics of transport activities, and prioritize the safety and accessibility of transportation facilities. The main objective of the TAP is to expand transportation choices beyond traditional highway projects and promote modes of transportation that are more sustainable, efficient, and environmentally friendly. The program recognizes the importance of developing transportation infrastructure that accommodates walking, biking, and other non-motorized modes of transportation.

TAP funds can be used for various types of projects, including the construction, planning, and design of pedestrian and bicycle facilities. The program also supports projects that improve safety for pedestrians and cyclists, enhance access to public transportation, preserve historic transportation structures, promote environmental mitigation, and encourage the development of recreational trails. By investing in projects under the TAP, communities can improve connectivity, accessibility, and safety for pedestrians and cyclists, while reducing congestion and environmental impacts associated with motorized transportation. TAP projects contribute to creating vibrant and live able communities, encouraging physical activity, reducing GHG emissions, and promoting a more sustainable and multimodal transportation system (Federal Highway Administration, 2022).

2.3.6. Sustainable Urban Mobility Planning Approaches

The sustainable urban mobility plan can be deifned as follows:

"A SUMP is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. It builds on existing planning practices and takes due consideration of integration, participation, and evaluation principles (Eltis)."

The Sustainable Urban Action Plans follow the principles listed below (OECD, 2013):

1. Plan for sustainable mobility in the "functional urban area"

2. Cooperate across institutional boundaries

3. Involve citizens and stakeholders

4. Assess current and future performance

5. Define a long-term vision and a clear implementation plan

6. Develop all transport modes in an integrated manner

7. Arrange for monitoring and evaluation

8. Assure quality

Planning for SUM is a deliberate, comprehensive strategy for solving the challenges of urban transportation. Its goal is to ensure a shift toward sustainable mobility in order to enhance accessibility and quality of life. SUMP encourages decision-making grounded on facts. This necessitates, among other things, a thorough evaluation of the current situation and projected tendencies, a common vision, and a combination of regulatory, promotional, fiscal, technical, and infrastructure measures to attain the goals-the latter of which should be implemented alongside methodical monitoring and evaluation (Eltis, 2019).

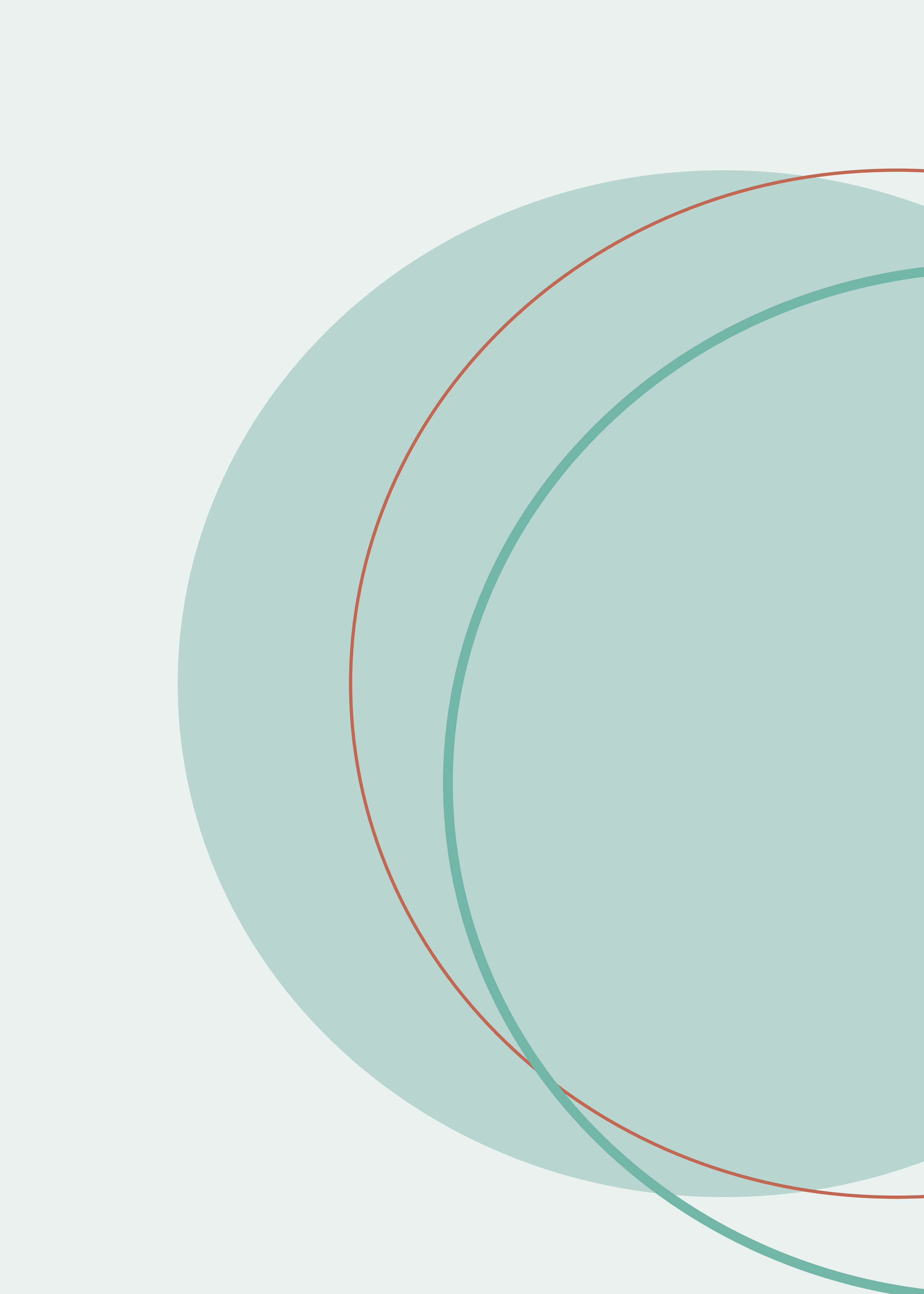
Association of Southeast Asian Nations (ASEAN) Policies Related to Urban Mobility

To address the complicated problems facing urban and transportation development, ASEAN has published many documents outlining its goals towards sustainable mobility. These show ASEAN's dedication to raising standards for sustainability as well as the level of belonging, urban mobility planning quality, and financial efficiency (ASEAN Sustainable Urban Mobility Plans, 2023).

ASEAN has established goals to reduce the challenges with transportation. The Master Plan on ASEAN Connectivity (MPAC 2025) includes these objectives as well as others, such as enhancing sustainability, urban mobility planning, economic efficiency, digital innovation, sustainable infrastructure, seamless logistics, human mobility, and regulatory excellence. According to the (ASEAN Secretariat , 2016), this strategy supports the political, economic, and sociocultural stability of the ASEAN region. Two other publications, the ASEAN Sustainable Urbanization Strategies and the ASEAN Regional Strategy on Sustainable Land Transport (ARSSLT), also contribute to the effective execution of the MPAC 2025 (ASEAN Sustainable Urban Mobility Plans, 2023).

Green Transport Fund in Denmark

The Green Transport Fund, or Grøn Transportfond, is a government initiative aimed at promoting sustainable transport and reducing carbon emissions in Denmark. The fund, which was established in 2010, provides financial support for a range of projects focused on developing the uptake of electric and alternative-fuel vehicles, improving cycling and walking infrastructure, and promoting sustainable urban development. The fund is financed through a tax on fossil fuels, and has provided funding for a range of projects, including the development of new cycling routes, the installation of charging infrastructure for electric vehicles, and the encouragement of car-sharing and transit services. The Green Transport Fund is seen as an important policy instrument in promoting sustainable mobility and reducing carbon emissions in Denmark (Ministry of Transport, 2020).



CHAPTER 3

3. Methodology

3.1. Explanation of the Case Studies and Field Visits

In order to develop a guide to comprehensively identify and measure the environmental impacts of transportation infrastructure in OIC member countries, a rigorous methodology has been developed that includes both desk-based case studies and extensive field trips. This multifaceted approach aims to gain insights from a variety of countries and their transportation systems, and to provide a more refined understanding of best practices, challenges, and potential pathways for sustainable development. Case study countries were selected based on the specifications provided in the Terms of Reference for this project. Three good practice case studies outside the OIC geography were reviewed through extensive desk research. In addition, two OIC member countries with the most advanced environmental awareness and measurement practices were selected for field visits.

Table ***3-1*** presents the classification of these five case study countries.

Table 3-1: Selected Case Study Countries

Visit/Desktop	Country	OIC Membership	Region
Field visit	Malaysia	Member	Asia
	Jordan	Member	Asia
Desktop research	United States of America	Not member	America
	United Kingdom	Not member	Europe
	Singapore	Not member	Asia

The good practice countries were selected for their well-documented and successful initiatives to reduce the environmental impacts of transportation. By including countries from different continents, the aim was to benefit from a global perspective that considers diverse geographical, cultural and infrastructural contexts. The United States, known for its extensive highway network and diverse urban landscape, has a wide range of strategies, including the development of electric and hybrid vehicles, investment in public transportation systems, and pioneering research into sustainable fuel technologies. The United Kingdom, with its focus on compact urban planning and multimodal transport systems, highlights the benefits of effective integration between public transport, cycling infrastructure and pedestrian routes, and shows potential ways to reduce emissions and improve accessibility. Singapore is seen as a good example of innovative urban planning that includes smart traffic management, efficient public transport systems, and policies to promote electric mobility. Singapore's approach demonstrates the importance of comprehensive, data-driven decision making for the sustainability of the transport sector.

In addition to the desk-based case studies, the methodology includes field visits to two representative OIC countries. These field trips are essential to gain first-hand knowledge of the environmental impacts of transport infrastructure in the OIC context. Through direct interaction with local transport systems, stakeholders and sustainable practices, these trips provide experiential learning opportunities that significantly enrich the depth and breadth of the research. Field trips provide an opportunity to directly observe transportation systems, infrastructure arrangements, and their actual functioning, contributing to a more accurate assessment of environmental impacts. Through the field trips, the challenges faced by Malaysia and Jordan in their efforts to achieve environmentally sustainable transport were better identified, and tailored solutions sensitive to the specific needs of the countries covered by the guidebook were evaluated. Interacting with local authorities, experts and communities during the field trips allowed different perspectives to be brought together and meaningful discussions to be held, fostering a collaborative approach to developing effective strategies. Interviews with key informants (national officials, policy makers, private sector representatives, beneficiaries, producers, suppliers, vendors, consumers, etc.) and detailed face-to-face surveys were conducted during the field visits. In addition, the study of transport within the cultural and social fabric of Malaysia and Jordan helped to understand the complex interactions between transport, social behaviour and environmental considerations. The field visits focused on collecting data and information that was not otherwise available, and on issues related to impacts, policies and current practices related to transportation issues.

The case studies provide a detailed overview of the transport sector in the countries, the relevant legal regulations and regulatory mechanisms, the main methodologies, programs and guidelines followed, data collection mechanisms and parameterization frameworks, and the efforts undertaken to mitigate and adapt to the environmental impacts. The framework followed in the case studies is presented in Table 3-2.

Table 3-2: Framework Followed for Case Studies

Framework for case studies
An overview of the transport sector
Relevant legislation, strategies and regulatory mechanisms
Country-specific literature review
Methodologies, programs and guidelines
Data collection mechanisms and used parameters
Mitigation and adaptation efforts

A total of five countries were identified for the case studies. Each case study examined in detail the policies and guidelines that the countries had already implemented in relation to measuring the environmental impact of transport infrastructure, and the practices that could serve as examples for other countries. The review of these case studies will help to create a common understanding among the OIC member countries on project assessment procedures and to highlight the importance of transport infrastructure and services.

3.2. Explanation of the Data Collection Process

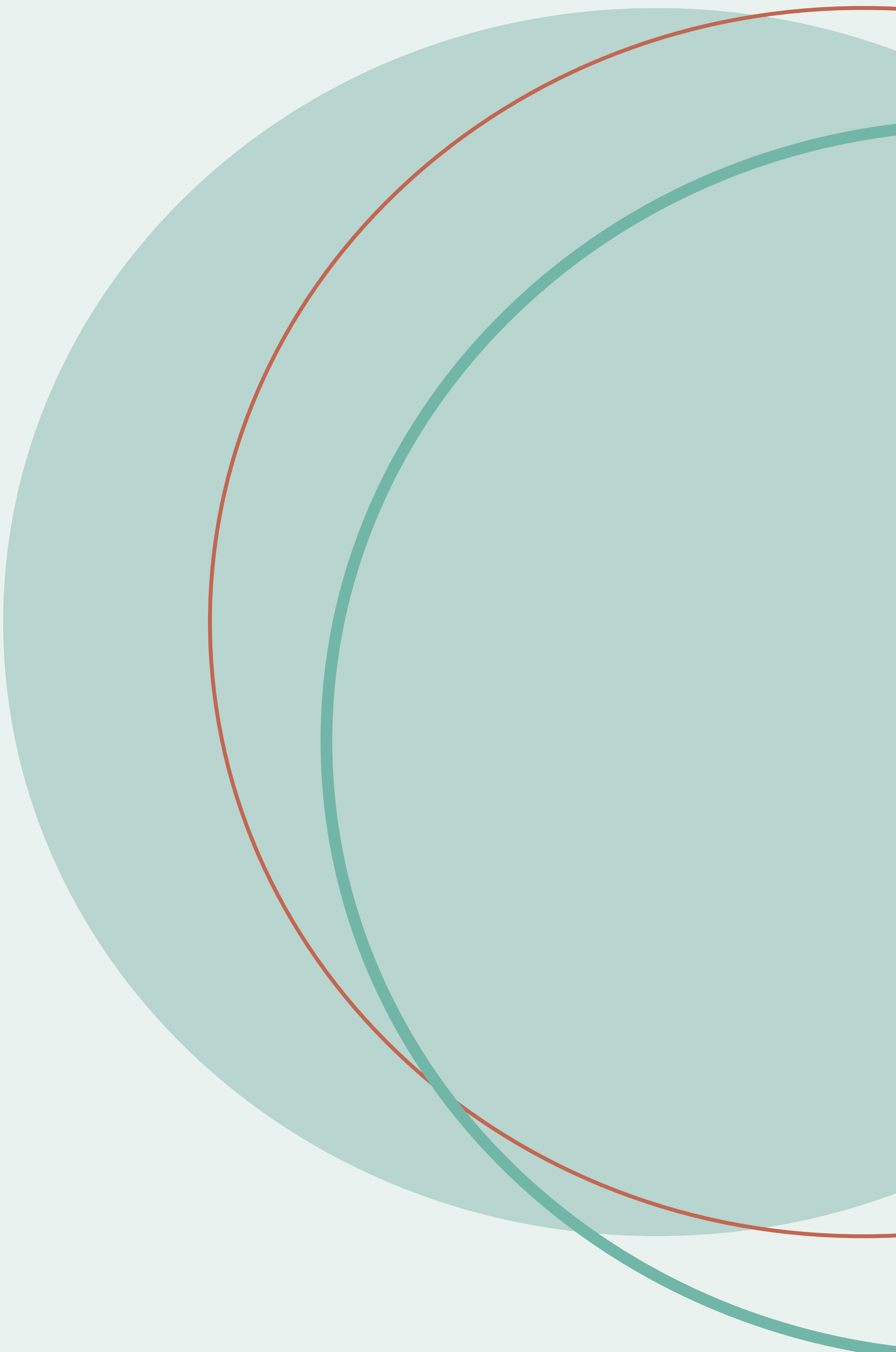
Apart from the case studies, a questionnaire for interested parties was designed and implemented to identify what is required in terms of measuring the impacts of transport infrastructure investments and services as per the Terms of Reference of the Project. A rigorous data collection methodology is required to comprehensively measure the environmental impacts of transportation infrastructures across the diverse geography of OIC countries. This methodology relies on systematically collecting information from a wide range of stakeholders, including government officials, experts, practitioners and communities. To facilitate data collection, a web-based questionnaire was designed and implemented. The web-based questionnaire serves as a basic tool to obtain quantitative views from a global group of stakeholders.

Twenty questions were prepared to obtain measurable data on key metrics such as project management, policy structure, measured environmental impacts, approach to energy consumption and emission reduction, emerging technologies and innovative practices, standardized indicators and metrics, investment allocation and modal split. The format ensures consistent and measurable responses. The questionnaire link was shared widely through various channels. Special efforts were made to engage key stakeholders with expertise in transport and environment topics. An extensive webpage search was conducted to collect personal e-mail addresses of stakeholders to which the survey was delivered. In addition, the support of contacts in many OIC countries was sought to disseminate the survey link. The stakeholder groups with whom the survey was shared are given in Table 3-3.

Table 3-3: Stakeholder Groups That the Survey was Shared with

Stakeholder Groups
Ministries of transport and their affiliated bodies such as civil aviation authority, state highways administration, port administrations
Ministries of environment and other government agencies directly or indirectly working on sustainability
Participants of the OIC Working Group Meeting
Public and private transport service providers (railways, airlines, shipping companies, road transport operators)
Sector organizations and associations regarding transportation and logistics
Trade and industry unions
NGOs
Academicians working on transportation, logistics, public administration, public health, and environment/sustainability.

Participants were given a specific deadline to complete the questionnaire, striking a balance between adequate data collection and timely analysis. Structured questions were subjected to statistical analysis, revealing quantitative trends and insights. Depending on the scope of the data collected, relevant analysis of the questionnaire based on geography, economic status and size is reported and policy implications are drawn. The relevant results are shared in Survey Results. This data-driven questionnaire approach is intended to ensure that the guidelines are based on reliable insights, enabling OIC countries to make well-informed and sustainable transport decisions that are unique to them.



CHAPTER 4

4. Good Practices Outside the OIC Member Countries

4.1. Case Study-1: The United States of America (USA)

In the USA, the transportation industry is one of the two top largest energy user sectors with a 28.3% share, only second to the energy input at electric utilities (Figure 4.1). It is followed by industrial and residential and commercial sectors with shares of 21.7% and 10.8%, respectively. For this reason, its environmental impacts have been becoming of greater concern over time. In addition, several factors have been contributing to the challenges in dealing with environmental problems associated with the transportation sector.

First, urban sprawl and high car dependency in road transportation (in fact, these two are creating the chicken or the egg causality dilemma) are the two barriers to implementing environmentally friendly policies in the transportation sector. Second one, which is also related to the urban sprawl, is the low density of the residential areas reducing the effectiveness and efficiency of transit operations. Third, because of the federal structure of the USA government, developing and implementing strong and coercive nationwide policies is easier said than done.

Figure 4.1: USA Energy Use by Sector *(Bureau of Transportation Statistics, 2017)*

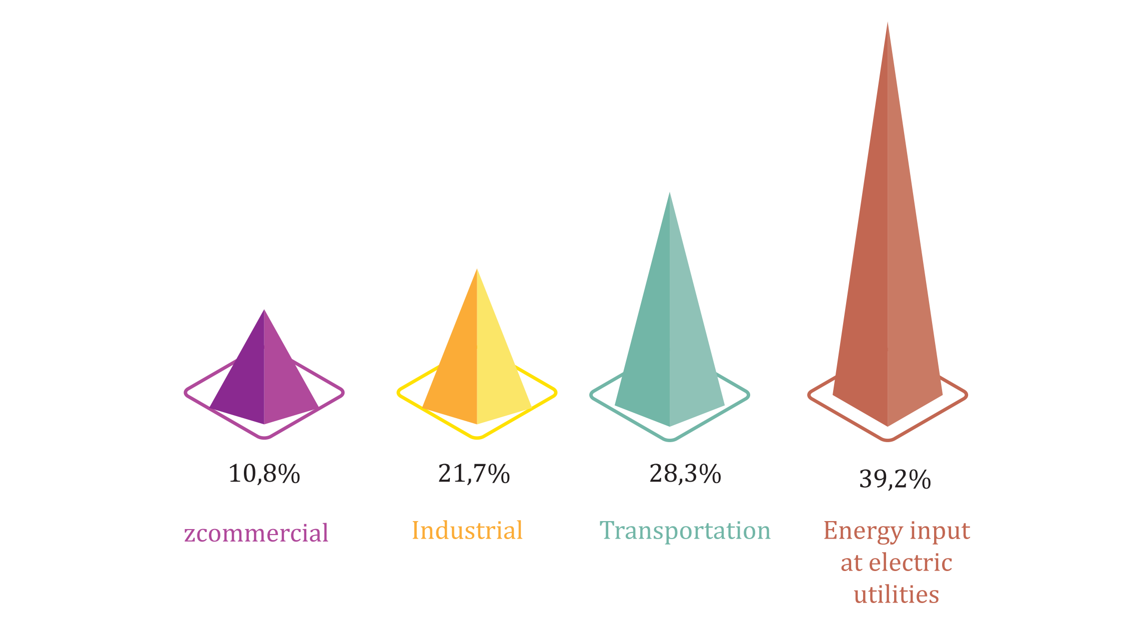


Figure 4.2 provides evidence for the above-mentioned dominance of road transportation in general and car-based travel in particular regarding the energy use. Among all energy use in the transportation industry, 84.1% is used in road transportation and 61.6% is used alone for light-duty vehicles.

Figure 4.2: Energy Use by Mode of Transportation
(Bureau of Transportation Statistics, 2017)

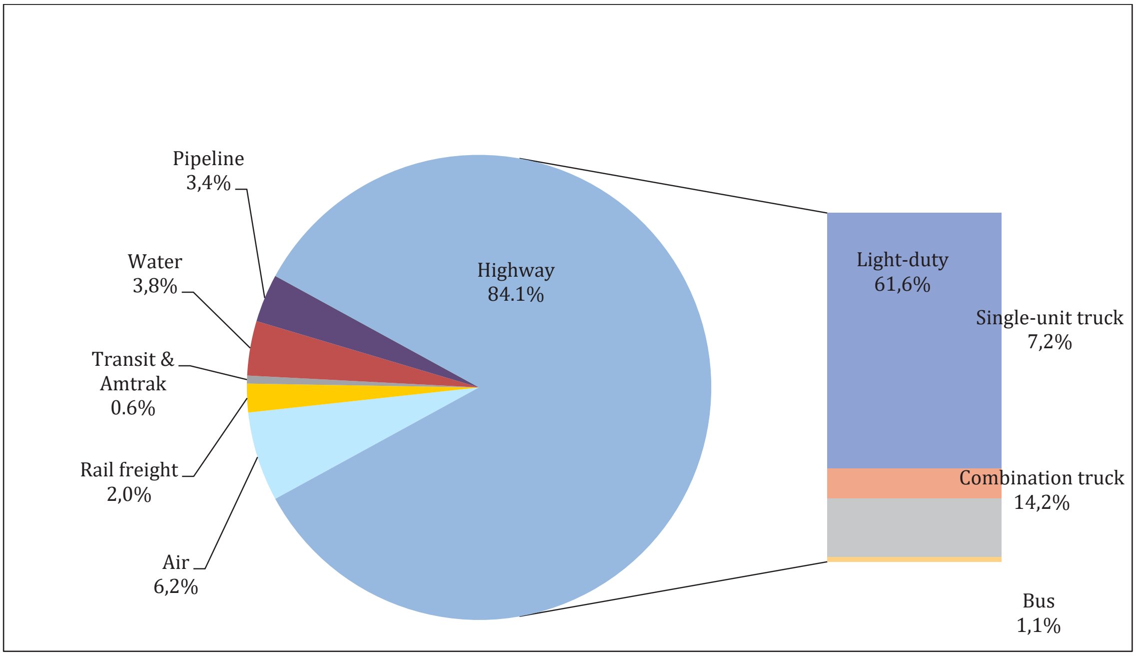
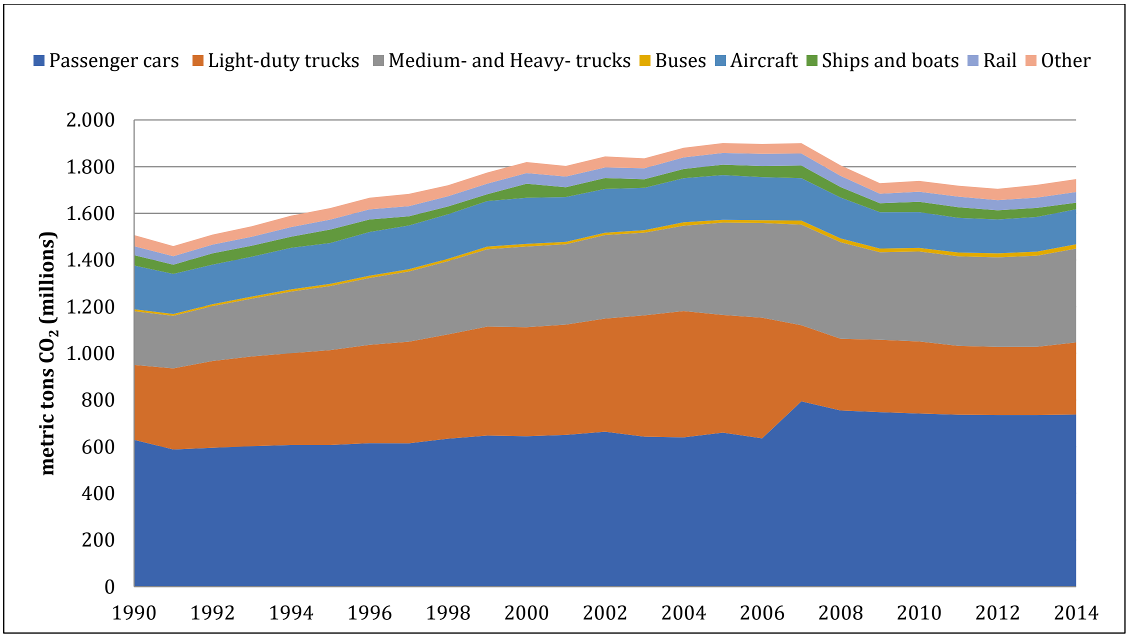


Figure 4.3, which shows the CO_2 GHG emissions by transport mode over the 1990-2014 period, provides supporting evidence to that of Figure 4.2. In line with the intensity of road transportation in energy use, passenger cars, light duty trucks and medium & heavy trucks are accountable for more than three-quarters of CO_2 GHG emissions in the transportation sector.

Figure 4.3: CO2 GHG Emissions by Mode: 1990-2014
(Bureau of Transportation Statistics, 2017)



4.1.1. The Related Legislation and The Governmental Agencies Involved

The government system of the USA is characterized by the "layer cake federalism" analogy, which implies that the federal and state governments are separate in their duties and responsibilities and each looks like a layer of a cake. The Department of Transportation (DOT) is the federal department responsible for the transportation sector. It administers its activities through its central units and agencies. At the state level, each state has its transportation department (such as The California Department of Transportation). Furthermore, local governments administer transportation activities under their jurisdictions.

The federal structure of the government requires the division of duties and responsibilities. The federal agencies draw the general rules and conditions for the sector, while project-level decisions and regional policy development and implementation remain at the states' and local governments' responsibility. For example, while nationwide CAFE standards are administered by the DOT, the Californian government can mandate that all new light- and medium-duty vehicles sold by 2035 must be zero-emission vehicles (through a rule passed by the California Air Resources Board) using its legislative power granted by the Clean Air Act (Bosch, 2022).

When the linkage between transportation and the environment is analysed, cooperation between the DOT and The Environmental Protection Agency is noticed. The major legislation on this linkage is **The National Environmental Policy Act (NEPA)**, which creates a framework for federal agencies' environmental planning and decision-making as well as creating a national environmental strategy. Within this circumstance, NEPA becomes a fundamental reference for DOT when regulating the sector and designing and implementing respective policies.

Apart from NEPA, the federal transportation authorization acts listed below provide power to DOT to carry out specific programs and administer specific funding schemes (Federal Highway Administration, 2023):

- **Bipartisan Infrastructure Law**
- **FAST Act**
- **Inflation Reduction Act**
- **Inflation Reduction Act**
- **SAFETEA-LU**

In addition to the acts outlined above, there are tens of regulations and rules administering the association between transportation and the environment. For the sake of simplicity, we will not go into the detail of these regulations. Table 4-1 presents the federal agencies operating in transport sector and their major tasks and activities regarding the linkage between transportation and environment.

Table 4-1: Government Agencies and Their Roles

Government Agency	Task/Role/Activity
Federal Aviation Administration	Environmental Review Process for Licensed/Permitted Commercial Space Transportation Activities Environmental Assessments Environmental Impact Statements
Federal Highways Administration	Air Quality Noise Alternative Fuel Corridors Bicycle and Pedestrian Program Sustainable Transportation (Energy and emissions) Environmental Justice Natural Environment

Government Agency	Task/Role/Activity
Federal Railroad Administration	Environmental Assessments / Environmental Impact Statements Locomotive Emissions Regulation
Federal Transit Administration	Environmental Assessment Environmental Impact Statement
United States Maritime Administration	International Environmental Standards and Regulations Carbon Emissions and Energy Conservation

4.1.2. The Major Guidelines, Handbooks, Programs and Methodologies

The DOT has prepared tens of guidelines and handbooks and it has been administering a very large number of programs regarding environmental aspects of transportation. It should be noted that a very large part of these guidelines and programs are specifying the application procedures, necessary documentation to be submitted and other noteworthy information. Likewise, a very long list of environmental analysis tools is available. To illustrate,

Table ***4-2*** provides the list of such analysis tools just dedicated to GHG analysis (Airport Cooperative Research Program, 2023) . Among the total of 41 tools listed in the table, some are developed or sponsored by government agencies while others are developed by private entities, universities, and research labs. Given the long list of such guidelines, programs, and methodologies (tools), this section will focus relatively on the more significant ones and attempts at exploring them with solid examples.

Table 4-2*: A Summary of Transportation GHG Analysis Tools*

GHG Tool	Developer/Sponsor Agency	Year of Inception/Update1
Emission Factor Models/Tools		
MOVES	U.S. EPA	2015 (update)
EMFAC	CARB	2017 (update)
GREET	Argonne National Labs	2017 (update)
VISION	Argonne National Labs	2017 (update)
Mobile Combustion Version 2.6	WRI	2015 (update)
Emission Factors from Cross-Sector Tools spreadsheet	WRI	2017 (update)
Inventory and Forecast Accounting/Support Tools		
GreenDOT	ICF Intl.	2010
ClearPath	ICLEI	Ongoing

GHG Tool	Developer/Sponsor Agency	Year of Inception/Update1
Local Greenhouse Gas Inventory Tool	U.S. EPA	2018 (update)
PATHWAYS	E3	2008+ updates
Simplified GHG Emissions Calculator	U.S. EPA	2018 (update)
Tools to Evaluate Agency Construction, Maintenance, and Operations Activities		
Infrastructure Carbon Estimator	FHA/MnDOT	2010/2019 (update)
Pavement Life-cycle Assessment Tool (PaLATE)	UC Berkeley	2013
Greenhouse-Gas Assessment Spreadsheet for Capital Projects (GASCAP)	Rutgers University for New Jersey DOT	2014
Inventory of Carbon and Energy (ICE)	Circular Ecology	2005
Waste Reduction Model (WARM)	U.S. EPA	2016
U.S. Environmentally Extended Input-Output Model (USEEIO)	U.S. EPA	Ongoing
Smart Location Calculator	U.S. EPA	2017
Construction Carbon Calculator G4C	Good Company	
General GHG, Energy, and VMT Reduction Strategy Analysis Tools		
VisionEval	Oregon DOT and FHA	Ongoing
Energy and Emissions Reduction Policy Analysis Tool (EERPAT)	FHA	2016
Rapid Policy Analysis Tool (RPAT)	Strategic Highway Research Program 2 (SHRP 2)	2015
Regional Strategic Planning Model (RSPM)	Oregon DOT	
Impacts 2050	NCHRP	2014
Trip Reduction Impacts of Mobility Management Strategies (TRIMMS)	University of South Florida	2018 (update)
SB1 Grant Programs Emissions Calculator	Caltrans	2017 (update)
CMAQ Emissions Calculator Toolkit	FHA	Ongoing
CCAP Transportation Emissions Guidebook Emissions Calculator	CCAP	2007
Climate Action for Urban Sustainability	World Bank	2017

GHG Tool	Developer/Sponsor Agency	Year of Inception/Update1
Limited Focus/Strategy-Specific Analysis Tools		
Envision Tomorrow	Fregonese Associates Inc.	2018 (update)
CommunityViz	City Explained, Inc.	2018 (update)
UrbanFootprint	Calthorpe Analytics	2018 (update)
Sketch7	Sacramento Area Council of Governments	2012
Conserve by Bicycling and Walking Benefits Calculator	Florida DOT	2009
Transit Greenhouse Gas Emissions Estimator	U.S. DOT	2016
Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET)	Argonne National Lab	2017 (update)
Heavy-Duty Vehicle Emissions Calculator (HDVEC)	Argonne National Lab	2017
Diesel Emissions Quantifier (DEQ)	U.S. EPA	2018 (update)
Market Acceptance of Advanced Automotive Technologies (MA3T)	Oak Ridge National Lab	2019 (update)
Other Tools		
Infrastructure Voluntary Evaluation Sustainability Tool (INVEST)	FHA	2018 (update)
Greenhouse Gas Equivalencies Calculator	U.S. EPA	2017 (update)

4.1.3. Congestion Mitigation and Air Quality Improvement (CMAQ) Program

Congestion Mitigation and Air Quality Improvement (CMAQ) Program is a state grant program to fund transportation projects and programs meeting the requirements of the Clean Air Act (CAA). CMAQ program can fund a wide range of projects ranging from shared micro-mobility projects, electric cars, and charging stations to diesel engine replacements and retrofits, transit enhancements, and bicycle and pedestrian facilities (Federal Highway Administration, 2023).

Federal Highway Administration (FHA) developed several tools to calculate and document the expected air quality improvements of the proposed fund transportation projects and programs. The project sponsors are anticipated to input the necessary information to the spreadsheet-based tools accessible online before submitting their proposals. We should note that these spreadsheet-based tools are necessary not only for the project proposals but also for the annual reporting requirements of some transport operations and activities.

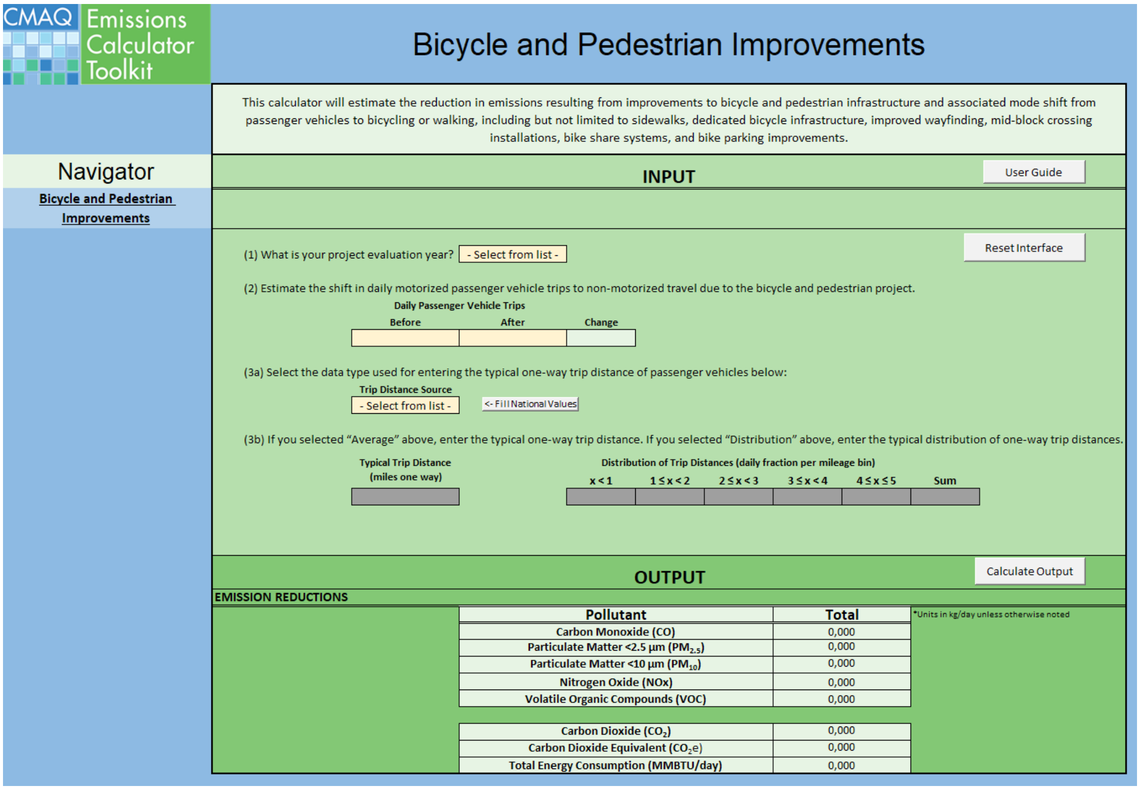
The spreadsheet-based tools are as follows:

- Adaptive Traffic Control Systems (ATCS)
- Alternative Fuel Vehicles and Infrastructure
- Bicycle and Pedestrian Improvements
- Carpooling and Vanpooling
- Congestion Reduction and Traffic Flow Improvements
- Diesel Idle Reduction Strategies
- Diesel Truck and Engine Retrofit & Replacement
- Dust Mitigation
- Electronic Open-Road Tolling (EORT)
- Electric Vehicles and EV Charging Infrastructure
- Locomotive & Marine Engine Retrofit and Replacement Tool
- Managed Lanes
- Non-Road Construction and Intermodal Equipment
- Transit Bus Upgrades & System Improvements
- Transit Bus Service and Fleet Expansion
- Travel Advisories

As can be seen from the above list, the scope of the air quality improvements is quite wide.

The spreadsheet-based tools developed are user-friendly and accompanied by respective user guides, data documentation, and training webinars. Figure 4.4, Figure 4.5 and Figure 4.6 below present the screen view of the spreadsheet-based tool developed for Bicycle and Pedestrian Improvements, Diesel Idle Reduction Technologies, and Carpooling and Vanpooling, respectively, whereas Box 4.1, Box ***4.2***, and Box ***4.3*** present examples for measuring the emission benefits using these tools.

Figure 4.4: Spreadsheet-based Tool for Bicycle and Pedestrian Improvements



Box 4.1: Calculation of Emission Reductions of a Bicycle and Pedestrian Improvements Program

This box shows the calculation of emission reductions of a bicycle and pedestrian improvements program by using the respective tool depicted in Figure 4.4.

Assume that a local government proposes the construction of a protected bicycle infrastructure to shift a part of the motorized trips to bicycle use and walking. The parameters of a proposed program are as follows:

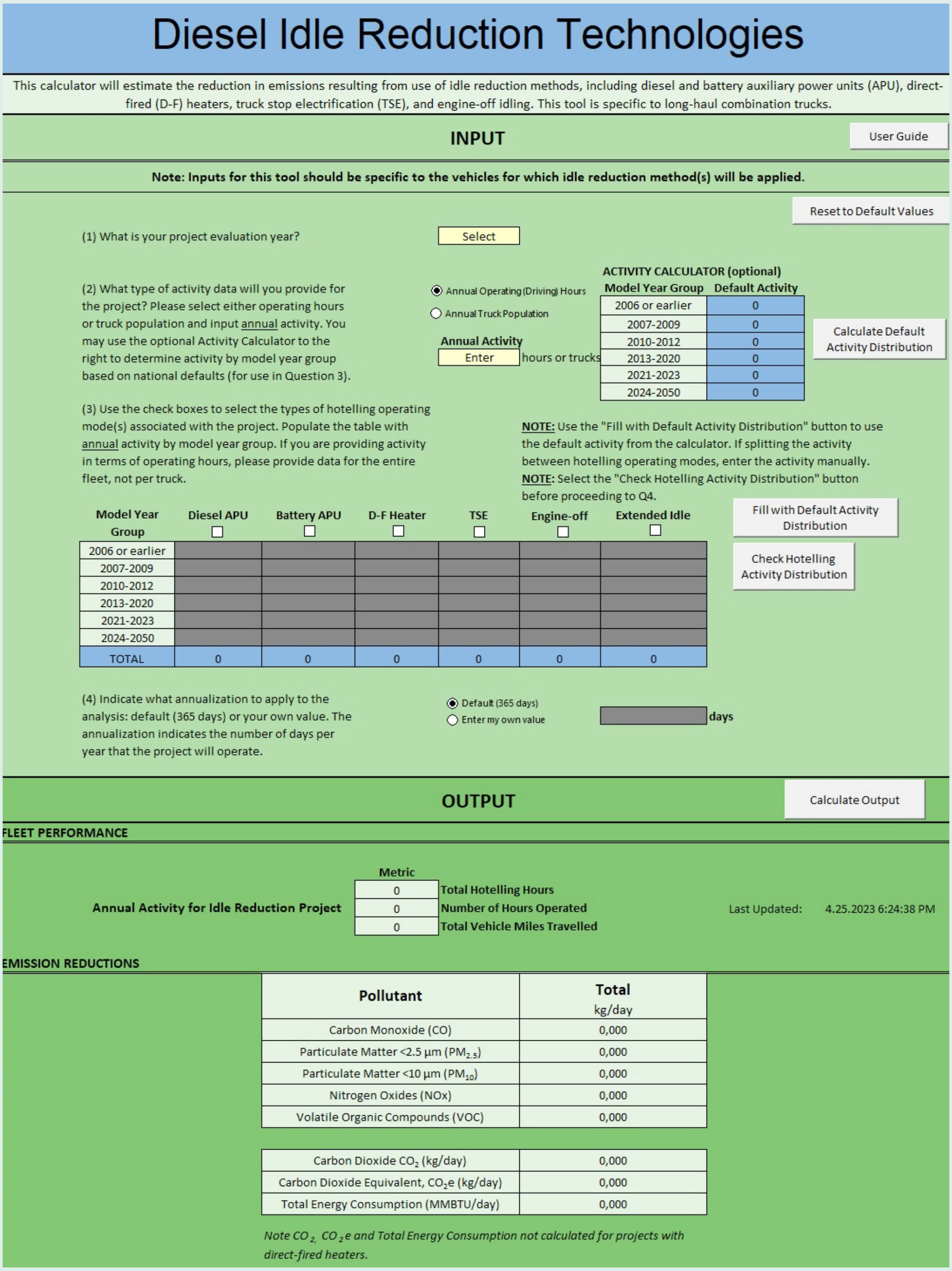
- Total daily work trips: 65,000
- Percentage of personal car use: 95%
- Percentage of commuting trips shorter than 15 minutes: 50%
- Estimated modal shift: 10%
- Evaluation year: 2030
- Trip distance source: Distribution
- Distribution of Typical trip distance: $x < 1$ = 33% $1 \le x < 2$ = 23% $2 \le x < 3$ = 28% $3 \le x < 4$ = 14% $4 \le x \le 5$ = 2%
- Typical trip distance – Passenger vehicles: 1.79 mi (derived from the distribution above)

Clicking the “Calculate Output” button outputs the following table:

Table 4-3: Output Table Emission Reductions of the Proposed Bicycle and Pedestrian Improvements Program

Pollutant	Total
Carbon Monoxide (CO)	26,021
Particulate Matter <2.5 µm ($PM_{2.5}$)	0,101
Particulate Matter <10 µm (PM_{10})	0,491
Nitrogen Oxide (NOx)	0,846
Volatile Organic Compounds (VOC)	0,898
Carbon Dioxide (CO_2)	3630,685
Carbon Dioxide Equivalent (CO_2e)	3648,268
Total Energy Consumption (MMBTU/day)	49,054

Figure 4.5: Spreadsheet-based Tool for Diesel Idle Reduction Technologies



Box 4.2: Calculation for the Idle Diesel Reduction Program

This box shows the calculation of emission reductions of an idle diesel reduction program by using the respective tool depicted in Figure 4.5.

Assume that the parameters of a proposed diesel idle reduction program, which aims at switching from idling the main propulsion engines to alternative power sources, are as follows:

- Project Evaluation Year: 2025
- Type of Activity: Operating Hours
- Annual Activity: 250,000 hours

Once these parameters are inputted, we click the "Calculate Default Activity Distribution" button. This estimates a distribution based on USA national averages. The output table for Activity Distribution is shown below.

Table 4-4: Activity Distribution Table

ACTIVITY CALCULATOR (optional)	
Model Year Group	**Default Activity**
2006 or earlier	10.979
2007-2009	7.831
2010-2012	12.545
2013-2020	119.631
2021-2023	60.040
2024-2050	38.975

- Hotelling Activity Type – Engine-off

After the Hotelling Activity Type is determined, the values in the Activity Distribution Table are inputted into the "Activity Calculator".

- Model Year Group 2006 or Earlier Activity: 10,979
- Model Year Group 2007-2009 Activity: 7,831
- Model Year Group 2010-2012 Activity: 12,545
- Model Year Group 2013-2020 Activity: 119,631
- Model Year Group 2021-2023 Activity: 60,040
- Model Year Group 2024-2050 Activity: 38,975

Clicking the "Calculate Output" button will produce the following tables:

Table 4-5: Fleet Performance

	Metric	
Annual Activity for Idle Reduction Project	200.000	**Total Hotelling Hours**
	250.000	**Number of Hours Operated**
	27.777.778	**Total Vehicle Miles Travelled**

Table 4-6: Emission Reductions

Pollutant	Total kg/day
Carbon Monoxide (CO)	22,352
Particulate Matter <2.5 µm ($PM_{2.5}$)	0,409
Particulate Matter <10 µm (PM_{10})	0,444
Nitrogen Oxides (NOx)	30,477
Volatile Organic Compounds (VOC)	2,164
Carbon Dioxide CO_2 (kg/day)	3.999,516
Carbon Dioxide Equivalent, CO_2e (kg/day)	4.009,516
Total Energy Consumption (MMBTU/day)	51,463

Figure 4.6: Spreadsheet-based Tool for Carpooling and Vanpooling

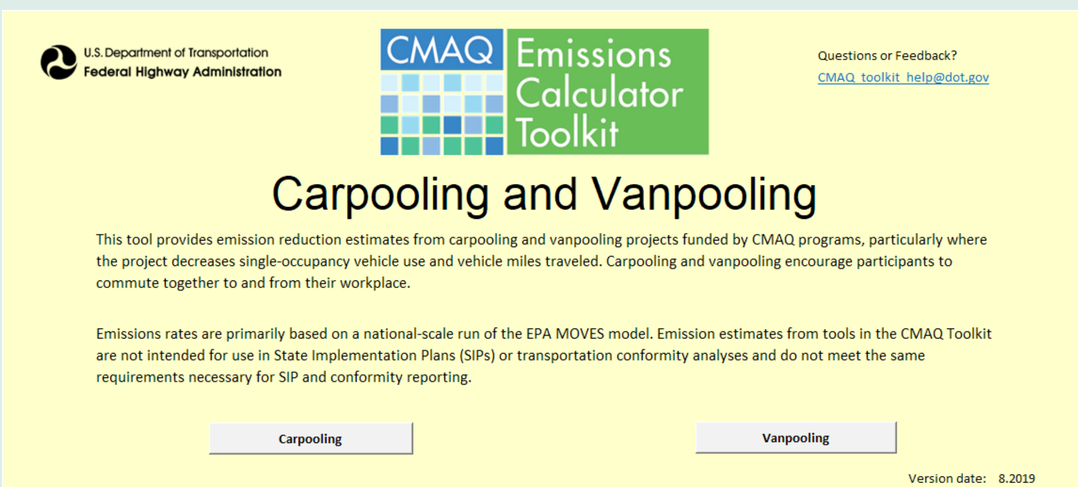
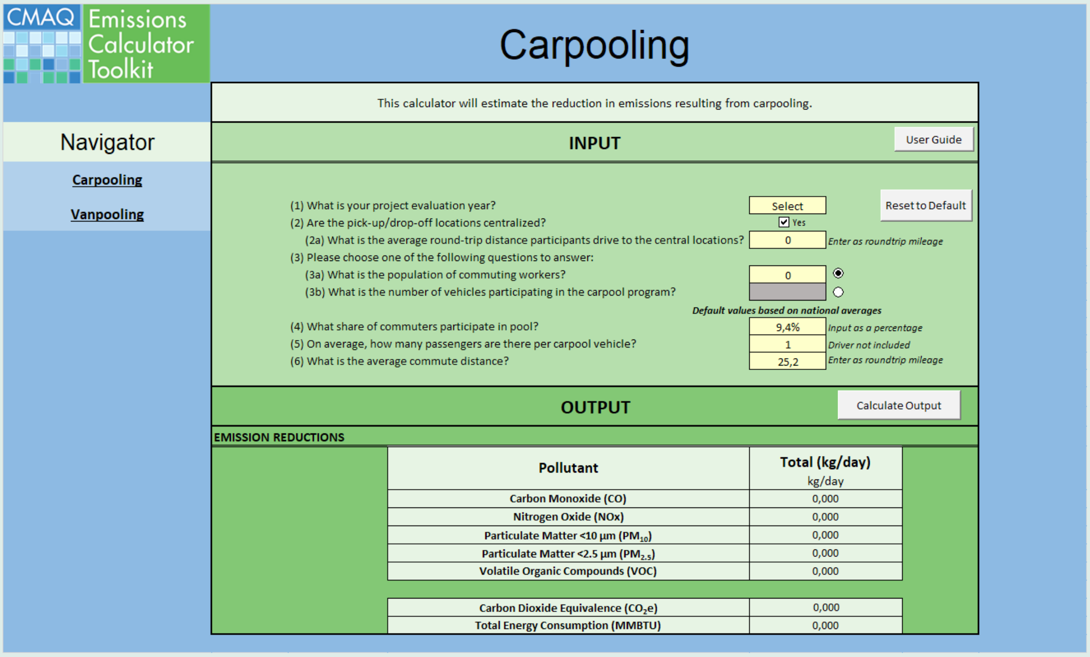


Figure 4.7: Spreadsheet-based Tool for Carpooling and Vanpooling



Box 4.3: Calculation of Emission Reductions of a Proposed Carpooling Program

This box shows the calculation of emission reductions of a carpooling program by using the respective tool depicted in Figure 4.6 and Figure 4.7.

Assume that the parameters of a proposed carpooling program are as follows:

- Average round-trip distance participants drive to the central locations: 5 miles
- The total number of people who participated: 120 (including the drivers)
- The average number of passengers in each car: 3 passengers per car (excluding the drivers)
- Total number of participating cars: 30 cars
- Average commute distance: 30 miles

When the above parameters are imputed, the spreadsheet-based tool produces the following output table for the year 2023:

Table 4-7: Emission Reductions of the Proposed Carpooling Program

Pollutant	Total (kg/day)
Carbon Monoxide (CO)	3,902
Nitrogen Oxide (NOx)	0,079
Particulate Matter <10 µm (PM_{10})	0,018

Pollutant	Total (kg/day)
Particulate Matter <2.5 µm ($PM_{2.5}$)	0,237
Volatile Organic Compounds (VOC)	0,041
Carbon Dioxide Equivalence (CO_2e)	693,256
Total Energy Consumption (MMBTU)	9,128

As noted above, there are 16 different possible programs/project types to reduce transport-related emissions as a part of the CMAQ. Such a wide range can resemble the case of "Comparing apples with oranges" and therefore make a possible comparison of benefits quite challenging. To deal with this problem, FHA conducted a cost-effectiveness assessment of the different program/project types. The results of the mentioned cost-effectiveness assessment are in Table 4-8.

Table 4-8: Summary of Median Cost-Effectiveness Analyses

Project Type	CO	NOx	VOCs	PM10	PM2.5	Total Median Cost per Ton
Dust Mitigation				A	B	$15,932
Idle Reduction Strategies	A	A	A	B	B	$58,999
Diesel Engine Retrofit Technologies	B	B	C	D	D	$407,684
Intermodal Freight Facilities and Programs	B	A	C	D	D	$494,834
Carsharing	A	B	B	D	E	$766,199
Incident Management	B	B	D	D	D	$1,071,991
Transit Service Expansion	A	C	C	E	F	$2,766,431
Traffic Signal Synchronization	C	D	F	D	F	$3,042,950
Park and Ride	A	C	D	E	F	$3,622,288
Natural Gas Re-Fuelling Infrastructure	A	B	D	F	F	$3,675,107
Electric Vehicle Charging Stations	A	C	D	F	F	$6,380,581
Transit Amenity Improvements	B	D	D	F	G	$7,457,446
Rideshare Programs	B	D	D	F	G	$8,194,085
Roundabouts	D	D	F	G	F	$8,786,402
Extreme Temperature Cold-start Technologies	B	F	D	F	F	$10,850,034
Bikesharing	B	G	F	F	G	$13,834,816
Bicycle and Pedestrian Improvement Projects	B	D	E	F	H	$19,423,016
Intersection Improvements	D	F	F	H	H	$30,823,921

Project Type	CO	NOx	VOCs	PM10	PM2.5	Total Median Cost per Ton
Employee Transit Benefits	D	F	F	H	I	$50,281,268
Subsidized Transit Fares	D	F	F	H	I	$50,281,268
Heavy-Duty Vehicle Replacements	D	D	F	I	I	$69,830,233

Benefit-Cost Analysis Guidance for Discretionary Grant Programs of the Department of Transportation

The Department of Transportation published the Benefit-Cost Analysis Guidance for Discretionary Grant Programs in January 2023. As the name implies, the document aims at drawing the general principles and dimensions of a benefit-cost analysis report to be submitted to the Department's discretionary programs. It defines and specifies the use of the discount rate and the associated benefits and costs incorporated in a benefit-cost analysis.

With respect to the discounting, the document has made a distinction between the discounting of the benefits/costs associated with greenhouse gases and those associated with other air pollutants. While it is suggested to use a discount rate of 7% for the air pollutants such as Sulphur oxides (SO_x), NO_x, and fine particulate matter (PM2.5), a 3% discount rate is recommended for the costs and benefits regarding CO_2 emissions due to their longer period and even across generations impacts.

The guidance lists the following benefits:

- Safety benefits and travel time savings
- Operating costs savings
- Emissions reduction benefits
- Facility and vehicle amenity benefits
- Pedestrian Facilities
- Cycling Facilities
- Transit System, Facility, and Vehicle Amenities
- Reduced Facility and Vehicle Crowding
- Passenger Transfer Reduction
- Health benefits
- Agglomeration Economies and Land Use
- Noise Pollution
- Temporary Loss of Emergency Services
- Stormwater Runoff
- Wildlife Impacts

- Repurposed Right-Of-Way

As can be seen above, rather than grouping under a single heading (such as the "environmental impact benefits"), the environmental impacts to be examined as a part of the benefit-cost analysis are distributed under various headings.

New transport infrastructure can reduce emissions in various ways. First, it can reduce travel distances meaning that with the same amount of traffic and vehicle type, the total emissions are lowered. Second, it can shift both the passengers and freight to more efficient modes of transportation. Last, it can initiate an operational improvement or investments in technologies targeting fuel usage reduction.

The applicants of the discretionary program are expected to provide their assumptions or scenarios explaining how the new transport infrastructure project will reduce emissions. Once the total emission savings are calculated (as in the case of calculated emission savings by the tools explained earlier), they should be incorporated into the benefit-cost analysis. To achieve this, the guidance monetizes the benefits and costs for each of the pollutants and greenhouse gases (Table 4-10). The monetary values reported in Table 4-10 should be used to calculate the final environmental benefit that occurred as a result of the reduction in emissions. Box 4.4 provides an example.

Table 4-9: Recommended Monetized Values for Emissions

Emission Type	NOx	SOx	PM2.5	CO_2
2022	$ 16,600.00	$ 44,300.00	$ 796,700.00	$ 56.00
2023	$ 16,800.00	$ 45,100.00	$ 810,500.00	$ 57.00
2024	$ 17,000.00	$ 46,000.00	$ 824,500.00	$ 58.00
2025	$ 17,200.00	$ 46,900.00	$ 838,800.00	$ 59.00
2026	$ 17,500.00	$ 47,800.00	$ 852,100.00	$ 60.00
2027	$ 17,900.00	$ 48,700.00	$ 865,600.00	$ 61.00
2028	$ 18,200.00	$ 49,500.00	$ 879,400.00	$ 62.00
2029	$ 18,600.00	$ 50,400.00	$ 893,400.00	$ 63.00
2030	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 65.00
2031	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 66.00
2032	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 67.00
2033	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 68.00
2034	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 69.00
2035	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 70.00
2036	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 72.00
2037	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 73.00
2038	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 74.00
2039	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 75.00

Emission Type	NOx	SOx	PM2.5	CO_2
2040	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 76.00
2041	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 78.00
2042	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 79.00
2043	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 80.00
2044	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 81.00
2045	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 82.00
2046	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 84.00
2047	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 85.00
2048	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 86.00
2049	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 87.00
2050	$ 18,900.00	$ 51,300.00	$ 907,600.00	$ 88.00

Box 4.4: The Measurement of Emissions Reduction Benefits

The Benefit-Cost Analysis Guidance for Discretionary Grant Programs of The Department of Transportation specifies the damage costs for emissions per metric ton for four emission types [i) NO_X, ii)SO_X, iii)PM2.5, iv)CO_2] over the 2022-2050 period. For example, the respective damage costs for the year 2040 are as follows:

NO_X: $18,900/ton

SOX: $51,300/ton

PM2.5: $907,600/ton

CO_2: $76/ton

Assuming that a new transportation project will lower each of these four emission types by 10 metric tons annually; the emission reduction benefit for the year 2040 will be calculated as follow:

NO_X $Reduction\ Benefit = Quanity\ Reduced\ x\ Monetized\ Value\ in\ given\ year = 10\ metric\ tons\ in\ 2040\ x\ \$18{,}900/metric\ ton = \$189{,}000\ in\ 2040$

SO_X $Reduction\ Benefit = Quanity\ Reduced\ x\ Monetized\ Value\ in\ given\ year = 10\ metric\ tons\ in\ 2040\ x\ \$51{,}300/metric\ ton = \$513{,}000\ in\ 2040$

$PM2.5\ Reduction\ Benefit = Quanity\ Reduced\ x\ Monetized\ Value\ in\ given\ year = 10\ metric\ tons\ in\ 2040\ x\ \$907{,}600/metric\ ton = \$9{,}076{,}000\ in\ 2040$

CO_2 $Reduction\ Benefit = Quanity\ Reduced\ x\ Monetized\ Value\ in\ given\ year = 10\ metric\ tons\ in\ 2040\ x\ \$76/metric\ ton = \$760\ in\ 2040$

TOTAL EMISSION REDUCTION BENEFIT = $189,000 + $513,000 + $9,076,000 + $760 = $9,778,760 *in* 2040

Box 4.5: The Measurement of Pedestrian and Cycling Facility Improvements

Active transportation modes like walking and cycling have positive implications for the environment. They not only reduce noise coming from the traffic but also substantially emit less emission when compared with motorized modes. In addition, a shift from motorized modes to these active transportation modes will reduce both the traffic congestion and the need to build more transport road and rail infrastructure, which in turn also contribute to more environmentally friendly mobility. For all these reasons, an improvement in walking and cycling infrastructure should be environmentally monetized and included in the respective benefit-costs analysis. The Benefit-Cost Analysis Guidance for Discretionary Grant Programs specifies how a group of such measures should be monetized. **Box *4.5*** presents an example for measuring the improvements after an improvement in pedestrian and cycling facilities.

Table 4-10: Monetized Value*s (U.S. Department of Transportation, 2023***)**

Improvement Type	Recommended Value per Person-Mile Walked (2021 $)
Expand Sidewalk (per foot of added Width)2	$0.11
Reducing Upslope by 1%	$1.05
Reducing Traffic Speed by 1 mph (for speeds ≤45 mph)	$0.09
Reducing Traffic Volume by 1 Vehicle per Hour (for ADT ≤55,000)	$0.0009

Table 4-11: Monetized Values *(U.S. Department of Transportation, 2023)*

Improvement Type	Recommended Value per Person-Mile Walked (2021 $)
Install Marked-Crosswalk on Roadway with Volumes ≥10,000 Vehicles per Day	$0.18
Install Signal for Pedestrian Crossing on Roadway with Volumes ≥13,000 Vehicles per Day	$0.48

Take a project which will extend a two-mile sidewalk by five feet. The daily average pedestrian trip is 3,000. Based on the figures shown in

Table ***4-12***, the monetary value of the benefit to pedestrian walking will be calculated as follows:

Benefit per Mile Walked = *Sidewalk Value per Foot of Added Width x Additional Width* = $0.11 *per Foot of Added Width x* 5 *Feet* = $0.55 *per Mile Walked*

Benefit to Pedestrians = *# of Daily Users x Block Length x Value per Mile Walked x* 365 *Days*= 3,000 *Pedestrians x* 2 *Miles x* $0.55 *per Mile Walked x* 365 *Days* = *$1,204,500 per Year*

Table 4-12: Monetized Values *(U.S. Department of Transportation, 2023)*

Facility Type	Recommended Value per Cycling Mile (2021$)
Cycling Path with At Grade Crossings	$1.49
Cycling Path with no At Grade Crossings	$1.87
Dedicated Cycling Lane	$1.77
Cycling Boulevard/"Sharrow"	$0.28
Separated Cycle Track	$1.77

Assuming that a new on-street cycling lane will be built on a 2-mile street with 100 daily cyclists and having no other parallel facility currently in use. Estimating that an additional 50 daily cyclist trips will be induced after the introduction of the new cycling lane, the daily benefit will be as follows:

$Existing\ User\ Benefits = \#\ of\ Cyclists\ x\ Bike\ Lane\ Value\ per\ Cycling\ Mile\ x\ Distance =$ $100\ Cyclists\ x\ \$1.77\ per\ Mile\ x\ 2\ Miles = \$354$

$Benefits\ to\ Additional\ Users = 1/2\ x\ \#\ of$ new $Cyclists\ x\ Bike\ Lane\ Value\ per\ Cycling\ Mile\ x\ Distance = 1/2\ x\ 50\ Induced\ Cycling\ Trips\ x\ \$1.77\ per\ Mile\ x\ 2\ Miles = \$88{,}5$

Total Annual Benefits = 365 x (354 + 88,5) = $161,512,5

Noise Measurement Handbook of FHA

FHA published a Noise Measurement Handbook (NMH) (Federal Highway Administration, 2018). In 2018 with a goal of offering best-practice advice on identifying which measurement methodologies apply to which project types, how to plan a noise measurement program, descriptions of measurement methodologies and related considerations, terminology and measurement instrumentation related to highway traffic noise, sample report documentation for measurements, and supporting information for various methodologies.

In its first chapter, NMH identifies the types of the road projects and the respective reason to measure the noise. In aggregate terms, road projects are classified into Type I and Type II projects. Type I projects include new greenfield road projects, capacity expansion projects, or those involving drastic horizontal or vertical alignment changes. Type II projects, on the other hand, are implemented to reduce noise at the existing roads.

Noise measurement for Type I road projects are done to estimate the noise impact of the project, to help noise abatements designs and to predict the noise of the construction activities. For Type II road projects, the measurement of the noise is done not only to monitor the existing noise levels with the acceptable limits, but also to check the e effectiveness of the existing noise barriers or o validate FHA traffic noise model (TNM).

The planning of the noise measurements requires determination of a group of factors. First of all, the project type and the purpose of the measurement should be decided. Then, the measurement sites should be identified based on the respective plans and maps and a site visit. Depending on the scope and size of the measurement, the human resource and technical equipment needs should be estimated. This procedure is completed with the final resource planning and scheduling (based on the decisions such as the timing, duration and frequency of the measurement) of the noise measurement.

Airport Benefit-Cost Analysis (BCA) Guidance of the Federal Aviation Administration (FAA)

Environmental impact evaluations are necessary for intended airport-related projects and programs that require FAA approval under the NEPA and other related environmental laws and regulations. Before a project starts, the environmental review procedure must be finished. The Airport Benefit-Cost Analysis Guidance of FAA serves as a comprehensive and detailed guide for airport sponsors on how to prepare a benefit-cost evaluation for the projects. For this purpose, the guidance classifies related impacts an airport project, including environmental impacts. This means that apart from financial and economic impacts, the environmental benefits and costs of an airport project should be identified and incorporated into the BCA analysis. Environmental assessment may be required in two different ways.

On the one hand, an airport project may not directly be an environmental project such as capacity expansion (like the extension of the existing runway or construction of a new airport passenger terminal), but may have environmental considerations. In these circumstances, a BCA analysis should be submitted. On the other hand, the airport project may directly be an environmental one like "*Noise mitigation for pre-existing infrastructure (noise insulation, structure removal)*" or "*Fuel and chemical containment for pre-existing infrastructure*". In such cases, however, there is no need to prepare and submit a dedicated BCA but the Project should be completed "*in most cost-effective manner acceptable to FAA*".

Aviation Emissions and Air Quality Handbook

Aviation Emissions and Air Quality Handbook has been released to guide the practitioners with respect to the organizing, planning, and completing air quality assessments for aviation projects, programs, actions.

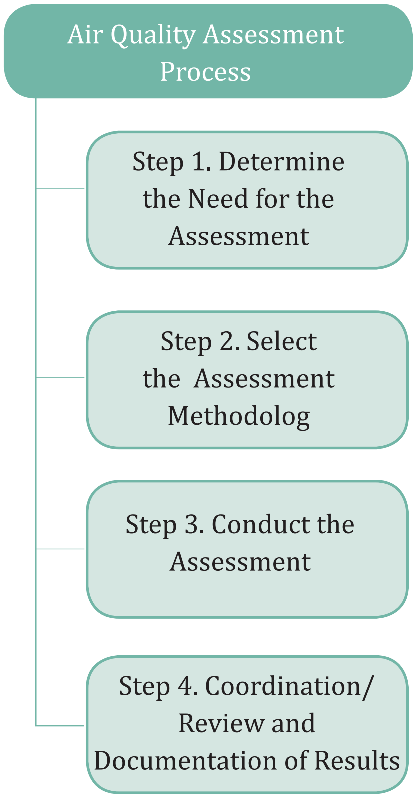
The NEPA and the CAA have been the two major acts FAA has to comply regarding the environmental impacts of aviation. The fundamental reference of the Handbook is the set of National Ambient Air Quality Standards (NAAQS), which have been established by the EPA to protect public health and environmental welfare from the harmful impacts of air pollution. Table 4-13: **National Ambient Air Quality Standards** reports the respective standards for each of the six air pollutants.

Table 4-13: National Ambient Air Quality Standards *(EPA, 2023)*

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3-month average	0.15 mg/m3 (1)	Not to be exceeded
Nitrogen Dioxide (NO2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM2.5	primary	1 year	12.0 µg/m3	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m3	98th percentile, averaged over 3 years
	PM10	primary and secondary	24 hours	150 µg/m3	Not to be exceeded more than once per year on average over 3 years
Sulphur Dioxide (SO2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

According to the Handbook, the practitioners of the Handbook should follow a four-step process for the assessment of the air quality (Figure 4.8):

Figure 4.8: Air Quality Assessment Process



The assessment should start with the determination of the Need for the Assessment. In other words, the first step of the assessment is to determine whether the assessment is necessary or not (Step #1). This stage includes describing the project's projected scope, which may be confined to a change in the airport's design and its infrastructure, or it may be about the features of how the airport and aircraft operate. Once the scope is defined, it should be investigated whether the project or action involves FAA involvement or not. Here the FAA involvement may range from approving and permitting to funding. Next, it should be determined whether the project or action will result in or cause an increase in air emissions. Such projects may include those increasing aircraft operations and those altering the flight paths of airplanes and vehicles as a result of a change in the roadways, parking facilities, and runway/taxiway upgrades.

The second step of the Air Quality Assessment Process is to select the assessment methodology (Step #2). This starts with the Qualitative Assessment, which is required when it is determined that a project or course of action won't result in or create a rise in air emissions. This qualitative assessment should bring clarification on how or why carrying out the project/action won't result in or produce an increase in air emissions.

Next, the air pollutant emissions should be modelled and predicted. The analysis should be detailed in terms of the pollutant type, emission source, and project/action options.

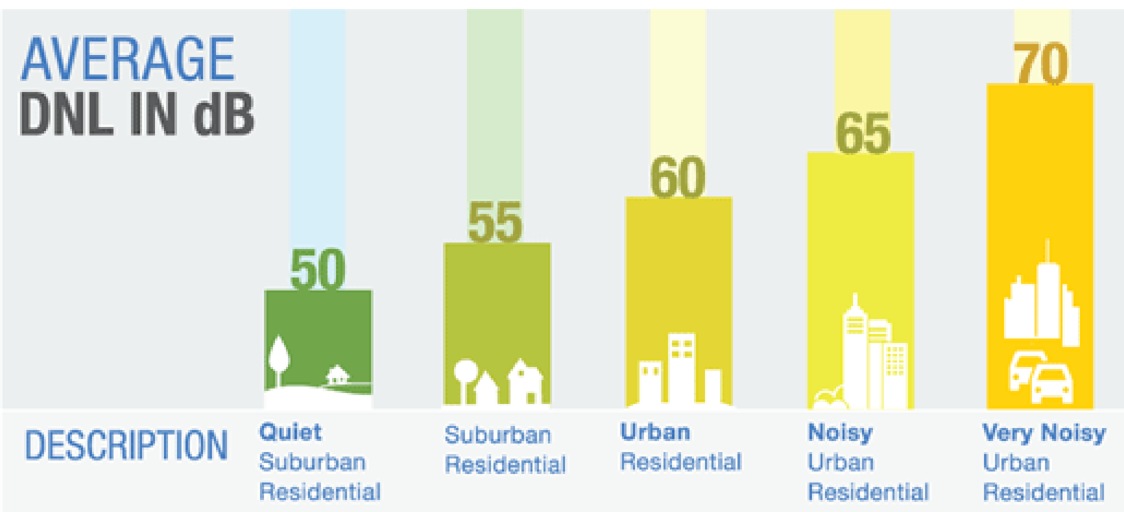
The third step is to conduct the assessment (Step #3). This step may entail choosing the analysis years, defining the emission types and sources of interest, acquiring and/or producing the relevant input data, and executing the applicable models/procedures. In the last step, which is the coordination/review and documentation of results (Step #4), the analysis carried out towards air quality assessment is coordinated and discussed with the appropriate agency. This activity comprises communicating the assessment results to the evaluating agencies and the broader public.

Aviation Emissions

An overview of the FAA's regulations suggests that aviation noise seems to be of a larger concern when compared with aviation emissions. One explanation for this inclination might be that aviation emissions are largely regulated with international initiatives whereas aviation noise is more of the responsibility of the national authorities.

In the US, the residential areas are classified based on the day-night average sound level (Ldn) values, as shown in Figure 4.9. According to this classification, areas with Ldn values of 50 dB or less are defined as quiet suburban residential areas, which is followed by suburban residential, urban residential, noisy urban residential, and very noisy urban residential areas, respectively.

Figure 4.9: Day-night Average Sound Level Values in Residential Areas
(Federal Interagency Committee, 2023)



4.1.4. The Related Statistics Collected Regularly

The Bureau of Transportation Statistics (BTS) (of the DOT) is the primary sources of statistics on the linkage between transportation and environment. The following list indicates the major statistics compiled by BTS (Bureau of Transportation Statistics, 2017):

i. Energy Use by Sector:

ii. Transportation Energy Use by Energy Source

iii. E85 Refuelling Stations by State

iv. Energy Use by Mode of Transportation

v. GHG Emissions by Mode

vi. Transportation-Related GHG Emissions

vii. Car and Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG):

viii. Vehicle-Miles of Travel and Fuel Use by Personal Vehicles

ix. Energy Intensity of Passenger Modes

x. Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles

xi. Electric Vehicle Refuelling Stations by State

xii. Compressed natural gas (CNG) and liquefied natural gas (LNG) Refuelling Stations by State

xiii. Transportation Energy Use: Projected 2015–2040

xiv. Highway Vehicle Fuel Use and Travel: 2014-Projected to 2040

xv. Indexes of Key Air Pollutant Emissions from U.S. Transportation

xvi. Air Quality Index for 169 U.S. Cities

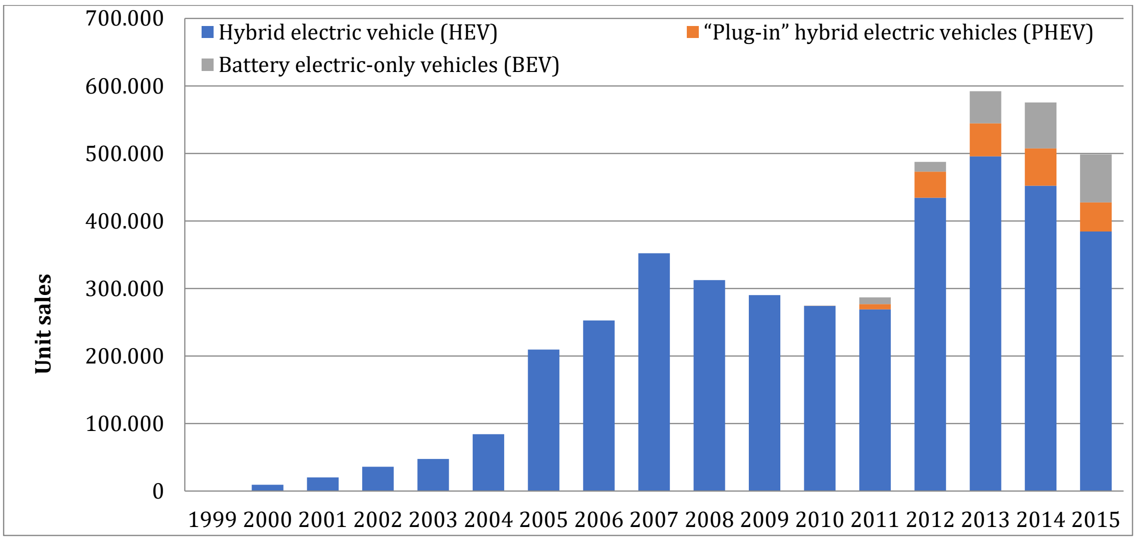
xvii. Petroleum Spills Impacting Navigable Waterways

4.1.5. The Current Efforts to Deal with The Environmental Effects of Transport Infrastructure and Services

Hybrid and Electric Cars

Hybrid and electric vehicles are one of the popular ways of reducing the environmental impacts of the transport activities. Because of this tendency, governments take different measures to encourage the use of these vehicles. For example, in the USA and Canada, drivers can use their electric vehicles on highways by obtaining the right to use lanes in High Occupancy Vehicles (HOV) or carpool lanes where traffic congestion is generally less and help the owners of the electric vehicles save significant time. In addition, in various countries significant tax reductions are provided to those who buy electric vehicles. Such advantages, combined with consumers' growing environmental concerns, are steadily increasing sales of electric vehicles. Norway became the first country where the share of electric vehicles in new vehicle sales exceeded 50% in 2020. It is possible to see the reflection of this trend toward electric vehicles in the financial markets. Electric vehicle manufacturer Tesla is by far the first among all automotive companies in terms of market value. The difference is so high that the sum of the market values of Toyota, Volkswagen, Daimler, General Motors, and NIO, which follow Tesla in terms of market value, is below Tesla's market value. Parallel with the trend, the number of electric and hybrid vehicles is significantly increasing in the USA market (Figure 4.10) (Bureau of Transportation Statistics, 2017).

Figure 4.10: Sales of Hybrid, Plug-in Hybrid, and Battery Electric Vehicles: 1999-2015



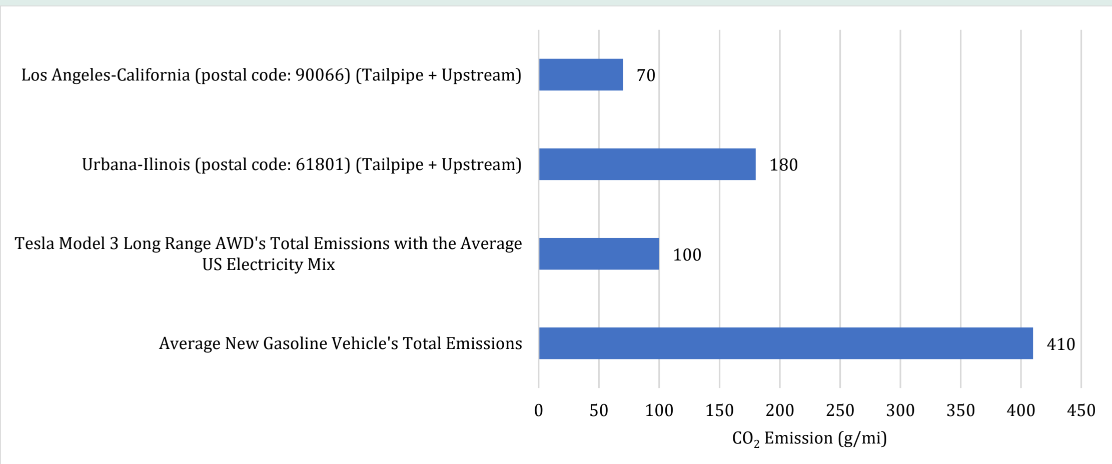
But electric cars are not totally emission-free. They may not emit emissions while driving (tailpipe emission is equal to zero), but the emission is produced during the generating of the electricity, meaning that mainstream emission is greater than zero. Therefore, we should increase the share of renewable energy sources in the electricity mix to improve the benefits of the electric car. Box 4.6 below provides a comparison to better exhibit this fact, using a tool developed by United States Environmental Protection Agency to measure the emission impacts of the regional electricity mix.

Box 4.6: How Electricity Mix Affect Emissions of The Electric Cars?

The United States Environmental Protection Agency (Environmental Protection Agency) has an interactive application (U.S. Fuel Economy, 2023) on the emissions of electric vehicles. By entering a zip code in the application, one can calculate the emission emitted by the specified vehicle using the electricity in that region.

To make a comparison, let's take the Tesla Model 3 Long Range AWD, which is the best-selling electric car in 2020. The 2021 Tesla Model 3 Long Range AWD vehicle in Los Angeles-California (postal code 90066) will emit 70 grams CO_2 per mile, while the CO_2 emissions generated by the same vehicle in Urbana-Illinois (postal code 61801) will be 180 grams per mile (Figure 4.11). The relatively high share of renewable energy sources (31.7%) and the low share of coal-based electricity generation (2.96%) in the electricity mix of the state of California contributed to the relatively low emission of vehicles used in Los Angeles (Energy Council of Canada, 2019). In the state of Illinois, however, these shares are 10% and 30%, respectively (Illinois Environmental Council, 2023). The difference between the electricity resource changes the electricity mix and explains the different emission figures in these two cities. As seen in Figure 4.11, the same vehicle will emit 100 grams of CO_2 per mile if it uses the average electricity mix of the United States. In other words, the electricity used in Los Angeles has lower CO_2 emissions than the USA average, while the electricity in Urbana is produced with a much higher CO_2 emission. The CO_2 emission value of a new average gasoline-powered vehicle sold in 2021 is 410 grams per mile. So, if we drive the Tesla Model 3 Long Range AWD vehicle, which we discussed in our comparison, in Los Angeles, we save 340 grams of CO_2 emissions per mile, which is about 83% compared to a petrol-powered equivalent vehicle.

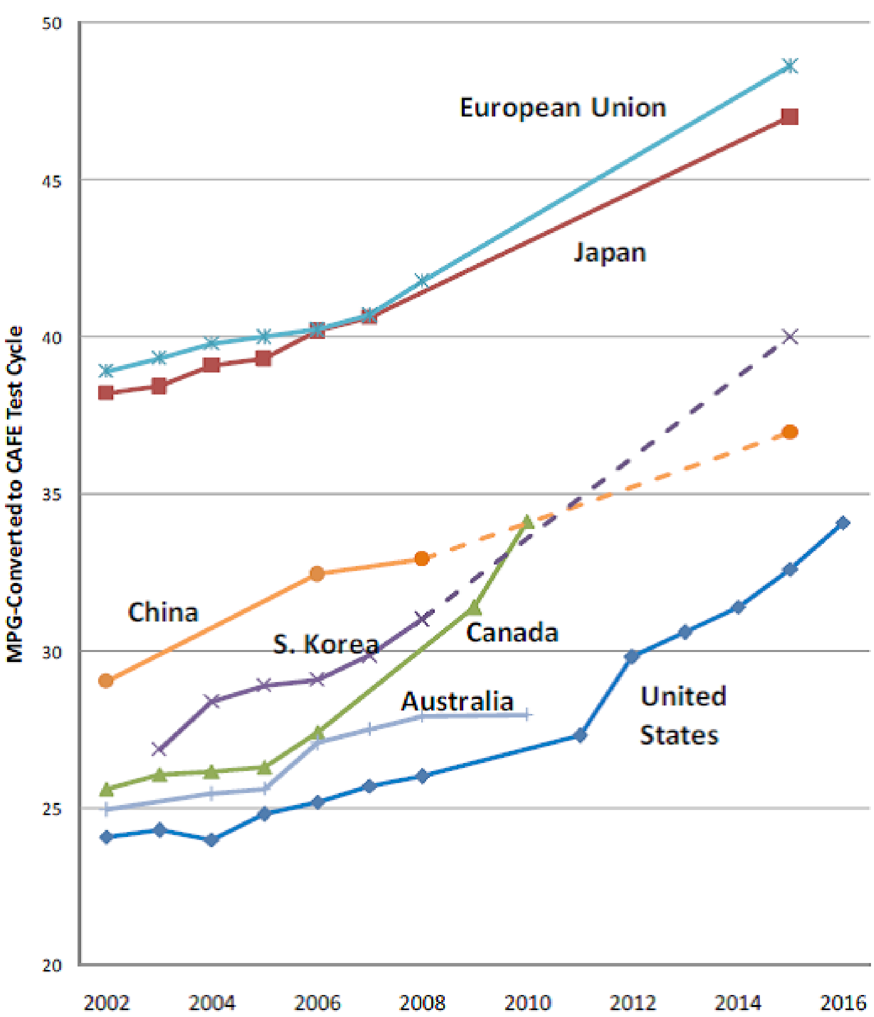
Figure 4.11: Fuel Economy Comparison Based on the Electricity Mix



Fuel Standards and New Vehicle Technologies

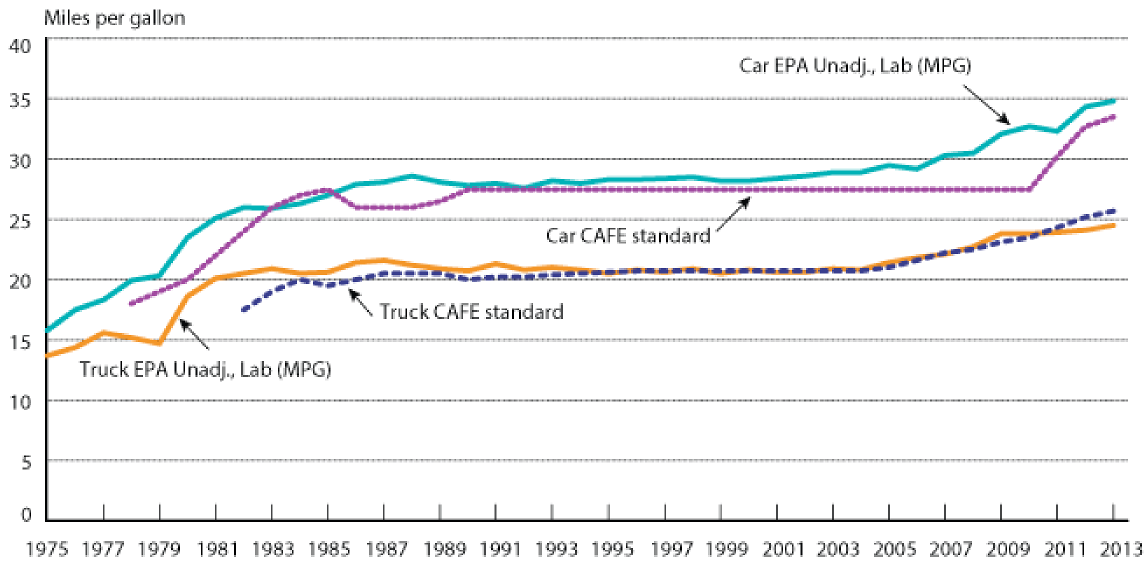
A common generalization points out that *"only 1 percent of the energy used by a car goes into moving the driver"* (MacKay, 2008). This implies that there is a large room for fuel economy in personal vehicles. This can be achieved by manufacturing lighter and smaller cars (Cheah & Heywood, 2011), developing more efficient and less powerful engines, and adopting newer technologies such as regenerative braking, which relies on storing the energy during the braking and re-using it. However, when the vehicle trends in the USA are considered, which favour larger vehicles and more powerful engines, these possible measures are relatively challenging to implement. As evidence of this fact, Figure 4.12 shows the fuel economy averages (measured in miles per gallon) in the US, together with those in Japan, Australia, Canada, South Korea, China, and the European Union. One major implication of Figure 4.12 is that the USA has been continuously the worst-performing country/region over the 2002-2016 period.

Figure 4.12: Fuel Economy Standards for New Passenger Vehicles by Country/Region
(Anderson, 2011)



Despite the inferior performance in terms of fuel efficiency, the USA has been setting more efficient targets over time. Figure 4.13 presents these changes over the 1978-2018 period. CAFE standards have been the major reference for fuel economy in the US. Though these standards are governed by the National Highway Traffic Safety Administration of the Department of Transportation, specific legislation like the case Energy Independence and Security Act of 2007 (EISA) can amend these CAFE standards.

Figure 4.13: Car and Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG): Model Years 1975-2013 *(Bureau of Transportation Statistics, 2013)*



HOV Lanes

HOV lane is a lane where the use is limited to vehicles having at least one additional person, aside from the driver, must be present. The eligibility criterion for the minimum number of passengers (such as at least 2 persons, 3 persons, etc.) may vary depending on the characteristics of the road.

In the United States, the first HOV lane (The I-395 HOV lanes in Virginia between Washington DC and the Capital Beltway) started its operations in 1969 (U.S. Federal Highway Administration, 2008). A report entitled "Review of HOV Lane Performance and Policy Options in the United States" indicates that there were 301 active HOV lanes in the USA (U.S. Federal Highway Administration, 2008).

HOV lanes have two major environmental consequences. First, they stimulate carpooling, which reduces the number of vehicles in the traffic. Second, by allowing hybrid and electric cars, they encourage drivers to switch to these environmentally friendly vehicles without needing to have a passenger with them. Evidence reveals that HOV lanes provided peak hour travel time savings in the range of 0,4-37 minutes.

Box ***4.7*** below is an example of the calculation of the environmental impacts of HOV lanes.

Box 4.7: Environmental Impact of HOV Lanes

Based on the environmental impacts published in Review of HOV Lane Performance and Policy Options in the United States and shown in the table below, we will calculate the peak hour environmental impact of HOV lanes assuming a peak hour total vehicle travel delay of 1,000 hours and using the assumption of the Texas Transportation Institute that the gasoline use is 0.68 gallons of fuel per hour of delay.

Table 4-14: Environmental Impacts

Air Quality - Pollutant	Passenger Car Average Emissions
CO (kg/gallon)	14.44
NOx (kg/gallon)	1.27
VOC (kg/gallon)	1.91
Carbon Dioxide (kg/gallon)	8.79

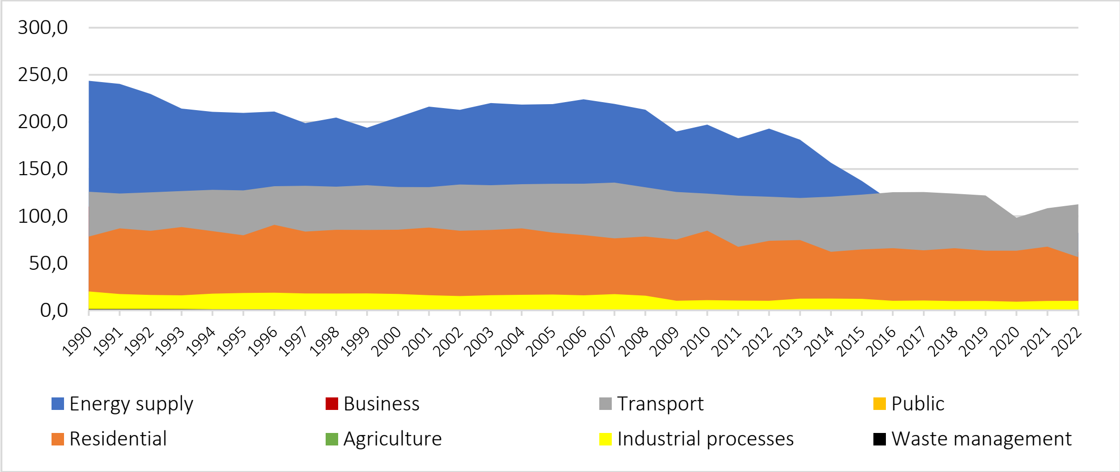
Table 4-15: Calculation of the Environmental Impact of HOV Lanes

Air Quality - Pollutant	Emission Reduction
CO (kg)	=1,000 * 0.68 * 14.44 = 9,819.2
NOx (kg)	=1,000 * 0.68 * 1.27 = 863,6
VOC (kg)	=1,000 * 0.68 * 1.91 = 1,298.8
Air Quality (kg)	=9,819.2+863,6+1,298.8=11,981.6
Carbon Dioxide (kg)	=1,000 * 0.68 * 8,79 = 5,977.2

4.2. Case Study-2: The United Kingdom (Europe)

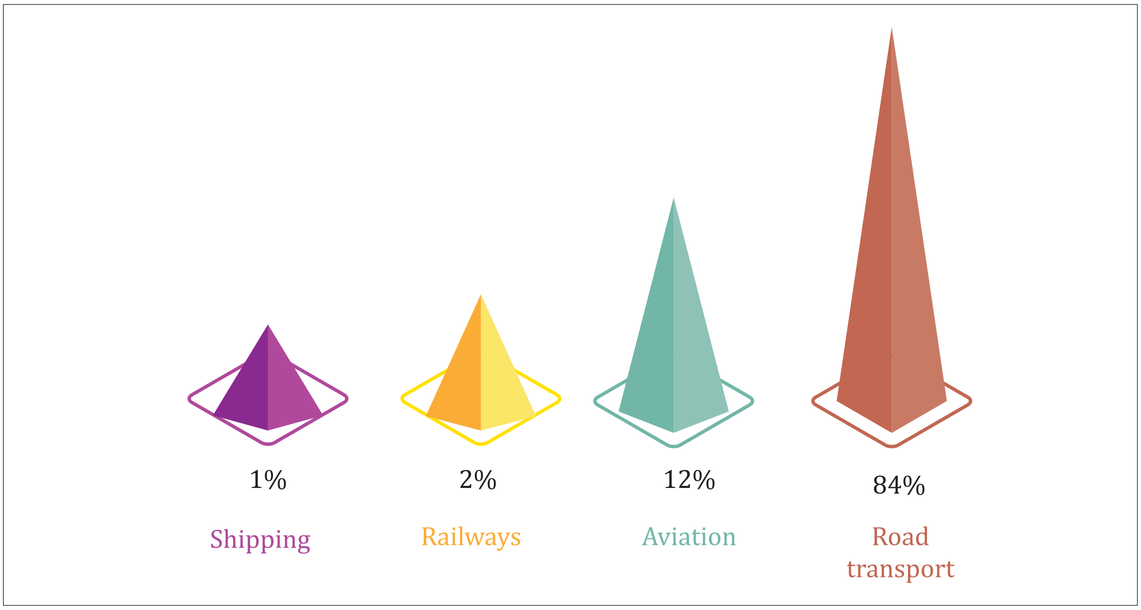
Transport sector is consistently one of the top three sectors regarding CO2 Greenhouse Gas Emissions, a fact depicted in Figure 4.15.

Figure 4.15: CO_2 Greenhouse Gas Emissions by Sector in the UK: 1990-2022 *(GOV.UK, 2023)*



As the in Figure 4.15 suggests, transport (shown in gray) is the number one sector regarding CO_2 greenhouse gas emissions staring from year 2016. Before that year, energy supply had been the top CO_2 emitter sector. Apart from transport and energy supply, business and residential are among the top four CO_2 emitting sectors. When compared with the United States, The United Kingdom has a more developed intercity rail transport system. In addition, the urban transit systems are better functioning and many congestion charge and low emission schemes are in place, which further encourage transit use. Therefore, the 84% share of road transport in the overall transport energy consumption (shown in Figure 4.16), which is equal to the share of the road transport in the United States, is partly surprising.

Figure 4.16: Energy Use by Mode of Transportation 2021 *(GOV.UK, 2023)*



4.2.1. The Related Legislation and The Governmental Agencies Involved

Environment Act 2021 is the framework act regulating the environmental issues. Apart from setting the environmental targets and governing the environmental plans, the act administers the tasks and responsibilities regarding various resources such as air and water. At the transport part, Transport Act 2000 is the framework act. It regulates individual transport modes like aviation, road and rail.

The Department for Transport (DfT) is the department (ministry) responsible for the overall administration of the transport sector. At the aviation side, The Civil Aviation Authority is the regulatory body of the DfT. Being a non-departmental public body of the DfT, its main responsibilities involve the oversight and regulation of the aviation industry. The UK is one of the pioneers of the airport privatization in the world. The British Airports Authority was privatized with the Airports Act 1986 (Parker, 1999), which involved the privatization of the largest UK airports (Heathrow, Gatwick, and Stansted, Glasgow, Edinburgh, Aberdeen and Southampton). This move was later followed by the commercialization of a large group of smaller airports (Humphreys, 1999). At the rail side, the UK is also one of the pioneers of the rail privatization. The train operations are franchised to the private sector (Wellings, 2014) whereas the infrastructure is administered by Network Rail, which is a public body of the DfT. The regulation is done by the Office of Rail Regulation (ORR), which is a ministerial department. At the road transport, National Highways, is responsible for the operation and development of roads.

4.2.2. The Major Guidelines, Handbooks, Programs and Methodologies

4.2.2.1. Cost Benefit Analysis and Valuation of Environmental Impacts

A Cost-Benefit Analysis (CBA) is prepared to evaluate policies, programs, and projects in the transport industry. The Green Book (The Green Book Central Government Guidance on Appraisal and Evaluation) published by HM Treasury in 2002 describes CBA as follows:

> *"Analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value."*

A typical CBA in the transport industry should consists of economic, environmental and social impact appraisals. Accordingly, five different guidance are produced and shared with the stakeholders. Transport analysis guidance (TAG) Unit A1 for Cost-Benefit Analysis whereas TAG Unit A2, A3, A4, and A5 focuses on Economic, Environmental, Social Impact, and Uni-Modal Appraisal Appraisals, respectively. Table 4-16 presents the classification of possible environmental impacts with respect to their category (UK Department for Transport, 2023).

Table 4-16: Appraisal Summary Table Impacts

Category of impact	Impacts that are typically monetized	Impacts that can be monetized but are not reported in the AMCB table	Impacts that it is currently not feasible or practical to monetize
Economy	Business users and private sector providers (including revenues)	Reliability impact on business users Wider Economic Impacts	
Environment	Noise Air quality Greenhouse gases	Landscape	Townscape Historic Environment Biodiversity Water environment
Social	Commuting and other users Accidents Physical activity Journey quality	Reliability impact on commuting and other users Option and non-use values	Security Access to services Affordability Severance
Public Accounts	Cost to broad transport budget Indirect tax revenues		

As noted earlier, The Green Book is the fundamental reference in measuring, quantifying and monetizing the environmental impacts. It classifies a wide array of environmental impacts ranging from air pollution, noise, waste, physical health benefits from nature, water quality and water resources, and flood risk to coastal erosion, vulnerability to climate change, biodiversity, nature-based carbon reduction, soil erosion, and energy efficiency and greenhouse gas (GHG) emissions.

Though these pollution types are discussed in detail within the Green Book, notable valuation and approaches will be shortly outlined below before providing longer examples.

The Green Book identifies three approached regarding the valuation of air pollution. The "damage cost" approach is recommended when appropriate when the valuation of air pollution does not exceed £50 million and it complies with the legal limits. In this case, the amount of additional emissions is multiplied by the pre-defined emission costs. The "impact pathway" approach works when the monetary value of the impact of the air pollution exceed £50 million. Unlike the two previous approaches, the authorities should adopt "abatement cost" approach when a proposed project/program might not comply with legal limits.

In the assessment of environmental impacts on the water quality and water resources, the cost of providing water, which is gathered from water companies, is used a s reference. This cost is around £5.7 million per day per million litres, according to 2020-2021 prices. Another dimension of the water quality is its impact on biodiversity, amenity and recreation. A positive change in the water quality of a water body (like a canal, lake, or river) corresponds to £22,000/km/year (from bad to poor), £25,400/km/year (from poor to moderate), or £29,500/km/year (from moderate to good), depending on the starting/ending point of the change in 2020/2021 prices.

Regarding the flood risk and coastal erosion, estimates reveal that the costs (including environmental costs) is around £8,000 to £11,000 per flood per property for a flood depth less than 0.1 metres whereas this range increases to 0.1 metres for floods higher than 0.1 metres depth according to 2020-2021 prices.

Table below presents the summary of environmental values, and land value uplift, referenced in Annex 1 (20/21 prices).

Table 4-17: Summary of environmental values, and land value uplift, referenced in Annex 1 (20/21 prices)

Value	Description	Low	Central	High	Unit
Air pollution (NOx)	National average damage cost values	£681	£7,120	£26,995	per tonne of pollutant
Air pollution (PM2.5)		£17,716	£81,847	£253,474	
Air pollutant removal by vegetation	Welfare/health benefit of reduced air pollution from vegetation	£17	-	£931	per hectare (various land covers
Noise	Marginal change in road noise levels	£13	-	£227	per 1 decibel
Noise reduction by vegetation	Average road noise damage costs avoided for households benefiting from noise mitigation by urban woodland	-	£96	-	per household
Nature based recreation	Welfare value of outdoor recreation sites	£48	-	£120,067	per hectare (various land covers)
Physical health benefits from nature	Indicative health savings/ benefits from every physically active visit to green space	£3.36	-	£14.34	per marginal physically active visit to greenspace
Local amenity	Average additional value per property within 100m - 500m of accessible green or blue space	£1,538	£3,076	£9,471	per property (capital value)
Visual amenity	Average price premium for a property with a view over green or blue space	-	£6,164	-	

Value	Description	Low	Central	High	Unit
Loss of amenity	Welfare cost from significant litter accumulation in residential areas	£20	-	£76	per household
Water availability Industry	Industry average present value lifetime social cost of providing water supply	-	£5.7m	-	mega litre per day
Water quality	Improvement in water quality status	£22,000	£25,400	£29,500	per km
Flood damage	Typical damage per property from a flood event	£8,000	-	£45,000	per property (flooding at different water depths)
Flood regulation (woodland)	Avoided water storage costs from woodland water storage in flood catchments	£97	-	£242	per hectare (woodland)
Nature based carbon reduction (peatland)	Carbon reduction value of restoring eroded peatland	£497	-	£5,297	per hectare (peatland)
Soil erosion	Average indicative cost of soil erosion (production, water quality, flood risk)	£130	-	£211	per hectare of average erosion
GHG values	Target consistent value	£121	£241	£362	per tonne CO2

For the planning of transport infrastructure, the Transport Analysis Guidance (TAG) of the Department for Transport draws and prepares not only the general principles for calculating the environmental impacts of transport infrastructure and services, but also it provides MS Excel-based software to evaluate and calculate the monetized effects of noise, air quality, noise, townscapes, biodiversity, and greenhouse gas emissions. These evaluation and calculations are then incorporated into the respective appraisals.

- Air quality valuation workbook
- Local air quality workbook
- Biodiversity worksheet
- Greenhouses gases workbook
- Historic environment worksheet
- Landscape monetization workbook
- Landscape worksheet
- Noise workbook
- Noise workbook-aviation

- Townscape worksheet
- Water environment worksheet

Below, some of the MS Excel-based software listed above will be discussed in detail together with some solid examples.

Noise Assessment Workbook

The TAG Unit A3 Environmental Impact Appraisal explains the methodology to calculate and monetize the noise impact of transport infrastructure and operations. In addition, a dedicated workbook is publicly available to ease these calculations.

To be able to calculate the net present value of the noise impact, the user of the workbook should input the duration variables. First, year of the appraisal, opening year, and forecast year (final year of the forecast) should be determined and inputted. The opening and forecast years are critical in that the predictions are made through a linear interpolation between the opening and forecast years. In addition, the transport mode (aviation, rail or road) should be selected to incorporate the mode-specific noise impacts into the calculations. The next step is the forecast of the affected population. To achieve this, first the number of the households affected together with the associated noise levels should be determined.

Apart from these users input parameters, the workbook gets other necessary parameters from the TAG data book/guidance such as the "values for changes in noise levels for different sources of noise (road, rail and aviation) and impact pathways", "standard 60-year appraisal period", "standard DfT base year for present values and prices", "HMT profile of discount rates", "GDP deflator series from TAG data book, and "real GDP/cap series for uprating values over time".

Below, a hypothetical example will be examined for the running of the noise workbook to better visualize the steps to monetize the noise impact.

Assume that a new rail project is being proposed. The parameters of a proposed project are as follows:

- Opening year: 2025
- Forecast year: 2055
- Scheme type: Rail
- Current year: 2023
- Night noise impact: Yes
- Night noise (dB Lnight) modelling: No
- Opening year, no. of households experiencing 'without scheme' and 'with scheme' noise levels: 500 households experiencing 51-54 (dB Leq, 16h) and 600 households experiencing 45-48 (dB Lnight) without scheme and 500 households ex-

periencing 69-72 (dB Leq, 16h) and 600 households experiencing 66-69 experiencing (dB Lnight) with scheme.

- Forecast year, no. of households experiencing 'without scheme' and 'with scheme' noise levels: 580 households experiencing 48-51 (dB Leq, 16h) and 700 households experiencing 54-57 (dB Lnight) without scheme and 580 households experiencing 72-75 (dB Leq, 16h) and 700 households experiencing 66-69 (dB Lnight) with scheme.
- Income base year: 2023
- Price base year: 2023
- PV base year: 2023
- Outputs price year: 2023

First, the opening year, forecast year and current year are inputted as shown in Figure 4.17. Then night noise impact option is selected as yes. As shown in Figure 4.18, the number of households experiencing noise with and without scheme is inputted together with their associated noise levels during the day and night time for the opening year. This procedure is later repeated for the forecast year as well as presented in Figure 4.19. As the last step, the income base year, price base year, PV base year, and outputs price year are inputted, as depicted in Figure 4.20. In addition, the appraisal period is defined as 30 years. The rest of the parameters shown in Figure 4.20 are automatically taken from the TAG data book/guidance. These include discount rates, GDP deflators, income elasticity, and household size. These parameters are standard projections and some of them come from the national averages. When necessary, revisions can be made for them.

Figure 4.21 shows the output table for the valuation of noise for the analyses hypothetical example. The net present value of change in noise is -£8,651,772. The negative value indicates that a net loss such that there will be an increase in noise as a result of the proposed rail project. The rows at the lower side of the table also presents the breakdown of the NPV in terms of the impacts on sleep disturbance, amenity, AMI, stroke, and dementia.

Figure 4.17: The Running of the Noise Workbook

Noise Workbook - Inputs		
Scheme details		
Scheme name	Test	
Opening year	2025	*Opening_year_in*
Forecast year	2055	*Forecast_year_in*
Scheme type (select from list)	rail	*Scheme_type_in*
Current year	2023	*Current_year_in*

Noise modelling inputs		
Night noise impact	yes	*Night_noise_impact_in*
If night time noise (and sleep disturbance impacts) are to be included, select 'yes'. If night time impacts are to be excluded, select 'no'.		
Night noise (dB Lnight) modelling	no	*Night_noise_modelling_in*
If night time (sleep disturbance) impacts are to be calculated from modelling of the Lnight period, select 'yes'. If night time impacts are to be translated from daytime noise metrics (for roads only), select 'no'.		

Figure 4.18: The Running of the Noise Workbook

Opening year: no. of households experiencing 'without scheme' and 'with scheme' noise levels																
(dB Leq, 16h)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
Without scheme																
<45																*Opening_without_45_with_xx_in*
45-48																*Opening_without_45_48_with_xx_in*
48-51																*Opening_without_48_51_with_xx_in*
51-54											500					*Opening_without_51_54_with_xx_in*
54-57																*Opening_without_54_57_with_xx_in*
57-60																*Opening_without_57_60_with_xx_in*
60-63																*Opening_without_60_63_with_xx_in*

(dB Leq, 16h)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
63-66																*Opening_without_63_66_with_xx_in*
66-69																*Opening_without_66_69_with_xx_in*
69-72																*Opening_without_69_72_with_xx_in*
72-75																*Opening_without_72_75_with_xx_in*
75-78																*Opening_without_75_78_with_xx_in*
78-81																*Opening_without_78_81_with_xx_in*
81+																*Opening_without_81_with_xx_in*

(dB Lnight)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
Without scheme																
<45																*Opening_without_45_with_xx_night_in*
45-48											600					*Opening_without_45_48_with_xx_night_in*
48-51																*Opening_without_48_51_with_xx_night_in*
51-54																*Opening_without_51_54_with_xx_night_in*

(dB Lnight)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
54-57																*Opening_without_54_57_with_xx_night_in*
57-60																*Opening_without_57_60_with_xx_night_in*
60-63																*Opening_without_60_63_with_xx_night_in*
63-66																*Opening_without_63_66_with_xx_night_in*
66-69																*Opening_without_66_69_with_xx_night_in*
69-72																*Opening_without_69_72_with_xx_night_in*
72-75																*Opening_without_72_75_with_xx_night_in*
75-78																*Opening_without_75_78_with_xx_night_in*
78-81																*Opening_without_78_81_with_xx_night_in*
81+																*Opening_without_81_with_xx_night_in*

Figure 4.19: The Running of the Noise Workbook

Forecast year: no. of households experiencing 'without scheme' and 'with scheme' noise levels																
(dB Leq, 16h)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
Without scheme																
<45																*Forecast_without_45_with_xx_in*
45-48																*Forecast_without_45_48_with_xx_in*
48-51												580				*Forecast_without_48_51_with_xx_in*
51-54																*Forecast_without_51_54_with_xx_in*
54-57																*Forecast_without_54_57_with_xx_in*
57-60																*Forecast_without_57_60_with_xx_in*
60-63																*Forecast_without_60_63_with_xx_in*
63-66																*Forecast_without_63_66_with_xx_in*
66-69																*Forecast_without_66_69_with_xx_in*
69-72																*Forecast_without_69_72_with_xx_in*
72-75																*Forecast_without_72_75_with_xx_in*

75-78																*Forecast_without_75_78_with_xx_in*
78-81																*Forecast_without_78_81_with_xx_in*
81+																*Forecast_without_81_with_xx_in*

(dB Lnight)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
Without scheme																
<45																*Forecast_without_45_with_xx_night_in*
45-48																*Forecast_without_45_48_with_xx_night_in*
48-51																*Forecast_without_48_51_with_xx_night_in*
51-54																*Forecast_without_51_54_with_xx_night_in*
54-57										700						*Forecast_without_54_57_with_xx_night_in*
57-60																*Forecast_without_57_60_with_xx_night_in*

(dB Lnight)	**With scheme**	<45	45-48	48-51	51-54	54-57	57-60	60-63	63-66	66-69	69-72	72-75	75-78	78-81	81+	
60-63																*Forecast_without_60_63_with_xx_night_in*
63-66																*Forecast_without_63_66_with_xx_night_in*
66-69																*Forecast_without_66_69_with_xx_night_in*
69-72																*Forecast_without_69_72_with_xx_night_in*
72-75																*Forecast_without_72_75_with_xx_night_in*
75-78																*Forecast_without_75_78_with_xx_night_in*
78-81																*Forecast_without_78_81_with_xx_night_in*
81+																*Forecast_without_81_with_xx_night_in*

Figure 4.20: The Running of the Noise Workbook

Value of a 1dB change in noise, £/HH/annum			
Income base year		2023	*Income_base_values_in*
Price base year		2023	*Price_base_values_in*
Assumed average household size		2,3	*Default_HH_size_in*

Appraisal period and discounting		
Appraisal period (years)	30	*Appraisal_period_length_in*
PV base year	2023	*PV_base_year_in*
Outputs price year	2023	*Price_base_outputs_in*
discount period 1	0	*Discount_period_1_in*
discount period 2	30	*Discount_period_2_in*
discount period 3	75	*Discount_period_3_in*
discount rate 1	3,5%	*Discount_rate_1_in*
discount rate 2	1,5%	*Discount_rate_2_in*
discount rate 3	1,3%	*Discount_rate_3_in*
source: TAG Data Book v1.15, July 2021, Table A1.1.1		

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
GDP deflator	100,00	102,13	103,63	105,88	107,23	108,00	110,03	112,00	113,94	116,35	123,52	123,28	129,56	133,30	135,84
Real GDP per capita	131,44	131,74	132,76	134,33	137,58	139,76	141,62	144,22	145,80	147,34	130,53	140,56	145,40	144,28	146,20
source:	TAG Data Book v1.21 May 2023, Annual Parameters														
Income elasticity (for uprating)	1,3	*income_elasticity_in*													
Household size - user input	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30	2,30

Figure 4.21: The Output of the Noise Workbook

Noise Workbook - Worksheet 1			
Proposal Name:	Test		
Present Value Base Year		2023	
Current Year		2023	
Proposal Opening year:		2025	
Project (Road, Rail or Aviation):		rail	
Net present value of change in noise (£):			-£8,651,772
*positive value reflects a **net benefit** (i.e. a reduction in noise)			
Net present value of impact on sleep disturbance (£):			£0
Net present value of impact on amenity (£):			-£5,137,761
Net present value of impact on AMI (£):			-£1,771,396
Net present value of impact on stroke (£):			-£694,818
Net present value of impact on dementia (£):			-£1,047,796
Quantitative results			
Households experiencing increased daytime noise in forecast year:			580
Households experiencing reduced daytime noise in forecast year:			0
Households experiencing increased night time noise in forecast year:			n/a
Households experiencing reduced night time noise in forecast year:			n/a

Air Quality Assessment Workbook

Transportation activities are an important source of sir pollution, ranging from PM2.5 and NOx to CO_2. An example to forecast and valuate the air quality impacts of a new transport project is provided below.

Assume that a new rail project is being proposed. The parameters of a proposed project are as follows:

- Opening year: 2025
- Forecast year: 2040
- Scheme type: Rail
- Current year: 2023
- Scheme type: Rail (average)
- Impact pathways or Damage costs: Damage costs

- Measured up to PM2.5 or PM10: PM2.5
- PM2.5 emissions without scheme (opening year): 50 tonnes
- PM2.5 emissions with scheme (opening year): 100 tonnes
- PM2.5 emissions without scheme (forecast year): 75 tonnes
- PM2.5 emissions with scheme (forecast year): 125 tonnes
- Income base year: 2010
- Price base year: 2010
- PV base year: 2010
- Appraisal period: 60 years

Once the values are inputted, the results presented in the output table show that the net present value

of air quality is -£54,412,370. The negative value indicates that a net loss such that there will be a decrease in air quality as a result of the proposed rail project.

Figure 4.22: The Running of the Air Quality Workbook

Air Quality Valuation Workbook - Inputs							
Scheme details							
Scheme name		Insert scheme name					*Scheme_ name*
Opening year		2025	*Opening_year_in*				
Forecast year		2040	*Forecast_year_in*				
Current year		2023	*Current_year_in*		**The scheme opening year should be after the current (appraisal) year**		
Scheme type/area category (select from list)		Rail (Average)	Scheme_type_damage_ cost_category		**See Sheet1 (column A) for all scheme type/area categories**		
Impact pathways or Damage costs		Damage costs	Choice_of_concentrations_ damage_costs				
Measured up to PM2.5 or PM10?		PM2.5	Choice_of_PM				

Figure 4.23: The Running of the Air Quality Workbook

PM2.5 emissions/concentrations or PM10 emissions				
PM2.5 emissions (tonnes)				
	Opening year			
Without scheme	50,0	*Opening_year_without_scheme_PM2.5_emissions_in*		
With scheme	100,0	*Opening_year_with_scheme_PM2.5_emissions_in*		
	Forecast year			
Without scheme	75,0	*Forecast_year_without_scheme_PM2.5_emissions_in*		
With scheme	125,0	*Forecast_year_with_scheme_PM2.5_emissions_in*		

Figure 4.24: The Running of the Air Quality Workbook

PM2.5 concentrations damage base values (2010£/capita/1ug/m3)												
Central	£36.68	*PM2.5_damage_base_value_central_in*										
Low	£14.54	*PM2.5_damage_base_value_low_in*										
High	£104.40	*PM2.5_damage_base_value_high_in*										
Source:		TAG data book v1.21 (May 2023). Table A3.2.2										
PM2.5 emissions damage base values (2010£/tonne)												
	All Sectors (National)	Aircraft	Rail (Average)	Ships	Road Transport (Average)	Road - Central London	Road - Inner London	Road - Outer London	Road - Inner Conurbation	Road - Outer Conurbation	Road - Urban Big	Road - Urban Large
Central	£50,612	£51,489	£38,371	£16,264	£57,232	£319,949	£304,758	£167,159	£113,550	£70,963	£65,385	£53,365
Low	£20,058	£20,318	£15,121	£6,404	£22,699	£126,790	£120,774	£66,295	£45,030	£28,145	£25,930	£21,161
High	£144,074	£139,478	£102,275	£42,916	£164,329	£910,144	£867,219	£479,782	£325,572	£203,756	£187,552	£152,902
Source:		TAG data book v1.21 (May 2023). Table A3.2.1										
Pm2.5/10 conversion factors												
	All Sectors (National)	Aircraft	Rail (Average)	Ships	Road Transport (Average)	Road - Central London	Road - Inner London	Road - Outer London	Road - Inner Conurbation	Road - Outer Conurbation	Road - Urban Big	Road - Urban Large
PM2.5/10 factor	0.646	0.819	0.894	0.947	0.622	0.647	0.647	0.623	0.626	0.622	0.625	0.628
Source:		TAG data book v1.21 (May 2023). Table A3.2.3										

Figure 4.25: The Running of the Air Quality Workbook

Appraisal period and discounting							
Appraisal period (years)	60	*Appraisal_period_ length_in*					
PV base year	2010	*PV_base_year_in*					
Outputs price year	2010	*Price_base_outputs_in*					
Discount period 1	13	*Discount_period_1_in*					
Discount period 2	30	*Discount_period_2_in*					
Discount period 3	75	*Discount_period_3_in*					
Discount rate 1	3.5%	*Discount_rate_1_in*					
Discount rate 2	1.5%	*Discount_rate_2_in*					
Discount rate 3	1.3%	*Discount_rate_3_in*					
Source:	TAG data book v1.21 (May 2023). Table A3.2.1						
	2010	2011	2012	2013	2014	2015	2016
GDP deflator	100.00	102.13	103.63	105.88	107.23	108.00	110.03
Real GDP per capita	131.44	131.74	132.76	134.33	137.58	139.76	141.62
Income elasticity (for uprating)	1.3						
Source:	TAG Data Book v1.21, May 2023, Annual Parameters. (For use of income elasticity for uprating purposes, see TAG Units A3 and A4.1)						

Figure 4.26: The Output of the Air Quality

Air Quality Valuation Workbook - Worksheet 3		
Scheme Name:	Insert Scheme name	
Present Value Base Year	2010	
Current Year	2023	
Proposal Opening year:	2025	
Project (Road/Rail or Road and Rail):	Rail (Average)	

Air Quality Valuation Workbook - Worksheet 3		
Overall Assessment Score:		
Damage Costs Approach (Emissions)		
Present value of change in NOx emissions (£):		£0
Present value of change in PM emissions (£):		-£54,412,370
Total Change		
Total value of change in air quality (£):		-£54,412,370 * positive value reflects a **net benefit** (i.e air quality improvement)

4.2.2.2. Measuring and Reporting Environmental Impacts: Guidance for Businesses

Freight transport companies may voluntarily report their Additionally, the government offers detailed instructions for freight transporters and businesses that want to report emissions from employee travel. Table 4-18 and Table 4-19 below shows the calculation of the carbon emissions, based on the MS Excel Spreadsheet published by the government (GOV.UK, 2019).

Table 4-18: Calculation of the CO_2 Emissions based on the litres used (primary method)

Primary (Recorded own Company) data		Veh type 1	Veh type 2	Veh type 3	Veh type 4
Road	Vehicle data	Co small van	Rigid 7.5	Rigid 22t	Artic 38t
	Total litres used	52,500	141,500	273,455	385,000
	Fuel mix data	% Used	% Used	% Used	% Used
	Diesel	100%	100%	100%	95%
	Biofuel	0%	0%	0%	5%
	Petrol	0%	0%	0%	0%
	Compressed Natural Gas (CNG)	0%	0%	0%	0%
	Liquid Petroleum Gas (LPG)	0%	0%	0%	0%
	Total tonnes of CO2 by vehicle	138.6	373.4	721.7	965.3
	Weighted CO2 per litre factor	2.6391	2.6391	2.6391	2.5071
	Weighted CO2 per litre factor	0.0000	0.0000	0.0000	0.0000
	Weighted CO2 per litre factor	0.0000	0.0000	0.0000	0.0000
	Weighted CO2 per litre factor	0.0000	0.0000	0.0000	0.0000
	Weighted CO2 per litre factor	0.0000	0.0000	0.0000	0.0000
	Total weighted CO2 per litre	2.6391	2.6391	2.6391	2.5071
	Total primary method CO2	**2,199**	**Tonnes**		

Assume that the fleet of a freight transport operator consists of 4 vehicle types (Table 4-18). The first (Co small van), second (Rigid 7.5) and third vehicle (Rigid 22t) types used 52,500, 141,500 and 273,455 litres of diesel whereas the last vehicle type (Artic 38t) used 385,000 litres of fuel, 95% of which is diesel and the remaining is biofuel. Once the total litres used in terms of each fuel type is inputted for each vehicle type, the dedicated MS Excel Spreadsheet calculates the total tonnes of CO2 by vehicle (the orange row). Then using the Weighted CO2 per litre factor, which comes with the spreadsheet, the spreadsheet calculates the total weighted CO2 per litre for each vehicle type as well as the total primary method CO2. In the case shown in Table 4-18 , total primary method CO2 is equal to 2.106 tonnes.

The calculations in Table 4-18 are based on the litres used and defined as the primary method. An alternative approach is also provided in the very same MS Excel Spreadsheet. Table 4-18 shows this secondary method for the calculation of the CO2 Emissions based on the total distance hauled.

Table 4-19: Calculation of The CO2 Emissions Based on The Total Distance Hauled (Secondary Method)

Secondary (Default Defra / DfT) data		Veh type 1	Veh type 2	Veh type 3	Veh type 4
Road	Vehicle data	Rigid 3.5-7.5 T	Rigid 7.5-17 T	Rigid > 17 T	Artic'd >3.5< 33 T
	Total hauled distance Km's	300,000	400,000	500,00 0	800,00 0
	Total tonnes lifted	1.00	1.00	1.00	1.00
	Total tonne KM's	300,000	400,000	500,00 0	800,00 0
	Vehicle lading % mix				
	% at 0% laden weight	0%	0%	0%	0%
	% at 50 % laden weight	0%	0%	0%	0%
	% at 100 % laden weight	0%	0%	0%	0%
	% at UK Average % laden weight	100%	100%	100%	100%
	Total tonnes of CO2 by vehicle	163.3	290.9	466.8	755.0
	Kg of CO2 per Tonne KM @ 0%	0.5088	0.6578	0.7513	0.6741
	Kg of CO2 per Tonne KM @ 50%	0.5530	0.7518	0.9162	0.8988
	Kg of CO2 per Tonne KM @ 100%	0.5973	0.8457	1.0811	1.1235
	Kg of CO2 per Tonne KM @ UK Ave %	0.5442	0.7273	0.9336	0.9437
	Total weighted CO2 TKm CIF	0.5442	0.7273	0.9336	0.9437
	Total secondary method CO2	**1,676**	**Tonnes**		

Assume that the fleet of a freight transport operator consists of 4 vehicle types (Table 4-19). First (Rigid 3.5-7.5 T), second (Rigid 7.5-17 T), third (Rigid > 17 T) and fourth (Artic'd >3.5< 33 T) vehicles type hauled 300,000, 400,000, 500,000 and 800,000 Km's, respectively and each vehicle lift one tonne. The total tonnes KM's are calculated for each vehicle type by simply multiplying the hauled distance and tonnes lifted (orange row). In the following stage, the total weighted CO2 tonnes-Km values are calculated based on the percentage laden weights (gray row). Then total tonnes of CO2 by vehicle is calculated by multiplying the total tonnes KM (orange row) and total weighted co2 TKm (gray row) and dividing the product by 1,000 (green row). The total secondary method CO2 is then calculated by summing the Total tonnes of CO2 by vehicle figures presented at the green row. The total secondary method CO2 for the case depicted in Table 4-19 is equal to 1,676 Tonnes (yellow row).

4.2.2.3. Valuation and Monetization of Other Environmental Impacts

Whereas valuation and monetization of noise, air quality, GHG emissions and landscape are done through quantitative approaches, other environmental impacts on i) townscape, ii) historic environment, iii) biodiversity, and iv) water environment are done through a qualitative approach, which is called "environmental capital approach". This qualitative approach follows the same steps just like the quantities approaches followed as discussed above. This starts with the "Scoping and identification of study area which is followed by "Identifying key environmental resources and describing their features", "Appraise environmental capital, "Appraise the proposal's impact", and ends with "Determine the overall assessment score". Unlike the quantities approaches, however, the qualitative environmental capital approach relies on an overall assessment score on a seven-point scale:

- Large beneficial (+)
- Moderate beneficial (+)
- Slight beneficial (+)
- Neutral
- Slight adverse (-)
- Moderate adverse (-)
- Large adverse (-)

4.2.3. The Related Statistics Collected Regularly

The Department for Transport Statistics of the of the DfT is the main body responsible for transport statistics compilation and publication. Among a large set of transportation statistics ranging from aviation, bus and coach, rail, and walking, cycling and journey time, the linkage between transport and environment is covered under the heading of "transport energy, environment and renewable fuel statistics". The following list indicates the major statistics compiled on this linkage:

i. Petroleum consumption by transport mode and fuel type

ii. Energy consumption by transport mode and energy source

iii. Petrol and diesel prices and duties

iv. Greenhouse gas emissions by transport mode

v. Carbon dioxide emissions by transport mode

vi. Air pollutant emissions by transport mode

vii. Average emissions from road vehicles in urban conditions

viii. Aircraft noise: population affected by noise around major airports

ix. Volumes of renewable fuel in the UK by fuel type country of source feedstock, and greenhouse gas emissions savings from the use of renewable fuels.

x. Number of electric vehicles charging devices by local authority.

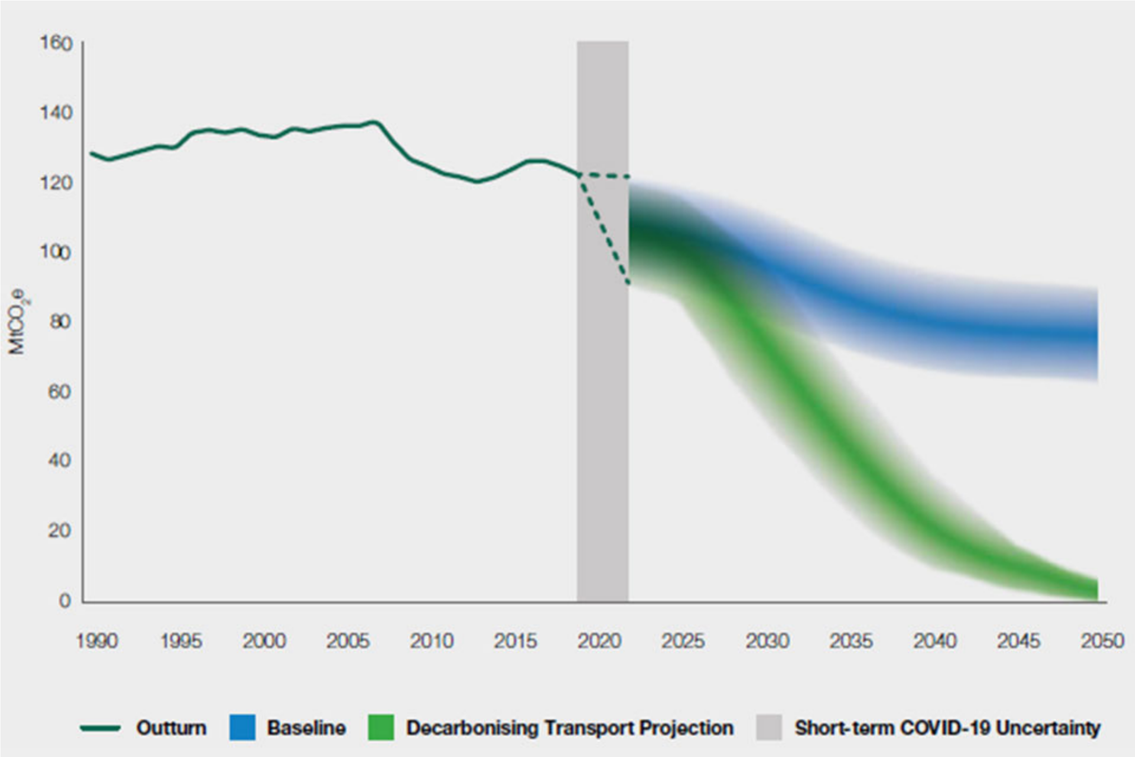
4.2.4. The Current Efforts to Deal with The Environmental Effects of Transport Infrastructure and Services

Transport Decarbonization Plan

Considering the weight of transport industry in the air quality and emissions, the UK government has been developing policies to mitigate the carbon effects of transport industry. The initial major policy action is the publication of the plan in 2020 entitled "Decarbonizing transport: setting the challenge" (UK Department for Transport, 2020). After summarizing different transportation modes, their current greenhouse gas emissions, and existing strategies and policies to achieve the current targets, this plan presents a projected trajectory of forecasted greenhouse gas emissions from transportation in the future and discusses the pathway to reach the targets. The plan identifies six strategic priorities to achieve a "net zero transport system". These are (UK Department for Transport, 2020):

- Accelerating modal shift to public and active transport
- Decarbonization of road vehicles
- Decarbonizing how we get our goods
- Place-based solutions
- UK as a hub for green transport technology and innovation
- Reducing carbon in a global economy

Figure 4.27: Decarbonizing Transport Domestic Transport GHG Emission Projections
(GOV.UK, 2023)



"Decarbonizing Transport: Setting the Challenge" is followed by a more comprehensive plan entitled "Decarbonizing Transport A Better, Greener Britain", which is published in 2021. The ultimate aim of the plan is to contribute to the decreasing tendency in domestic transport GHG emissions, as shown in Figure 4.27. This plan describes the steps to decarbonize all transport modes. Actions include:

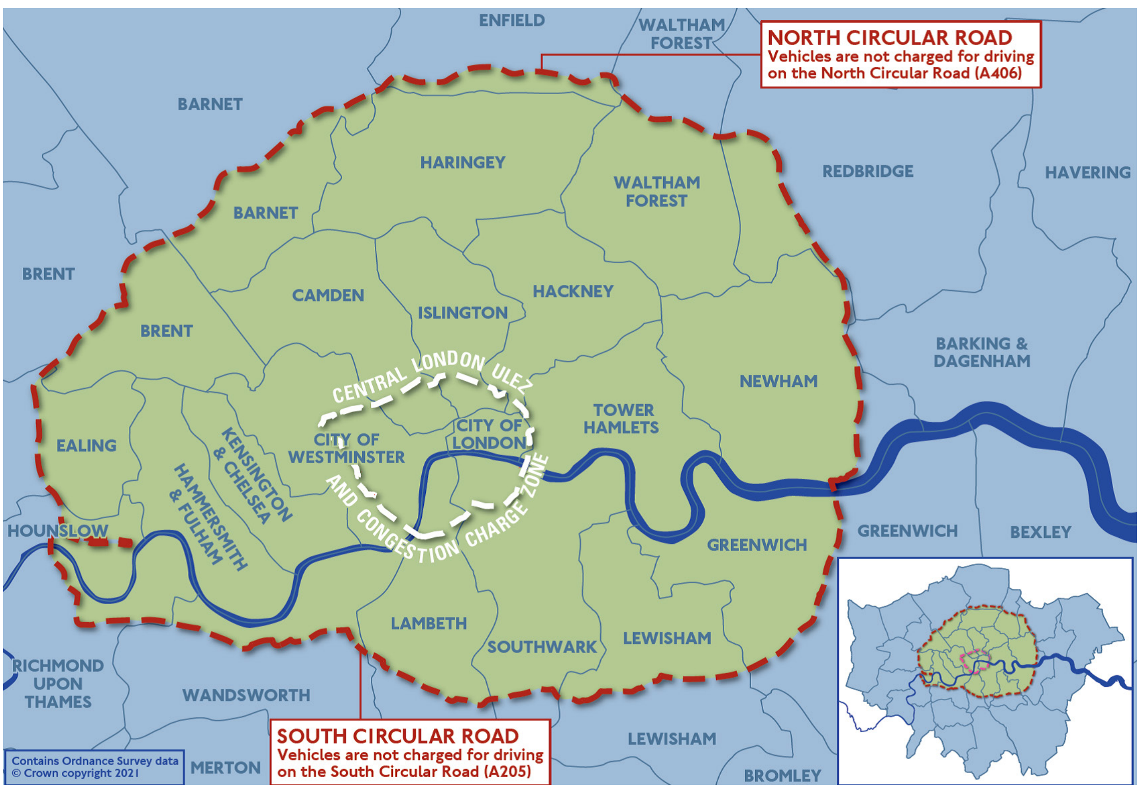
- Increasing cycling and walking
- Zero emission buses and coaches
- Decarbonizing our railways
- A zero-emission fleet of cars, vans, motorcycles, and scooters
- Accelerating maritime decarbonization
- Accelerating aviation decarbonization

As the most recent step, a follow up report entitled "Decarbonizing Transport A Better, Greener Britain One Year On" (UK Department for Transport, 2022) is published in 2022. The report provides a concise overview of the progress made in reducing emissions from transportation and outlines the upcoming initiatives and strategies that the government intends to implement in order to further support the decarbonization of the transport sector.

London Low Emission Zone Scheme

Low emission zones (LEZs) are an emerging phenomenon in reducing the environmental impacts of urban transportation. Low Emission Zones are operational in over 200 cities across ten European countries. Unlike congestion pricing where the vehicles are charged based on the entry to the congestion zones regardless of their emission performance (though some discount are available for low emission vehicles), the eligible vehicles are free to enter the LEZs whereas high emission vehicles are required to pay high entry charges. The other distinction between congestion charge and LEZ is that while congestion charge is implemented during specified hours (like 07:00-18:00 Mon-Fri and 12:00-18:00 Sat-Sun), LEZs is generally in effect 24 hours a day. The rationale behind the LEZ is to encourage drivers shifting to less emission vehicles, or simply motivating them to use public transit rather than private vehicles. In the UK, a group of cities such as London, Bristol, Oxford, Birmingham, Glasgow and Portsmouth have adopted low emission zone schemes, but London's low emission zone scheme is the most popular and largest one.

Figure 4.28: LEZ and ULEZ Maps *(Transport for London, 2023)*



The implementation of the low emission zone began on February 4, 2008, and it was gradually expanded with more stringent regulations until January 3, 2012. The management of the scheme falls under the responsibility of the Transport for London executive agency, which operates within the Greater London Authority. The Ultra-Low Emission

Zone (ULEZ) scheme started in 2020 and covers a smaller geography area when compared with LEZ scheme. However, by the 29th of August, 2023, the ULEZ will be enlarged to cover the entire Greater London. The coverage of LEZ and ULEZ (as of July 10, 2023) are shown at Figure 4.28.

Apart from the geographic coverage, the ULEZ and ULEZ schemes differs in terms of the standards applied. The comparison is presented in Table 4-20.

Table 4-20: Minimum emission standards for LEZ and ULEZ *(Transport for London, 2023)*

	LEZ	ULEZ
Motorcycles, mopeds, motorised tricycles and quadricycles	-	Euro 3
Petrol cars, vans, minibuses and other specialist vehicles	-	Euro 4 (Nox)
Diesel cars, vans and minibuses and other specialist vehicles	-	Euro 6 (Nox and PM)
Vans, minibuses and specialist diesel vehicles	Euro 3(PM)	
HGVs, lorries, vans, buses/minibuses, coaches and specialist heavy vehicles	Euro VI (Nox and PM)	

Transport for London offers four ways to mitigate the effects of LEZ charging scheme (Transport for London, 2023). The first option is to replace the vehicle with a one eligible for LEZ scheme. The second option is to retrofit the existing vehicle in a way that it will meet LEZ standards. The third option involves effectively managing the vehicle fleet, if possible, so that eligible vehicles are assigned to LEZ zones and non-eligible ones are used somewhere else. The last option is basically paying the LEZ charge.

If the last option is selected, a flat daily fee of £12.50 must be paid. For the ULEZ scheme, the charges are listed below (Transport for London, 2023):

- *£100 for vans or specialist diesel vehicles (over 1.205 tonnes unladen weight up to 3.5 tonnes gross vehicle weight) or minibuses (up to 5 tonnes) which do not meet Euro 3 standards.*
- *£100 for HGVs, lorries, vans and specialist heavy vehicles over 3.5 tonnes as well as buses/minibuses and coaches over 5 tonnes which do not meet Euro VI (NOx and PM) standards, but meet Euro IV (PM)*
- *£300 for HGVs, lorries, vans and specialist heavy vehicles over 3.5 tonnes as well as buses/minibuses and coaches over 5 tonnes which do not meet Euro IV (PM)*

Academic studies on the efficacy of London LEZ and ULEZ implementations do not present striking improvements in air quality and GHG emissions, especially during the Phase I of the scheme. From the fleet composition point of view, Ellison et al. (Ellison, Greaves, & Hensher, 2013) indicates London has achieved the lowest share of pre-Euro

III vehicles in 2011 although this share was above UK averages in 2007 before the start of the LEZ scheme (Ellison, Greaves, & Hensher, 2013). This evidences that the introduction of the London LEZ has an impact of the shift to more environmentally friendly vehicle types.

After examining the available evidence regarding the effectiveness of LEZs in improving urban air quality in five EU countries including the UK, Holma et al. (Holman, Harrison, & Querol, 2015) document that only in Germany, where LEZs target both passenger cars and heavy-duty vehicles, there is some evidence suggesting that these zones have led to a slight decrease in long-term average concentrations of PM10 and NO2.

Likewise, the analyses of Ma et al. (Ma, Graham, & Stettler, 2021) show that the ULEZ resulted in only marginal improvements in air quality, considering the long-term declining trend in London's pollution levels. More concretely, when the aggregate impacts are considered, the average reduction in NO2 concentrations was less than 3%, and the effects on O3 and PM2.5 concentrations were not statistically significant. As a supporting and complimentary evidence indicate that, although there have been marginal enhancements in the air quality of highly polluted urban areas after the introduction of London's LEZ, no indications were found of a decrease in the percentage of children with diminished lung capacity over the same timeframe. The paper further suggests that interventions focused on achieving more substantial reductions in emissions could potentially result in better health outcomes for children.

The findings of Zhai and Wolff (Zhai & Wolff, 2021) reveal that initial phase I of London's LEZ, which was the least stringent, led to a temporary increase in roadside PM10 levels within the zone by approximately 14.8%, whereas the subsequent phase II, which was more extensive and restrictive, resulted in a significant reduction of 5.5% in PM10 levels. When the underlying explanation behind these findings are further examined, it is observed that with the introduction of phase I, there was a substantial rise in the traffic volume of heavy goods vehicles (HGVs) targeted by the policy, as well as temporarily exempted light goods vehicles (LGVs) and this increase outweighed the environmental impact of a higher shares of more environmentally friendly vehicles.

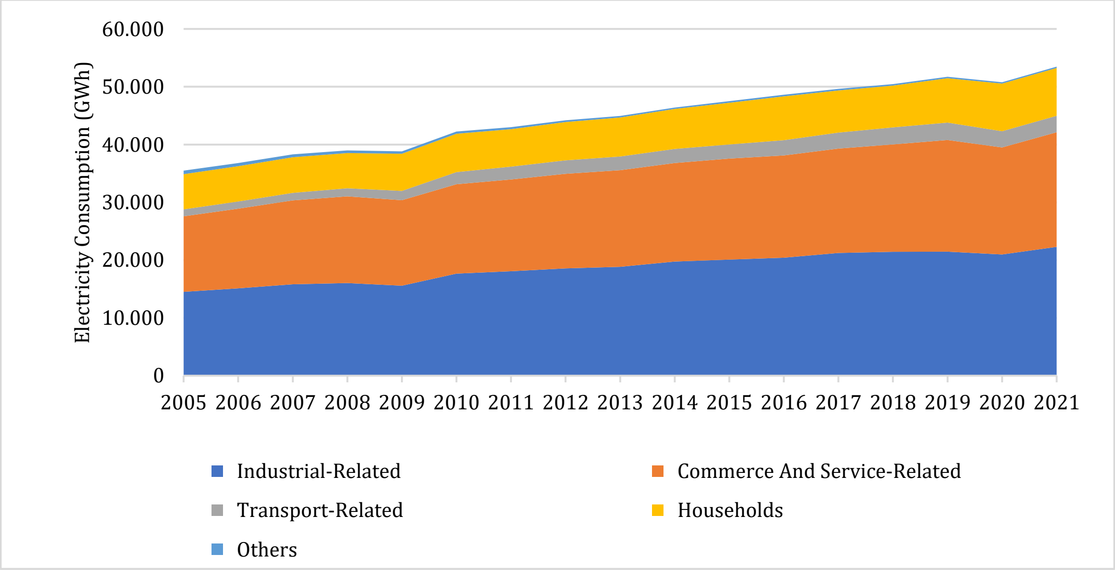
4.3. Case Study-3: Singapore (Asia)

Singapore's total population was 5.69 million in 2020 on 728.6 km2 of land area, which corresponds to 7,810 persons per square kilometer. This population makes Singapore the third densest country in the World after Macao and Monaco. Singapore is an island country and city-state in Southeast Asia.

4.3.1. General Situation of the Transport Sector in Singapore

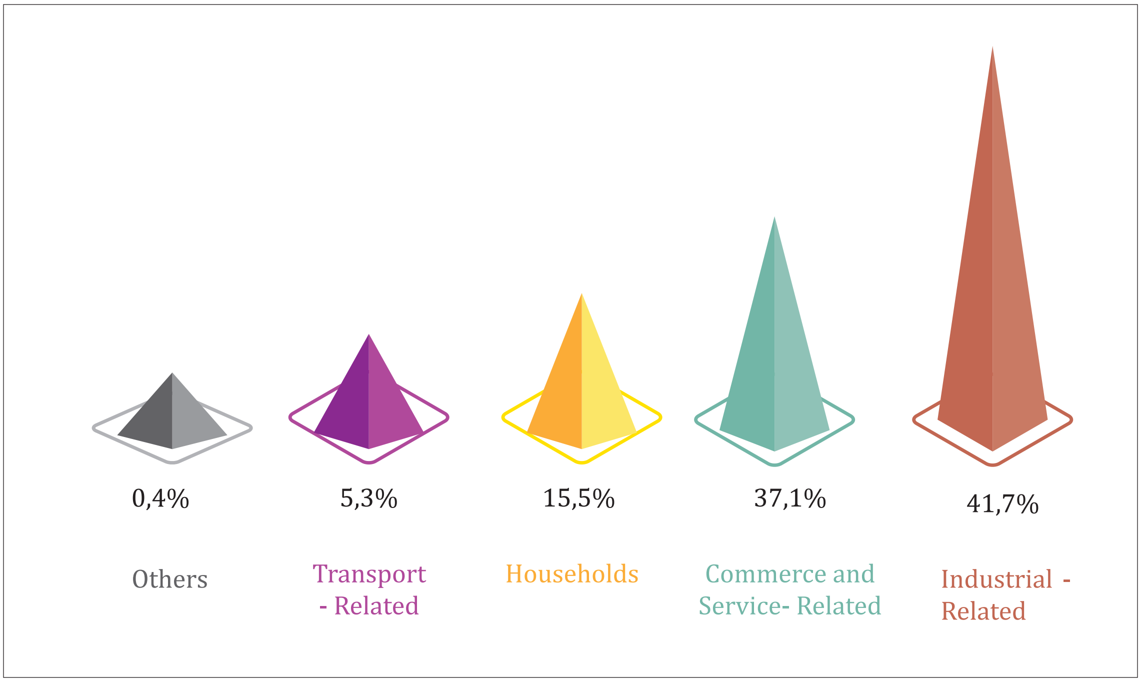
Energy consumption by sectors between 2005 and 2021 is given in Figure 4.29. The transport share in energy consumption fluctuated between 3.4% in 2005 and 5.8% in 2018.

Figure 4.29: Singapore Electricity Consumption by Sectors between 2005 and 2021
(Energy Market Authority, 2021)



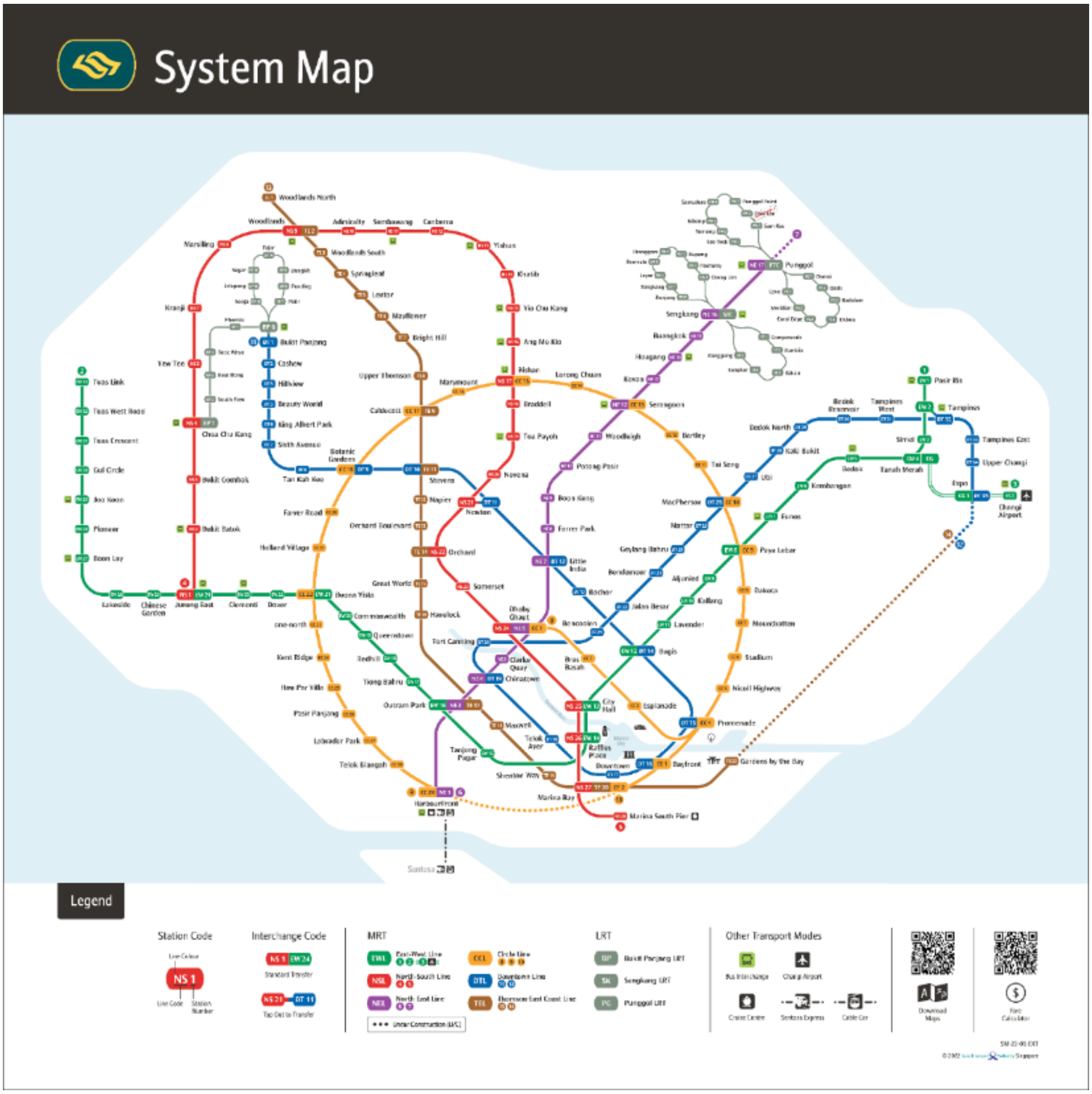
The shares of electricity consumption by sectors are given in Figure 4.30 for 2021. The Singapore transport industry is the fourth largest electricity consumer sector, with a 5.3% share in 2021. The first three sectors are industry, with a share of 41.7%; commerce and service, with a share of 37.1%; and households, with a share of 15.5%. Other sectors use only 0.4% of total electricity consumption. The 5.3% share of transport industry suggests that electric vehicles are playing an important role within the overall nation-wide vehicles fleet.

Figure 4.30: Singapore Electricity Consumption by Sectors in 2021
(Energy Market Authority, 2021)



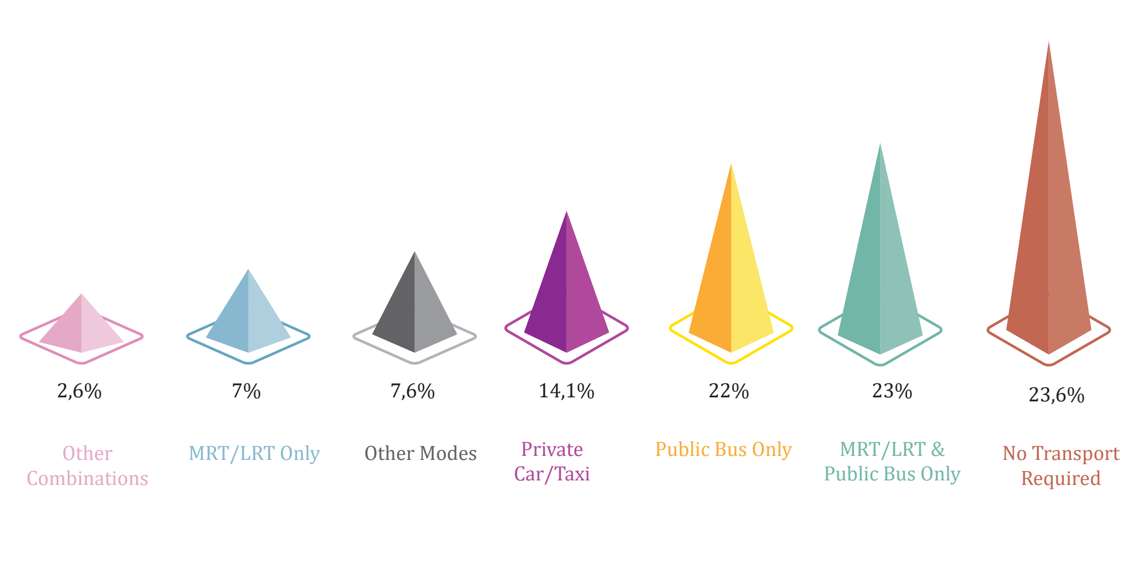
Singapore has an efficient, convenient, and connected public transport system consisting of railway (LRT - light rail transit and MRT - mass rapid transit) and bus networks. The rail network of Singapore is given in Figure 4.31 below.

Figure 4.31: Rail Network of Singapore *(Land Transport Authority, 2023)*



Modal shares for students are given in Figure 4.32 below. The percentage of public transport is 54.6%, composed of public bus only at 22%, MRT/LRT only (mass rapid transit/light rail transit) at 7%, and combinations of these two at 23%. Apart from public transport, private car or taxi has 14.1% share, no transport required has 23.6% and other modes has 7.6% share. These values show that public transport is also dominant in Singapore for students.

Figure 4.32: Mode of Transport for Students in Singapore in 2020 (Census of Population, 2020)



4.3.2. The Related Legislation and The Governmental Agencies Involved

There are many acts and subsidiary legislation for the transport sector in Singapore. Essential acts and regulations with main functions are given below:

- **Public Transport Council Act 1987** relating to the establishment of the Public Transport Council and fares
- **Land Transport Authority of Singapore Act 1995** relating to functions of authority such as planning, design, construction, management, and maintainance of roads, pedestrian walkways, bus stops, and other commuter facilities
- **Rapid Transit Systems Act 1995** relating to the planning, construction, operation, and maintenance of rapid transit systems
- **Planning Act 1998** relating to the planning and improvement of Singapore with land use
- **Environmental Protection and Management Act 1999** governs environmental pollution control, as well as the protection and management of the environment and resource conservation
- **Environmental Protection and Management (Vehicular Emissions) Regulations 1999** defining standards for exhaust emissions for vehicles and standards for noise emissions
- **Shared Mobility Enterprises (Control and Licensing) Act 2020** relating shared mobility services

Several institutions in Singapore have environmental and transport concerns in their missions. These institutions and their roles are summarized in the following table.

Table 4-21: Governmental Institutions and Their Roles in Singapore

Governments/Authorities/Agencies	Roles
Land Transport Authority (LTA)	- managing traffic flows - providing reliable public transport - supporting active modes (walking/cycling)
National Environment Agency (NEA)	- having a clean and sustainable environment - air/noise pollution
Energy Market Authority (EMA)	- building a clean energy future that is resilient, sustainable, and competitive
Urban Redevelopment Authority (URA)	- adopting a thorough, long-term planning process to create strategic plans like the Master Plan and the Long-Term Plan
National Climate Change Secretariat Singapore (NCCS)	- facilitating initiatives to reduce carbon emissions in all sectors - adapting to the consequences of climate change
Ministry of Transport (MOT)	- strengthening the connectivity of Singapore's transportation system - enhancing the sector's potential to improve both economic competitiveness and the quality of life

4.3.3. Environmental Impact Assessment

Singapore has a methodical procedure in place to evaluate and mitigate any possible environmental effect of new constructions. All development projects must undergo a rigorous evaluation process considering the effects on public health, traffic, heritage, and the environment.

Construction projects around sensitive natural areas are subject to even stricter scrutiny and may require advanced environmental studies. Throughout the planning review process, the results of all environmental studies are carefully taken into account for assessment of the suitability of suggested mitigation measures as well as the possible impact's magnitude. Only then a project will be allowed to proceed.

Some specific examples of how Singapore mitigates the environmental impact of new developments:

- Traffic impact assessment: Assessment of the effects of a new development on traffic congestion and air quality.
- Public health impact assessment: Assessment of the impact of a new development on noise pollution, water quality, and other factors that could affect public health.

- Heritage impact assessment: Assessment of the impact of new development on historical and cultural sites.
- Environmental impact assessment: This assesses the impact of new development on the environment, including air quality, water quality, and biodiversity.

By taking these steps, Singapore can ensure that new developments are compatible with the environment and do not negatively impact the standard of living of its citizens.

There are many environmental studies reports as examples on the websites of related governmental organizations. For the transport sector, the following reports were released:

- Road Widening and Sewer Works at Lorong Lada Hitam
- Road Improvement Works along Loyang Avenue, Telok Paku Road, Nicoll Drive and Changi Coast Road
- Tengah Vehicular Interchange at KJE
- Cross Island Line Phase II
- North-South Corridor at Sembawang Road
- Alignment Options for CRL (Central Catchment Nature Reserve)

4.3.4. Technical Guideline for Land Traffic Noise Impact Assessment

"Technical Guideline for Land Traffic Noise Impact Assessment" was developed by the National Environment Agency in 2016 and revised in 2023. This guideline an be used as a general reference by acoustic consultants and other qualified individuals when preparing land traffic noise impact evaluations.

This guideline is composed of two parts: The first part is about noise impact assessment on new noise-sensitive residential developments near existing land traffic noise sources (e.g., MRT tracks/expressways/major arterial roads), and the second part is about noise impact assessment on noise-sensitive existing residential developments nearby of new transport-related infrastructures (e.g., MRT tracks/bus interchanges/bus depots/expressway/major arterial roads) including expansion of existing ones.

This assessment considering Part 1 of the guideline should be composed of following chapters:

- Recognizing the current noise environment and determining the baseline condition;
- Forecasting the noise effects on the residential and noise-sensitive developments;
- Assessment of the noise effects on the residential and noise-sensitive developments;

- Determination of the need for mitigation measures to meet NEA's noise requirement; and
- Confirmation of the effectiveness of the required mitigation measures if needed.

On the other hand, the assessment considering second part of this guideline should also have a chapter on "prediction of future noise level which might be generated" in addition to the above chapters.

4.3.5. Estimation of Reckonable GHG Emissions

The National Environment Agency (NEA) in Singapore has created an Excel document named "Reckonable Emission Calculator" containing multiple spreadsheets that can be used to calculate greenhouse gas emissions resulting from fuel combustion. The calculations are based on the guidelines provided by the IPCC (Intergovernmental Panel on Climate Change, established by World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988). The file can also help determine emissions thresholds. The spreadsheet of "Fuel Combustion" is given in Box 4.8.

Box 4.8 Reckonable Emission Calculator of NEA of Singapore

This box shows fuel combustion spreadsheet of reckonable emission calculator file with a simple example.

The main sheet named "Total Reckonable GHG Emissions" is given below:

The following emissions thresholds are stated under Part 1 of the Second Schedule of the Carbon Pricing Act.

First Emissions Threshold **(Reportable)**	2.000	tonne CO_2e of Reckonable GHG emissions
Second Emissions Threshold **(Taxable)**	25.000	tonne CO_2e of Reckonable GHG emissions

TOTAL RECKONABLE GHG EMISSIONS		
Fuel Combustion (FC)	0,00	tonne CO_2e
Industrial Processes and Product Use (IPPU)	0,00	tonne CO_2e
TOTAL (FC + IPPU)	**0,00**	**tonne CO_2e**

The cells within this template are colour-coded to allow users to identify their functions according to the legend below.

User input	A light green cell(s) to input text information or numeric data.

Disclaimer | **Total Reckonable GHG Emissions** | 1. Fuel Combustion (FC) | 2.Ethylene Production | 3.Ethylene oxide production | 4

The sheet named as “1. Fuel Combustion (FC)” is given below:

Row			Energy Consumption			CO_2		CH_4		N_2O		TOTAL
10			A	B	C	D	E	F	G	H	I	J
11			Consumption (Annual Quantity)	Net Calorific Value	Consumption [C=AxB]	CO_2 Emission Factor	CO_2 Emissions [E=C*D/1000]	CH_4 Emission Factor	CH_4 Emissions [G=C*F/1000]	N_2O Emission Factor	N_2O Emissions [I=C*H/1000]	Actual CO_2-Equivalent Emissions
12	FUEL TYPES	Unit		(GJ/unit)	(GJ)	(kg CO_2 / GJ)	(tonne CO_2)	(kg CH_4 / GJ)	(tonne CH_4)	(kg N_2O / GJ)	(tonne N_2O)	(tonne CO_2e)
13	TOTAL RECKONABLE EMISSIONS FROM FUEL COMBUSTION						0,000		0,000		0,000	0,000
14	Anthracite	tonne		26,70	0,000	98,30	0,000	0,001	0,000	0,0015	0,000	0,000
15	Aviation Gasoline	tonne		44,30	0,000	70,00	0,000	0,003	0,000	0,0006	0,000	0,000
16	Biodiesel (non-reckonable CO2)	tonne		27,00	0,000	70,80	0,000	0,003	0,000	0,0006	0,000	0,000
17	Biogasoline (non-reckonable CO2)	tonne		27,00	0,000	70,80	0,000	0,003	0,000	0,0006	0,000	0,000
18	Bitumen	tonne		40,20	0,000	80,70	0,000	0,003	0,000	0,0006	0,000	0,000
19	Blast Furnace Gas	tonne		2,47	0,000	260,00	0,000	0,001	0,000	0,0001	0,000	0,000
20	Brown Coal Briquettes	tonne		20,70	0,000	97,50	0,000	0,001	0,000	0,0015	0,000	0,000
21	Charcoal (non-reckonable CO2)	tonne		29,50	0,000	112,00	0,000	0,200	0,000	0,0040	0,000	0,000
22	Coal Tar	tonne		28,00	0,000	80,70	0,000	0,001	0,000	0,0015	0,000	0,000
23	Coke Oven Coke / Lignite Coke	tonne		28,20	0,000	107,00	0,000	0,001	0,000	0,0015	0,000	0,000
24	Coke Oven Gas	tonne		38,70	0,000	44,40	0,000	0,001	0,000	0,0001	0,000	0,000
25	Coking Coal	tonne		28,20	0,000	94,60	0,000	0,001	0,000	0,0015	0,000	0,000
26	Crude Oil	tonne		42,30	0,000	73,30	0,000	0,003	0,000	0,0006	0,000	0,000
27	Ethane	tonne		46,40	0,000	61,60	0,000	0,001	0,000	0,0001	0,000	0,000
28	Gas Coke	tonne		28,20	0,000	107,00	0,000	0,001	0,000	0,0001	0,000	0,000
29	Gas / Diesel Oil (non-reckonable CO2, CH4, and N2O)	tonne		43,00	0,000	74,10	0,000	0,003	0,000	0,0006	0,000	0,000
30	Gas / Diesel Oil (high sulphur)[6]	tonne		43,00	0,000	74,10	0,000	0,003	0,000	0,0006	0,000	0,000
31	Industrial Waste[2]	tonne		10,00	0,000	143,00	0,000	0,030	0,000	0,0040	0,000	0,000
32	Jet Gasoline	tonne		44,30	0,000	70,00	0,000	0,003	0,000	0,0006	0,000	0,000

Disclaimer | Total Reckonable GHG Emissions | 1. Fuel Combustion (FC) | 2.Ethylene Production | 3.Ethylene oxide production | 4.Flares | 5.Ve ...

Any vehicle consumed 1,000 tonnes of motor gasoline annually, its GHG emissions can be estimated as follows:

Energy Consumption = Consumption * Net Calorific Value = 1,000*44.3=44,300

Emissions=Global Warming Potential*Emission Factor*Consumption/1,000

CO2 → 1*69.3*44,300/1,000 = 3,069.99

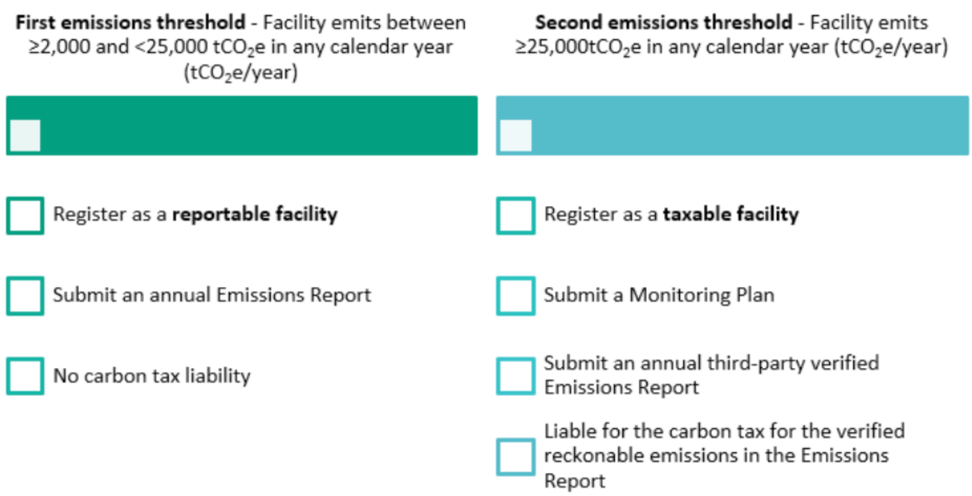
CH4 → 21*0.003*44,300/1,000 = 2.79

N2O → 310*0,0006*44,300/1,000 = 8.24

Total → 3,069.99+2.79+8.24 = 3,081,02

HG emission thresholds under carbon tax are given in Figure 4.33.

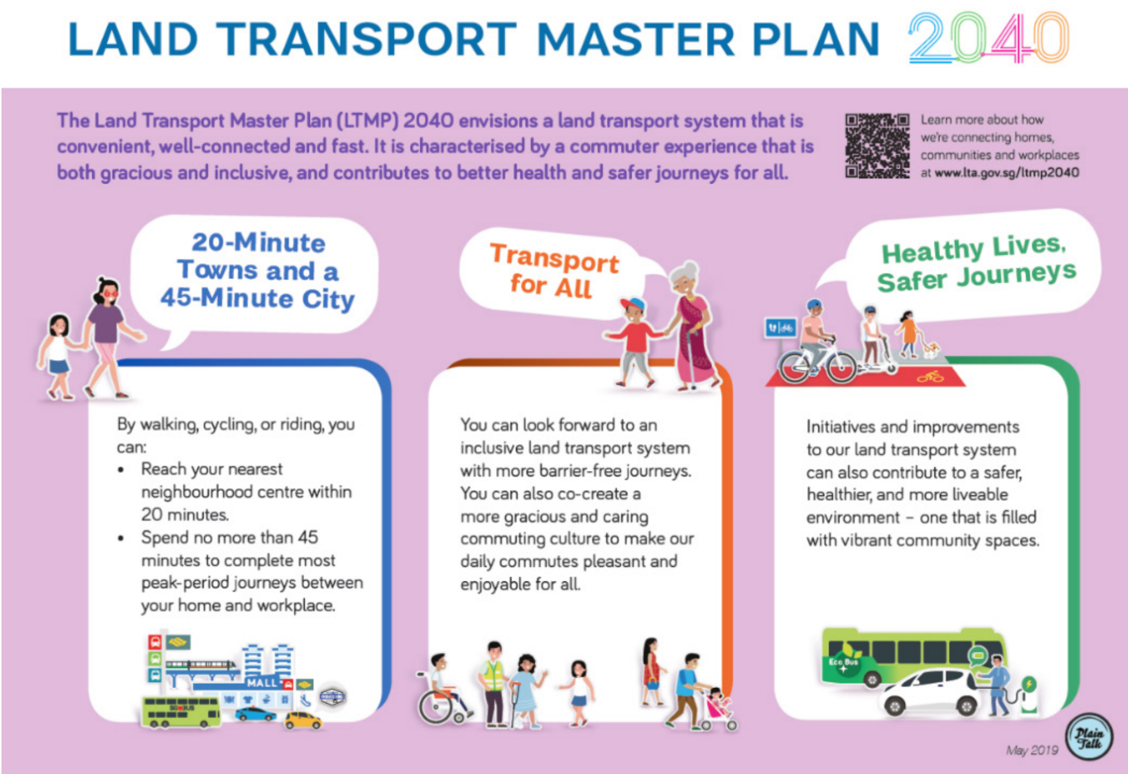
Figure 4.33 GHG Emission Thresholds *(National Environment Agency in Singapore)*



4.3.5. Land Transport Master Plan 2040

Land Transport Master Plan 2040 a is guidance to Singapore for its transport system for the next 20 years. It has three visions: "20-Minute Towns and a 45-Minute City", "Transport for All," and "Healthy Lives, Safer Journeys". These visions are given in Figure 4.34.

Figure 4.34 Three Visions of Land Transport Master Plan 2040
(Land Transport Authority, 2023)



Targets of 20-Minute Towns and a 45-Minute City are:

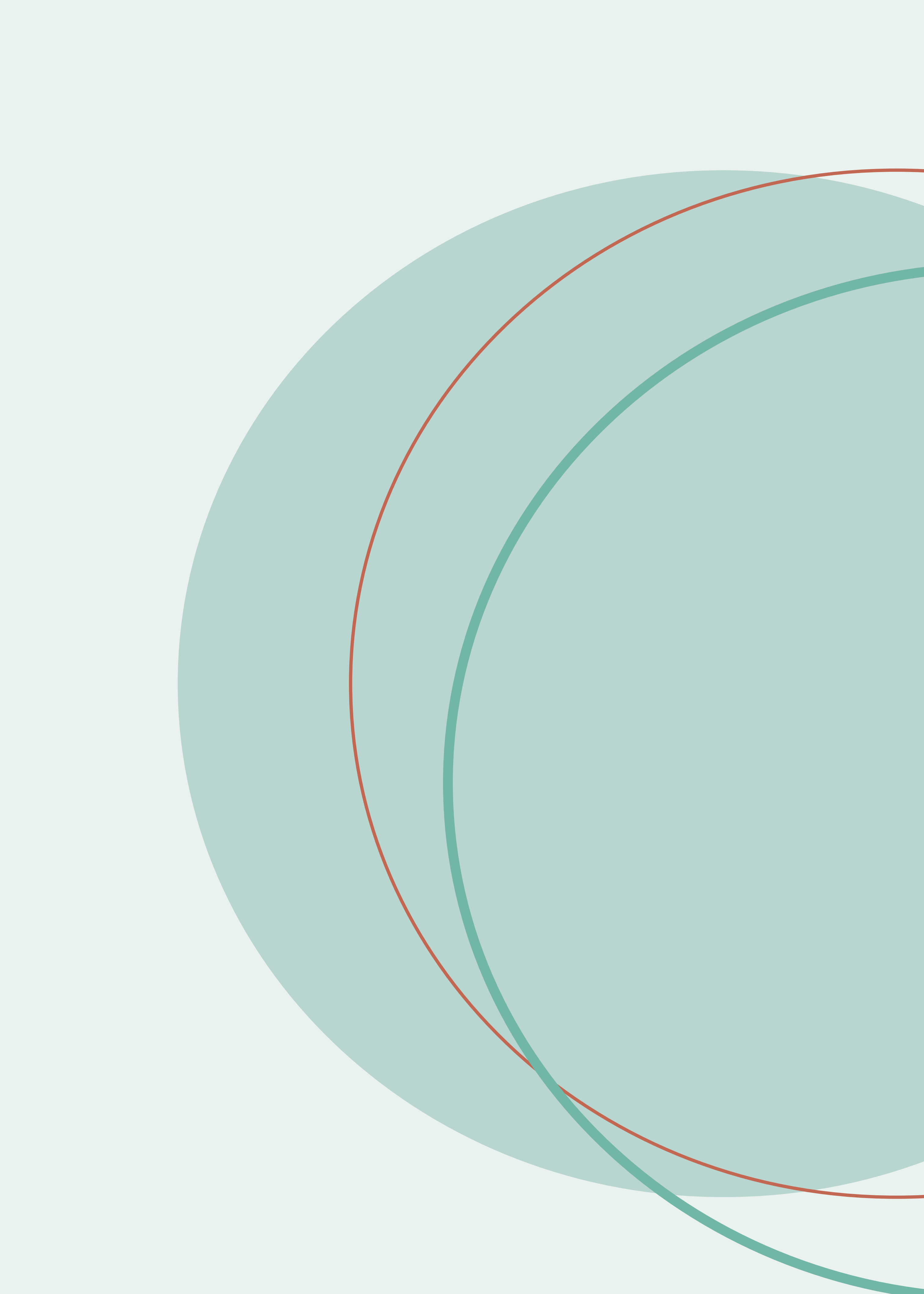
- "20-Minute Towns", wherein all door-to-door journeys using Walk-Cycle-Ride modes to the nearest neighborhood center are finished within 20 minutes;
- "45-Minute City", where 90 percent of peak-period door-to-door trips using Walk-Cycle-Ride modes are finished in less than 45 minutes; and
- 90 percent of trips during peak periods are made using preferred Walk-Cycle-Ride modes.

Targets of Transport for All are:

- Everyone plays a part in fostering a polite and compassionate commuting culture and
- More Walk-Cycle-Ride trips will be free of barriers, beginning with trips to public housing developments and infrastructure.

Targets of Healthy Lives, Safer Journeys are:

- Allocate additional space for public transport, active mobility, and community uses;
- Maintain cleaner energy fleets for a healthier environment and
- Lower the number of fatalities associated with land transportation towards a safer "Vision Zero" environment



CHAPTER 5

5. General Situation in OIC Member Countries and Comprehensive Evaluation of Selected Countries

5.1. Case Study-1: Malaysia (Field Visit)

The CO2 emissions of the transport sector in Malaysia has been continuously increasing over time, a fact depicted in Figure 5.1. An underlying reason of this tendency is the high dependency of the sector to the energy, which is largely carbon based.

Figure 5.1: The Changes in CO2 Emissions (million metric tons) Over the 1972-2012 Period *(Shahid, Minhans, & Puan, 2014)*

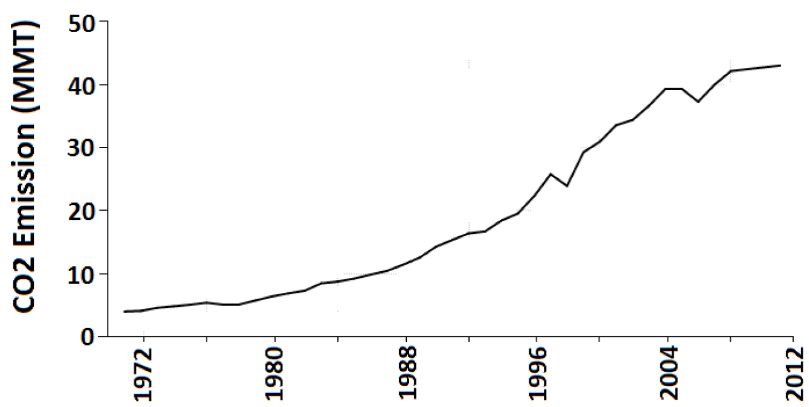


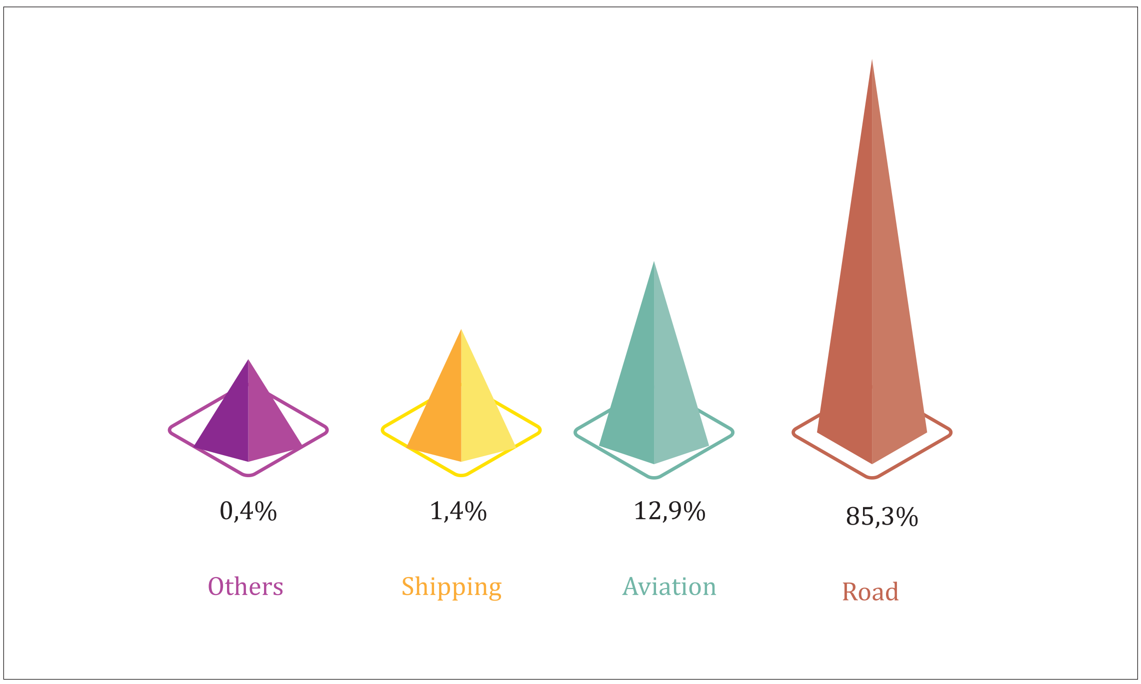
Table *5-1* below provides a supporting evidence to Figure 5.1. In Malaysia, the transport sector has been consistently the largest final energy consumer sector (Tenaga, 2020), though the decrease in its share when compared with 2015 figures is noteworthy. The forecasts suggest that because of the growing income and wealth, the transport sector will keep adding to CO2 emissions in the future (Soleymani, 2022).

Table 5-1: Energy Consumption by Sector in Malaysia (% of the total) *(Biennial Update Report to the UNFCCC, 2015)*

	2000	2005	2010	2015	2018
Agriculture	0,4%	0,3%	2,6%	1,73%	1,58%
Non-Energy	7,6%	5,7%	8,9%	11,44%	20,51%
Residential & Commercial	13,0%	13,4%	16,8%	14,59%	12,02%
Transport	40,6%	40,2%	40,6%	45,24%	36,43%
Industrial	38,4%	40,5%	31,2%	27,00%	29,46%

A close look at the composition of the CO2 emissions among transport modes reveals that road transport is the number one mode with an 85,3% share, which is followed by aviation and shipping with shares of 12,9% and 1,4%, respectively (Figure 5.2). The composition of road transport emissions reveal that cars are responsible for the 59% of all road-related CO2 emissions, which is followed by heavy duty vehicles, motorcycles, light duty vehicles and buses with shares of 17%, 11% and 10%, respectively (Ministry of Transport Malaysia, 2016). The high shares of cars and motorcycles suggest that there is a large room for improvement regarding a shift from such personal travel alternatives to public transport from an environmental perspective.

Figure 5.2: The Distribution of CO2 Emissions among Transport Modes in Malaysia *(Ministry of Transport Malaysia, 2016)*



5.1.1. The Related Legislation and The Governmental Agencies Involved

The major act governing the environmental procedures in Malaysia's the Environmental Quality Act 1974 (Act 127). In the regulations side, there are a group of transport-related regulations such as "Environmental Quality (Control of Emissions from Petrol Engines) Regulations 1996 – P.U. (A) 543/96", "Environmental Quality (Control of Emissions from Diesel Engines) Regulations 1996 – P.U. (A) 429/96", "Environmental Quality Control (Emissions from Diesel Engines) (Amendment) Regulations 2000 – P.U. (A) 488/2000", "Environmental Quality (Control of Emissions from Motorcycles) Regulations 2003 – P.U. (A) 464/2003" and Environmental Quality (Motor Vehicle Noise) Regulations 1987 – P.U. (A) 244/87" apart from horizontal regulation like "Environmental Quality (Clean Air) Regulations 2014". The details of the legislation on environment are reflected into the respective Environmental Impact Assessment (EIA) guidelines, which will be discussed in detail in the upcoming section.

Apart from these major legislations, there are a group of legislations relating directly or indirect the linkage between transport and environment, which are listed below.

- **Road Transport Act 1987** managing the licensing and inspection of motor vehicles.
- **Land Public Transport Act 2010** regulating the land public transport services.
- **Railway Act 1991** relating to the regulation, infrastructure and standards of rail transportation.
- **Civil Aviation Act 1969** regulating Malaysian Civil Aviation.
- **Port Authorities Act 1963** relating the responsibilities and authorities of the Malaysian ports.

Several institutions in Malaysia have been operating regarding the environment-transport linkage. These institutions and their roles are summarized in the following table.

Table 5-2: Governmental Agencies and Their Roles in Malaysia

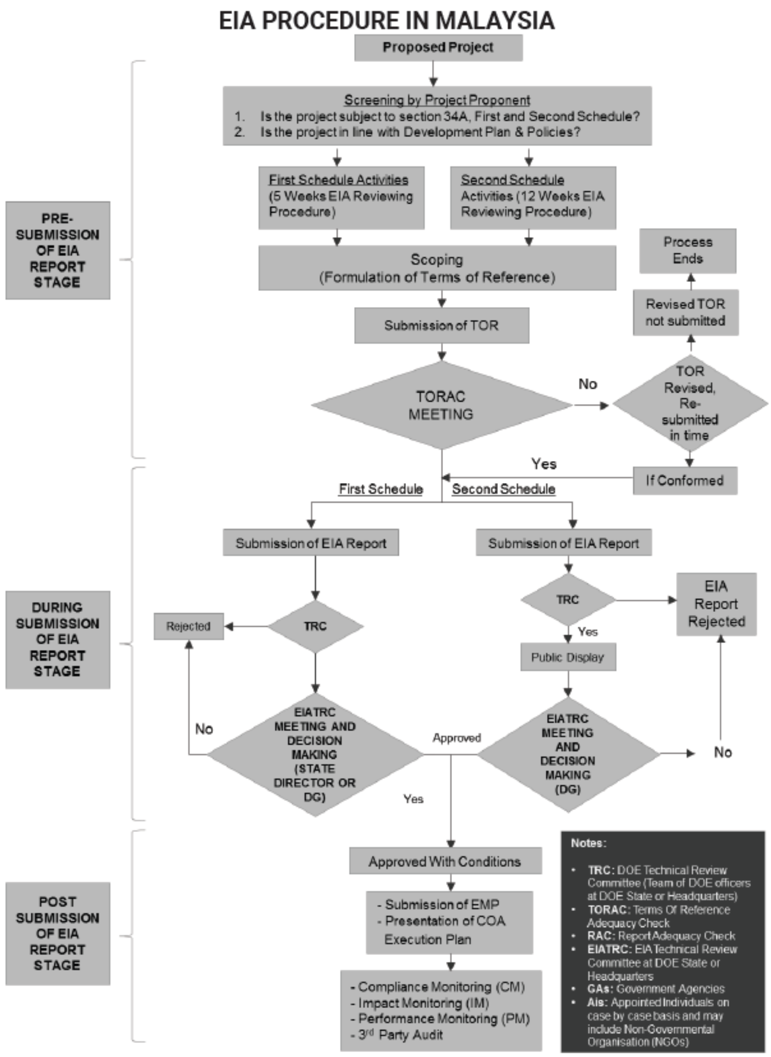
Government/Agencies	Their Roles
Ministry of Natural Resources, Environment and Climate Change	- overall responsibility regarding environmental issues
Ministry of Transport	- overall responsibility regarding transport sector
Civil Aviation Authority Malaysia	- regulating aerodrome operations and facilities - overseeing the civil aviation
Road Transport Department	- coordinating number plates - vehicle registration

Government/Agencies	Their Roles
Railway Assets Corporation	- railway infrastructure development - railway and development and management - maintenance of railway assets
Commercial Vehicle Licensing Board	- licensing of commercial road vehicles
Land Public Transport Agency	- regulating passenger public transport on land - regulating freight transport on land

5.1.2 Environmental Impact Assessment in Transport Projects

The Ministry of Natural Resources and Environment prepared an Environmental Impact Assessment Guideline in 2016 (Ministry of Natural Resources and Environment Malaysia, 2016) to share the fundamental rules and procedures with the respective stakeholders regarding the Environmental Impact Assessment (EIA) studies from the initial project identification to the operation phase of the infrastructure investments and facilities. The procedures followed to implement the EIA process are showed in Figure 5.3.

Figure 5.3: The EIA Processes in Malaysia



The EIA processes consist of three main stages, namely pre-submission of EIA report stage, during the submission of EIA report stage and post-submission of EIA report stage. The first stage, pre-submission of EIA report stage, starts with the screening step where the suitability of the proposed project is questioned form legal and policy point of view and ends with the finalization of the respective terms of reference of the project. During the submission of EIA report stage, the EIA report is submitted for approval. If the EIA report is approved, post-submission of EIA report stage includes the preparation of the execution plan, and the conduct of the associated monitoring activities.

The guideline for EIA is a general one for many sectors ranging from mining and industrial production to energy, waste treatment and transportation. One interesting point is that it makes a distinction between mass rapid transport and new railway route/branch projects (which are identified as transportation projects), road projects and port projects.

Following the Environmental Impact Assessment Guideline, The Ministry of Environment and Water published “Environmental Impact Assessment (EIA) Guidelines for Transportation and Road Projects” (The Ministry of Environment, 2020) in 2020. As the name implies, the guideline draws the general principles for the preparation of EIA reports for transport infrastructure projects. It is understood that the coverage of the guideline is limited to road, inter-city rail and urban rail projects. More specifically, the guideline specifies the applicable projects as follow (Page 4):

- Construction of expressways
- Construction of highways
- Construction of road, tunnel or bridge traversing/adjacent/near to environmentally sensitive areas Construction of new routes or branch line for a mass rapid transport project
- Construction of new railway route or railway branch lines

Table 5-3 shows the summary of the outputs of an EIA report prepared for East Coast Rail Link Project Section B (Dungun-Mentakab) Realignment at Kuantan Port City (Ministry of Environment, 2021). Please note that similar EIA reports can also be accessible online (Ministry of Environment, 2023) (some with English executive summary, other only in Malaysia) for other transport infrastructure projects including but not limited to East Coast Rail Link (ECRL) Project, Kuching Urban Transportation System Phase 1 –Samarahan Line and Serian Line and Westports Malaysia.

The respective report (EIA report prepared for East Coast Rail Link Project Section B Realignment at Kuantan Port City) identifies the impacts in six major headings, namely ecology, water quality, social, noise and vibrations, air quality and waste generation. The second column of Table 5-3 shows the summary of the predicted impacts., while the third column depicts their details. The last column exhibits the mitigation measures. The text in red letters correspond to the impacts and mitigation measures for the construction phase where the text in black letters stand for those for operation phase. The text in blue presents the benefits and, therefore, there is no mitigation measures for these benefits.

Table 5-3: East Coast Rail Link Project Section B (Dungun-Mentakab) Realignment at Kuantan Port City (Ministry of Environment, 2021)

	Summary of Predicted Impacts	Detail of the Impacts	Mitigation Measures
Ecology	Habitat loss and fragmentation Human-wildlife conflicts Poaching	Loss of natural vegetation due to clearance of 99 ha of Balok PRF and state land forest along Project corridor 9.84% - 12.83% of habitat fragmentation in Balok PRF Potential increase in human-wildlife conflicts due to human-induced disturbance from vegetation removal. Increased poaching activities from illegal usage of access road into Balok PRF Railway-related limitations and adversities: • Restrictions to wildlife movement due to the barrier created by the alignment • Potential wildlife-train collisions due to wildlife encroachment into railway Long-term forest degradation due to increased edge effects from cleared areas along alignment Increased human-wildlife conflicts along railway corridor Increased poaching threats into Balok PRF from abandoned access roads, cleared areas and culverts	**Phasing of vegetation clearance** Assist wildlife to retreat into surrounding forested areas in the right direction Clearing of forest within Balok PRF will be facilitated by Pahang State Forestry Department **Minimize excessive vegetation clearance** Using existing access roads leading to Project site reduces need to clear more forest for new access roads **Implement good housekeeping practices** Proper solid waste management to prevent wildlife scavenging at construction sites **Awareness raising and education** Educate site workforce to properly handle encroaching wildlife on-site **Monitor access roads and install barriers/gates** Prevent trespassers from entering forest reserve without any official purposes/permit from Forestry Department Appoint officer to patrol, report and liaise with enforcers Systematically record signs of trespassing to determine poaching entry and hotspots Establish CEPA programmes Monitoring of forest access points with enforcement agencies Empower local communities to deter poaching activities

	Summary of Predicted Impacts	Detail of the Impacts	Mitigation Measures
Ecology			Provision of wildlife crossing box culvert at 5 locations along alignment, viaducts at 2 locations can also serve as wildlife crossings Long-term wildlife monitoring Conduct habitat enrichment activities along forest edges to maintain habitat integrity Install wildlife warning signs at built-up areas Translocate persisting fauna species Establish CEPA programmes Monitoring of forest access points with enforcement agencies Empower local communities to deter poaching activities
Water Quality	Erosion and sedimentation of rivers from construction activities Water pollution from chemical, oil, and grease spillages Discharge of treated sewage for stations, depot, and heavy maintenance base	Land clearing and earthwork activities for railway embankments and foundations increases soil erosion risk along the alignment which will cause elevated levels of suspended solids in the receiving rivers. Untreated sewage and sullage discharge from portable toilets or individual septic tank will increase levels of DO, BOD, COD & NH3-N in the receiving rivers. Improper discharge or spillage at construction sites along the alignment leading to river water & soil contamination e.g., grease, diesel, etc.	Proper design and implementation of LD-P2M2 including: • 23 Sediment basins (18 along the alignment, 2 at KPC station, 1 at Cherating station, 1 at depot and 1 at heavy maintenance base) • Silt Traps • Silt Fences • Check Dams • Erosion Control Blanket • Wheel washing facilities **Sewage Management** • Temporary toilets to be connected to septic tank or portable sewerage system. • All discharge treated to Standard B of Environmental Quality (Sewage) Regulations 2009

	Summary of Predicted Impacts	Detail of the Impacts	Mitigation Measures
Water Quality		Sewage generated at stations, depot, and heavy maintenance base as well as toilet facilities within passenger trains if not managed properly will increase levels of DO, BOD, COD & NH3-N in the receiving rivers. Wastewater generated from depot and heavy maintenance base from washing and maintenance activities will increase risk of pollution in the receiving rivers. Improper discharge or spillage at construction sites along the alignment leading to river water & soil contamination e.g., grease, diesel, etc.	**Fuel, Oil and Lubricant Spillage Management** Provision of skid tanks, oil spill kits, containment bunds and implementation of SW management in accordance with Environmental Quality (Scheduled Wastes) Regulation 2005 **Sewage Treatment** Utilization of small sewage treatment system (SSTS) Regular desludging of sewage holding tanks Sewage discharge shall comply with Standard B of the Environmental Quality (Sewage) Regulations 2009 prior to discharge to receiving waterways Install grease interceptors to capture sullage, oil and grease and chemicals from being discharged Dispose scheduled waste according to Environmental Quality (Scheduled Wastes) Regulations 2005 Emergency Response Plan (ERP) and contingency plans for oil spill incidents Implement fuel, oil and lubricant spillage management such as skid tanks, oil spill kits and containment bunds.
Social	Noise, vibrations, and air pollutions during construction Potential hazards when there is a railway nearby settlements	Environmental changes (ambient air, noise, traffic) towards residents and workers Influx of foreign workers causing security concerns Boost in Logistic, Manufacturing and Tourism Industries which provides business and job opportunities for the locals and surrounding community Spur urban developments in the Kuantan conurbation area	Implement all mitigation measures for controlling noise, dust and traffic. Contractors to monitor their workers' movements. No new workers' camp to be built. Workers' accommodation will utilize existing Base Camp Site 2 and Site 3 near the Project

	Summary of Predicted Impacts	Detail of the Impacts	Mitigation Measures
Noise and Vibrations		Increased noise and vibration level from: piling works civil and structural works platform preparation works heavy vehicle movements construction machinery Noise and vibration from train passing through or near inhabited areas	Carry out construction site activities at permitted time only Temporary noise barrier facing Kg. Bkt. Palas and ASSB Workers Quarter Utilization of diaphragm sheet piles at sites with longer construction period (typically at station, depot and heavy maintenance base) Maintenance of vehicles and machinery Install noise barriers near ASSB Workers Quarter Installation of under-sleeper pads on rail track
Air Quality		Fugitive Dust (PM10) generation from earthwork activities Dust and gaseous emissions from construction equipment & vehicles (PM10, PM2.5, CO, NO2 and SO2) No air pollution expected as the trains are electric-powered. Negligible air pollution at stations where vehicles congregate to send/ receive passengers and goods. CO2e emissions avoided: 334,354 tCO2e/yr (2025) 821,290 tCO2e/yr (2035) 1,131,288 tCO2e/yr (2045)	Regular water spraying of construction sites, particularly along haul roads Wheel washing facility shall be provided Vehicles which carry particle-type materials shall be covered with tarpaulin

	Summary of Predicted Impacts	Detail of the Impacts	Mitigation Measures
Waste Genera-tion		Transport and handling of excavated material from earthworks activities within project site Generation of biomass from site clearing Activities Generation of construction waste from site clearing and construction activities Generation of domestic and sched-uled waste at stations, depot and heavy maintenance base	Soil stockpiling with erosion and sediment control. Cut & fill to be balanced within Project site Residual as backfill at identified few areas Clearing of forest within Balok PRF will be facilitated by Pahang State Forestry Department Minimise excessive vegetation clearance Implement construction waste management system Scheduled waste to be managed in accordance with the Environmental Quality (Scheduled Waste) Regula-tions 2005

5.1.3. The Current Efforts to Deal with The Environmental Effects of Transport Infrastructure and Services

The figures and tables presented above indicate that a group of policies can be imple-mented in Malaysia to reduce the environmental impacts of transport infrastructure and services. These policies include:

1. Shifting the passenger movements from personal vehicles to public transit
2. Shifting the freight movements from road to rail
3. Increasing the use of low-carbon energy in transport operations
4. Encouraging active transport modes

Malaysian Government and Kuala Lumpur City Hall have been adopting plans and policies to ensure the four actions listed above.

5.1.3.1. Twelfth Malaysia Plan 2021-2025

A significant policy emphasis is placed on the transport sector and sustainability within the Twelfth Malaysia Plan covering the 2021-2025 period.

Regarding the sustainability aspect, one of the three themes of the plan is “Advancing Sustainability” in addition to two other themes, namely “Resetting the Economy” and “Strengthening Security, Wellbeing and Inclusivity”. Related targets under this theme in-cludes the reduction of Greenhouse Gas Emissions Intensity to GDP up to 45% by 2020 and increasing the percentage of the renewable energy in the total capacity to 31%.

The plan identifies "Enhancing Connectivity and Transport Infrastructure" as one of the four policy enablers of the plan, the others being "Developing Future Talent", "Accelerating Technology Adoption and Innovation" and "Strengthening the Public Service".

The policy enabler "Enhancing Connectivity and Transport Infrastructure" consists of three priority areas and the majority of the strategies specified under these priority areas are directly and indirectly related to the linkage between transport and environment (Table 5-4).

Table 5-4: Strategical Linkage Between Transport and Environment

Policy Area	Strategy	Targets related to the transport-environment linkage
Priority Area A: Ensuring Integrated, Affordable, Reliable and Seamless People Mobility	Strategy A1: Improving Overall Accessibility of Public Transport	Annual Growth of Public Transport Ridership in GKL/KV: 5% (2021-2025)
	Strategy A2: Encouraging Behavioral Shift from Private to Public Transport	Increase in Air Transport Passengers (2025)
Priority Area B: Driving Transport and Logistics Industry Towards Competitiveness	Strategy B1: Enhancing Efficiency of Services	Increase in Cargo Volume via Rail, in Northern, Central and Southern Regions: 10% Ranking in the World Container Port's Report (within top 10) Ranking in the World Bank Logistic Performance Index (top 30)
	Strategy B2: Leveraging Digitalization in Services	
Priority Area C: Strengthening Institutional and Regulatory Framework	Strategy C1: Improving Governance	Standardized Warehouse Regulation
	Strategy C2: Promoting Green initiatives	Formulation of Green Transport Index

5.1.3.2. National Energy Policy 2022-2040

National Energy Policy 2022-2040 (Malaysia Ministry of Energy, 2022) underlines the priorities and targets regarding the energy industry. From a transportation point of view, the policy mainly aims at promoting the adoption of more green energy sources in transportation activities. The targets include (from year 2018 to 2040):

- Increasing the percentage of urban public transport modal share from 20% to 50%
- Increasing the percentage of the electric vehicle from <1% to 38%
- Changing the alternative fuel standard for heavy transport from B5 to B30
- Increasing the percentage liquefied natural gas as alternative fuel for marine transport from 0% to 25%.

5.1.3.3. The National Biofuel Policy

The National Biofuel Policy aims at, to name a few, increasing more use of renewable resources at the expense of fossil fuels, improving the export of biofuels and enjoying the advantages of palm oil in terms of price stability. The policy lists five strategic thrusts, one of which is the "Biofuel for Transport". This trust focuses on the inputting 5% palm oil into petroleum diesel and enhancing the nationwide accessibility of this diesel product.

5.1.3.4. The Green Technology Master Plan Malaysia (2017-2030)

The Green Technology Master Plan Malaysia (2017-2030) (Malaysia Ministry of Energy, 2017) is published in 2017. The aim of the master plan is to provides a roadmap to ensure *"green technology development to create a low-carbon and resource efficient economy"*. It targets five six important industries including transportation: construction, waste management, manufacturing, transportation, and energy. Specific targets for transport sector are presented in Table ccc. The targets depicted in table ccc suggest that the master plan relies on two major dimensions, namely improving public transport and enhancing energy efficiency in the transport sector.

Table 5-5: The Targets of Green Technology Master Plan Malaysia (2017-2030) for Transport Sector

	2020	2025
Public Transport	• 40% (Greater KL) • 20% (Other cities)	• 40% (All cities
Private Transport	• 85% Energy Efficient Vehicle (EEV)	• 10% • Reduction in electricity consumption

5.1.3.5. Kuala Lumpur City Plan 2020

One of the strategic directions specified in Kuala Lumpur City Plan 2020 is the "Connectivity & Accessibility for the City", which mainly targets the transport infrastructure and services. The details are provided in **Table *5-6***.

Table 5-6: Actions Regarding Connectivity & Accessibility for the City

Building a More Sustainable, Integrated and Environmentally Friendly Transport Infrastructure	• An integrated Transit Network • Extending Urban Rail Network with Regional Rail Network • Integrated Transportation Terminal and Park & Ride Facilities • Establishing Functional Road Hierarchy • Giving Priority to Buses • Developing Taxi Transformation Plan
Moving Towards Travel Demand Management Strategies	• Dispersing Peak-Period Traffic • Reducing SOV and Providing Incentives to Road Users • Managing Car Parking • Restraining Traffic within City Centre • Managing Heavy Vehicles • Integrated Traffic Information System (ITIS)
Integrating Developments with Pedestrian Connectivity in Kuala Lumpur	• Providing a Safe and Comfortable Walking Environment for all Groups of Pedestrian Network Users • Improving Pedestrian Connectivity and Accessibility at Key Locations • Developing Cycling Routes and Facilities

5.1.3.6. Kuala Lumpur Structure Plan 2040

Kuala Lumpur Structure Plan 2040 (PSKL2040), which is still in draft form, is the fundamental framework for guiding the Kuala Lumpur's future development. The document is an extensive planning blueprint covering various facets of Kuala Lumpur's physical and spatial growth. By its nature, one major topic focused by PSKL2040 is the transport infrastructure and services. In line with the current global emphasis on environmental sustainability, a considerable attention is paid on the transport and environment linkage.

One of the goals of the goals of the PSKL2040 is specified as follows:

"Kuala Lumpur an Efficient and Environmentally Friendly Mobility City".

This goal underlines the need to harmonize the growth of public transportation systems with the urban planning practices with the growth of public transportation systems for the sake of "efficient, clean and environment friendly" characteristics of the network of public transport and mobility. It aims at making public transport the number one choice for mobility. In more concrete terms, the plan targets to increase the share of the public transport to 70% by the year 2040, the respective target for the year 2030 is 60%.

The goal of "Kuala Lumpur an Efficient and Environmentally Friendly Mobility City" consists of 3 strategic directions and 10 actions. These are listed as follows:

Public Transport Network Provided with Varied Choices

- Strengthening Transportation Infrastructure and Expanding Urban Public Rail Networks
- Developing an Urban Tram System within Kuala Lumpur City Centre
- Prioritizing Public Bus Service Development
- Managing Traffic in the City Centre
- Planning for Taxi and E-hailing Services

Active Mobility Mode to Improve Accessibility Active Mobility Mode

- Ensuring a Safe, Quality, Connected and Accessible Pedestrian Network
- Providing Micro mobility Facilities to Achieve Higher Accessibility Level
- Carrying out Awareness Promotion and Safety Campaigns

Effective Traffic Management

- Enhancing Existing Road Functions
- Managing Car Park Spaces
- Strengthening Transportation Infrastructure and Expanding Urban Public Rail Networks
- Developing an Urban Tram System within Kuala Lumpur City Centre
- Prioritizing Public Bus Service Development
- Managing Traffic in the City Centre

5.1.3.7. Kuala Lumpur Low Carbon Society Blueprint 2030

Malaysia has an assertive goal to achieve a reduction of GHG emissions by 45% until 2030 when compared with 2005 levels. As a part of the efforts achieving this goal, Kuala Lumpur Low Carbon Society Blueprint 2030 (KL LCSBP 2030) is prepared as a result of studies launched in 2016 and completed in 2017. The KL LCSBP 2030 is an aggregate strategy consisting of 10 main strategies, 37 sub-strategies, 82 specific steps, and 245 initiatives to be executed across three central areas:

- Prosperous, Robust and Globally Competitive Economy
- Healthy, Creative, Knowledgeable and Inclusive Community
- Ecologically Friendly, Liveable and Resilient Built Environment

Transportation sector is a major focus of KL LCSBP 2030 since it is one of the biggest sources of greenhouse gases in the city. Accordingly, one of the 10 main strategies, which is entitled “Green Mobility”, is dedicated solely to transportation activities.

Table 5-7 below presents the action-wise composition of these three areas, as well as their respective carbon reduction targets. As shown in the Table, actions as a part of the Green Mobility (Action 3) strategy are predicted to contribute to 14,2% of the carbon reductions, which corresponds to 6,868 ktCO2eq.

Table 5-7: Carbon Reduction Contribution and Share of 10 LCS Actions

Table iv: Carbon emission reduction contribution and share of 10 LCS Actions

Thrusts	Actions	Reduction ($ktCO_2eq$)	Share by Actions (%)*	Share by Thrust (%)
Economy	Action 1 Green Growth (GG)	2,502	5.2	59
	Action 2 Energy Efficient Spatial Structure (SS)	2,872	6.0	
	Action 3 Green Mobility (GM)	6,868	14.2	
	Action 4 Sustainable Energy System (SE)	16,327	33.9	
Social	Action 5 Community Engagement and Green Lifestyle (CE)	9,015	18.7	19
Environment	Action 6 Low Carbon Green Building (GB)	9,673	20.1	22
	Action 7 Green and Blue Network (BG)	316	0.7	
	Action 8 Sustainable Waste Management (WM)	527	1.1	
	Action 9 Sustainable Water and Wastewater Management (WW)	105	0.2	
Enabler	Action 10 Green Urban Governance (UG)	-	-	0
	Total	**48,206**	**100**	**100**

**Numbers may not add up precisely to 100% due to rounding*

According to KL LCSBP 2030, Green Mobility consists of five pillars:

- Active mobility
- Integrated public transportation
- Diffusion of low carbon vehicles
- Enhance traffic flow conditions and performance
- Green freight transportation.

Active mobility involves actions to foster both walking and cycling for short-medium trips (which are up to 3 km) and dedicating certain pedestrian-only areas, with an overall goal of shifting from car use to these active mobility modes. The specific steps include "Provision of bicycle facilities", "Pedestrian and cycling priority at crossings", "Cycle Safe and Right", "Promote cycling as an attractive transport mode beyond recreational purposes", "Establish bike rental program – KL Cycle Hire Scheme" and "Identify potential activity centers for implementation of pedestrian zones".

Integrated public transportation aims at improving public transportation to make it more appealing for the private car users. To achieve this, the existing bus and rail systems will be upgraded and the intermodal transfer will be ensured. The specific steps include expanding the route network (GM7), Re-nationalising the existing bus lane network (GM8), strengthening the measures taken to prevent the inappropriate use of exclusive bus lanes, collaborating with relevant agencies to ensure high-capacity, fast, frequent, and dependable rapid transit, delivering real-time arrival information at bus stops and rail stations, improving the image of transit operations, introducing uniform-rate tickets and complimentary shuttle services in central areas, and improving 'Park and Ride' facilities at suburban transit nodes.

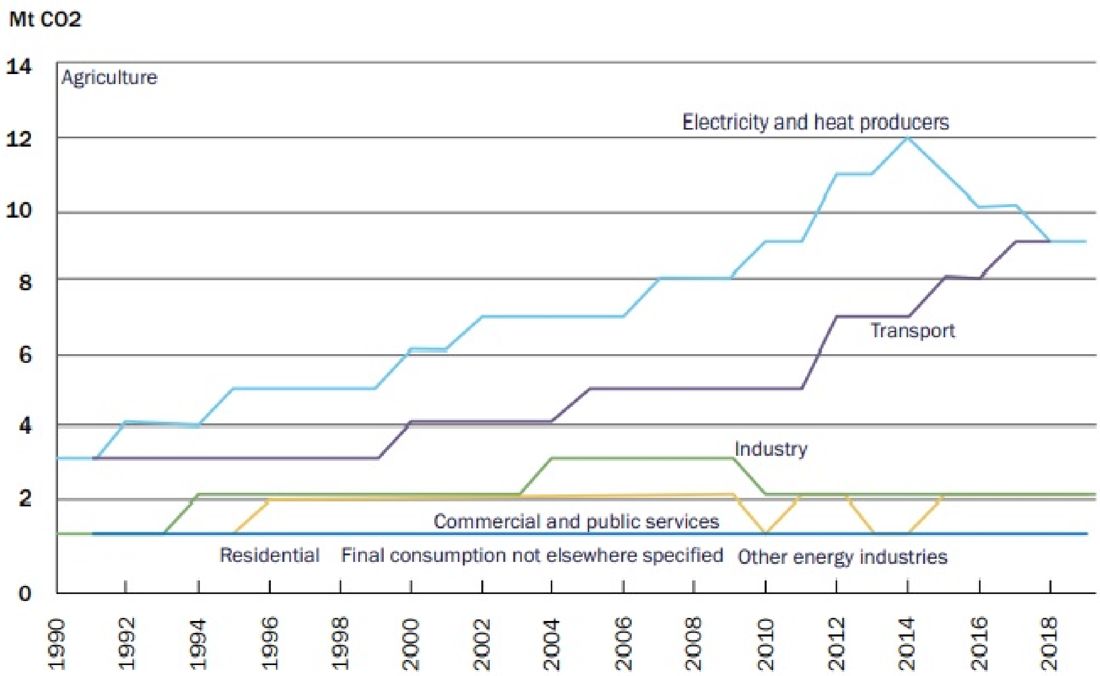
The underlying logic behind the "Diffusion of low carbon vehicles" moving towards greener vehicles (electric and biodiesel vehicles). As a first step, it is proposed that KLCH can include such vehicles into the official vehicle fleet. In addition, establishing collaborations with electric vehicle car sharing companies will be taken into consideration. Last but not least, in line with a common global practice, a tax incentive scheme for greener vehicles will be adopted.

Enhance traffic flow conditions and performance is a composition high-tech solution, mostly in the form of employing intelligent transport systems to mitigate congestion and improve the efficiency of the flows. Apart from intelligent transport systems such as the provision of real-time traffic congestion data, flexible use of traffic signalling and use of congestion pricing schemes and HOV lanes, the adoption of parking demand management to discourage private car use by increasing parking fees and reducing available parking spots.

5.2. Case Study-2: Jordan (Field Visit)

In 2018, Jordan produced 0.06 percent of global emissions (35.81 metric tons of CO_2 equivalent) and the leading source was by far the energy sector that produced 65.5 percent of all GHG emissions in Jordan; waste, industrial processes and agriculture sectors followed energy sector with shares of 15.6 percent, 5.6 percent and 3.3 percent, respectively (The World Bank Group, 2022). The sectoral composition of emissions shows that the energy consumption of transport sector has reached almost half of total energy consumption and it is expected to become the leading emission source at current path (The World Bank Group, 2022). The sectoral decomposition of CO_2 emissions in 1990-2019 period in displayed in Figure 5.4.

Figure 5.4:Cardon dioxide emissions by sector In Jordan (1990–2019)



According to the World Bank estimates, transport-related GHG emissions in Jordan surged from 4,706 to 8,787 Gg of CO_2 equivalent between 2006-2016, costing the Jordanian economy between JD 227.6 million and JD 455.1 million in 2016 (The World Bank Group, 2022). In 2021, GHG emissions from the transport sector reached 10,600 Gg, costing the Jordanian economy JD 272.8–545.7 million, measured in shadow price of carbon (SPC). Without any intervention, the annual GHG emissions from the transport sector could surpass 11,000 Gg of CO_2 equivalent until 2030. This would cost the economy JD 391.4-780 million per year, measured in SPC (The World Bank Group, 2022).

The Jordanian transport services are heavily dependent on the road network for both passenger and freight transport. Passengers travel entirely by road transport except for a limited number of domestic flights whilst an inadequate rail line is used for transport of certain mining products. Dependency on cars and trucks for passenger and freight transport causes severe environmental negative externalities including the noise pollution, increased fuel consumption, and emission of pollutants which leads to deterioration of air quality especially in urban areas.

Non-motorized modes of transport such as walking and cycling are not common due to the lack of appropriate infrastructure; in particular, cycling represents an extremely low share in the modal split, which also exerts pressure on the road infrastructure, leads to increased traffic congestion and thereby negative impacts on public health, environment, and the economy (The World Bank, 2022).

Jordan Transportation Network

Road Transport

Jordan's road network, which is the only transport network of the Kingdom, is composed of 7,377 km of road infrastructure, 2,754 km of which can be classified as main roads that mainly operates as a north-south corridor (Ministry of Transport, 2016).

As a consequence of the underdeveloped public transport system, most of the passenger transport are realized by private cars. Public transport is provided only by buses. Except for bus terminals in major cities, there is no clearly defined public transport network including terminals, transfer stations, stops and integrated fare systems (Ministry of Transport, 2016) . Services are unreliable without proper timetables and low frequencies and concentrated in densely populated profitable areas which creates underserved parts in the country.

Despite the dependency on private transport, the number of vehicles per capita remains low in many cities. Private cars constitute the most important mode of transport for passenger trips in Jordan, however, car ownership at national level is less than 150 vehicles per 1,000 inhabitants. Amman differs from the rest of the Kingdom with 285 cars per 1,000 inhabitants. Car ownership rate in Amman increased at an annual average rate of 6.7% between 1990 and 2007 which caused soaring passenger trips by motorized vehicles, emission of more pollutants, and thus more greenhouse gases and more noise (Ministry of Transport, 2016).

Rail Transport

Rail network is not used as an alternative to road network due to limited infrastructure (approximately 509 km) that requires to be modernized as well. Aqaba Railway Corporation manages the only railroad used for freight transport, which is the 294 kilometres long narrow-gauge railway line, that is used for the transport of phosphate and other mining products to the port of Aqaba.

Jordan Hejaz Railway Corporation operates passenger trains on an irregular basis on the rest of the rail sections. Thanks to its ancient infrastructure, the historical Hejaz railway and its vintage trains are used to provide touristic services between Amman and Wadi Rum (The World Bank, 2022).

Air Transport (Civil Aviation)

Three international airports, namely Queen Alia International Airport and Amman-Marka Civil Airport in Amman and King Hussein International Airport in Aqaba operate in the Kingdom. Main airport used for international flights is Queen Alia International Airport while the traffic in other airports are negligible. There is a low number of domestic flights operating between Amman and Aqaba.

Maritime Transport

Jordan has access to sea through its 26 km coastline to the Red Sea and the unique sea port is in the south of Aqaba. There are daily ferry services for passengers and passenger cars operated by Arab Bridge Maritime Company to Nuweiba and Taba on the coast of the Red Sea.

For freight transport, Aqaba Port operates with three port units; main port, middle port and southern/industrial port for handling goods, mainly imports and exports to and from Jordan (Ministry of Transport, 2016).

5.2.1. The Related Legislation and the Governmental Agencies Involved

5.2.1.1. Institutional Framework in Jordan Transportation Sector

Various ministries, regulatory authorities, public institutions, service providers and private companies take role as stakeholders in Jordan transport industry. For each mode of transport different institutions assume the role of planning, building and maintenance of infrastructure, regulation and operation. Table 5-8 summarizes the main entities in the sector, including public and private institutions and NGOs, for different facilities for each mode of transport.

Table 5-8: Institutional Framework in Jordan Transport Sector *(Ministry of Transport, 2016)*

Transport Mode	Category	Entity/Component of the Industry
Road Transport	Planning authority, infrastructure development, maintenance and operation	Ministry of Public Works and Housing Greater Amman Municipality
	Regulatory authority	LTRC – Public Transport Directorate LTRC – Freight Transport Directorate
	Private passenger transport operators (private vehicles)	Royal Automobile Club of Jordan Drivers and Vehicles Licensing Department
	Public passenger transport operators	JETT Buses AUTOBUS General Union of Jordanian Bus Owners Greater Aman Municipality
	Freight transport operators	Syndicate of Jordanian Trucks Owners Forwarders Association Owners Syndicate

Transport Mode	Category	Entity/Component of the Industry
Rail Transport	Planning authority	Ministry of Transport
	Regulatory authority	LTRC – Railways Transport Directorate
	Infrastructure development	Ministry of Transport
	Infrastructure maintenance and operation	Jordan Hejaz Railway Aqaba Railway Corporation
	Public passenger transport operators	Jordan Hejaz Railway
	Freight transport operators	Aqaba Railway Corporation
Civil Aviation	Planning authority	Ministry of Transport
	Regulatory authority	Civil Aviation Regulatory Commission
	Infrastructure development	Ministry of Transport – Project Management Unit Airport International Group
	Infrastructure maintenance and operation	Jordan Airports' Company Aqaba Airports' Company Airport International Group
	Public passenger transport operators Freight transport operators	Royal Jordanian Airlines
	Service provider	Jordan Meteorological Department
Maritime Transport	Planning authority	Ministry of Transport Aqaba Special Economic Zone Authority
	Regulatory authority	Jordan Maritime Authority
	Infrastructure development	Aqaba Development Corporation
	Infrastructure maintenance and operation	Aqaba Ports Corporation Aqaba Container Terminal
	Public passenger transport operators Freight transport operators	Jordan Shipping Association Contractors Association
	Service provider	Jordan Meteorological Department Jordan Investment Board Arab Bridge Maritime

Transport Mode	Category	Entity/Component of the Industry
All Modes	Infrastructure development companies	Contractors Association
	Service provider	Jordan Investment Board
	Economic System	Development Zones Commission

Planning, policy formulation and infrastructure development roles are mainly shared by the Ministry of Transport (MoT) and the Ministry of Public Works and Housing (MoPWH). While MoT is responsible for planning, policy formulation and/or infrastructure development for rail transport, maritime transport and civil aviation, MoPWH assumes these roles for road transport, deals with the development and maintenance of the road networks and ensures their construction and maintenance. As road network is the major infrastructure in Jordan, MoPWH is the prominent institution in transport infrastructure. Nevertheless, the MoT is also responsible for formulating general transport sector policy, including the road infrastructure development.

Ministry of Environment and Ministry of Interior also take part in the sector for EIA approval and road safety issues, respectively.

Regulation in the sector is pursued by separate entities, namely the Land Transport Regulatory Commission (LTRC), the Civil Aviation Regulatory Commission, and Jordan Maritime Authority.

Aqaba Special Economic Zone (ASEZA) is subject to exclusive regulations. In line with the Aqaba Special Economic Zone Law, ASEZA assumes many governmental roles in the dedicated area. ASEZA area is a crucial part of Jordan economy as it covers the Aqaba Port, which is the main facility for international trade.

5.2.1.2. Environmental Policies and Regulations in Jordan:

To confront the negative externalities of economic activities, Jordan has announced an ambitious objective of raising GHG reduction goals from 14% to 31% by 2030 in revised **Nationally Determined Contributions** Document submitted in 2021.

Jordan announced inclusive policies and strategies in line with their sustainable development objectives and prepared several policy documents to achieve green growth while meeting the needs of the expanding economy and increasing population. Main strategy and policy documents can be analysed in three main categories: (i) environmental strategies and policy documents at national level and (ii) environment-related transport sector strategies and policy documents at national level (iii) transport sector strategies and plans at local level.

Sustainable transport initiatives in Jordan are planned and executed in three main pillars:

i) Promoting and expanding public transport with a multi-modal approach and improving efficiency of public transport systems

ii) Establishing a national railway network for freight and passenger transport

iii) Decarbonization of transport by encouraging replacing fossil fuel vehicles with electric or hybrid vehicles and renewing vehicle fleets

A. Environmental Strategies and Policy Documents at National Level

Jordan established Directorate of Climate Change under the Ministry of Environment (MoEnv) in 2014 to tackle with the accelerating need for adaptation to climate change and mitigate related risks. After the establishment of this dedicated Directorate, MoEnv prepared or revised several policy documents involving various sectors in Jordan economy at national scale.

The National Climate Change Policy (2022-2050)

The National Climate Change Policy (2022-2050) was set forth by MoEnv to provide guidance for building a climate resilient society in line with the national growth and development objectives and the objectives of United Nations Framework Convention on Climate Change (UNFCCC). The document is prepared as a framework for embedding climate change perspective in sectoral policies and action plans and aims at reaching an ambitious low-carbon and climate resilient society (Ministry of Environment, 2022). The policy document has also been prepared in line with the terms of Paris Agreement.

The long-term objective of the document is stated as:

"*To have national developments and efforts supporting Jordan being part of the global effort towards carbon neutrality by 2050, while simultaneously securing all sectors to the impacts of present and future climate change and climate variability in order to achieve the SDGs in the shorter-term and to secure a high quality of life for all*"

As set forth in the policy document (Ministry of Environment, 2022), the policies and related actions are planned to contribute to:

- Climate change mitigation, through the reduction of GHG emissions and the promotion of a low carbon economy,
- Climate change adaptation, through the adoption of practices that reduce climate vulnerabilities and increase climate resilience,
- Sustainable development, through the promotion of inclusive and sustainable growth, the creation of employment and the overall improvement of the quality of life of individuals.

The document presents a full-fledged strategy by setting policies in various sectors, providing action lists to implement the policies, time frame (as short, medium and long term), legal and institutional arrangements and monitoring and evaluation mechanisms including indicators. The policy document aims at promoting low carbon transport modes and facilitating the change to low-carbon transport technologies to achieve a climate change-resilient Jordan. Mitigation strategies in the documents focus particularly on energy consumption related transport policies and measures. Policies set in transport field are as follows:

- Integrated land use planning to support sustainable land transport
- Promoting low carbon modes of passenger transport
- Fuel switch to decrease transport emissions
- Increasing transport efficiency
- Promoting low carbon freight transport

National Green Growth Plan

The starting point of National Green Growth Plan (NGGP), which was prepared by MoEnv, is "Jordan 2025 National Vision and Strategy" document prepared by the Ministry of Planning and International Cooperation with a participatory approach. NGGP seeks to improve the harmonization of green growth policies and government strategies and aligns its priorities and objectives with development goals set in in the Vision 2025. Green growth objectives to be integrated with Vision 2025 policies are identified as:

- Enhanced natural capital
- Sustainable Economic Growth
- Social Development and Poverty Reduction
- Resource Efficiency and
- Climate Change Mitigation and Adaptation

By a cost-benefit analysis approach, the NGGP identifies the challenges and opportunities for project implementation and focuses six sectors: Agriculture, Energy, Tourism, Transport, Waste and Water. Cost-benefit analyses integrate every positive and negative externality (such as emissions of GHG) into the estimations to understand green growth opportunities accurately.

The four priority transport projects assessed in the Plan are Aqaba-Amman Freight Rail Route, Amman-Zarqa Bus Rapid Transport, Ma'an Dry Port and Electric Vehicles in Amman. These projects yielded benefit-cost ratios of 3.5, 2.6, 1.8 and 1.2, respectively. The ratios present the green growth opportunities of the sector clearly.

B. Environment-Related Transport Sector Strategies

Green Growth Action Plan 2021-2025, Transport Sector

To ensure implementation of NGGP principles and achieve its objectives, action plans were prepared in six sectors. Green Growth Action Plan for transport sector presents a green growth framework and list actions aligned with NGGP, Jordan Vision 2025, and Nationally Determined Contributions (NDCs) in the scope of the Paris Agreement.

13 priority actions are proposed in the Action Plan. These actions focus on two fields: (i) to achieve a modal shift from private cars to public transport by promoting multimodality and improving public transport, which would result in a reduction of congestion levels on the road network and, in turn, in a reduction of GHG emissions and air pollution and (b) to replace fossil fuel vehicles and internal combustion engine private cars with hybrid or electric vehicles (World Bank, 2023). 7 of these 13 actions are about investment preparation and demonstration while the remaining 6 actions are about enabling policy and institutional reform. These actions and their relevancy with the objectives of NGGP are presented in Table 5-9.

Table 5-9: Summary of Transport Sector Green Growth Action Plan
(Ministry of Environment, 2022)

#	Action Title	Total Estimate Implementation Cost (US$)	Relevant Green Growth Objectives				
			Enhanced Natural Capital	Sustainable Economic Growth	Social Development and Poverty Reduction	Resource Efficiency	Climate Change Mitigation and Adaptation
TR 01	Develop and/or update Transport and Mobility Action Plans and Capital Investment Plans for the secondary metropolitan areas of Mafraq, Zarqa, and Irbid	5,000,000		**X**	**X**		**X**
TR 02	Approve and activate the National Public Transport Fund and identify mechanisms to raise capital for public transport infrastructure	51,000,000		**X**	**X**		**X**
TR 03	Implement transport sector governance enhancement program and reform agenda to increase the effectiveness and efficiency of the public transport policy – making process	1,000,000		**X**	**X**		**X**

#	Action Title	Total Estimate Implementation Cost (US$)	Relevant Green Growth Objectives				
			Enhanced Natural Capital	Sustainable Economic Growth	Social Development and Poverty Reduction	Resource Efficiency	Climate Change Mitigation and Adaptation
TR 04	Scale up the provision of public-school bus services in all municipalities (Scale – Up Smart Move Project)	15,000,000	X	X	X		
TR 05	Implement a pedestrian green infrastructure enhancement program in local commercial areas and near public transport	25,000,000	X		X		X
TR 06	Develop a public – private dialogue and road map for improving road transport services linked to the tourism sector	1,000,000		X			X
TR 07	Support the deployment of ITS to allow a modal and fare integration of the public and private transport systems in the city of Amman	9,870,000	X	X			X
TR 08	Establish a national center of excellence and capacity – building program for sustainable transport	1,000,000		X			X
TR 09	Develop a joint public – private strategy and road map to improve the environmental sustainability of the logistics sector	1,000,000		X			X
TR 10	Develop and implement a PPP for improved parking management in Amman	11,000,000		X	X	X	X

#	Action Title	Total Estimate Implementation Cost (US$)	Relevant Green Growth Objectives				
			Enhanced Natural Capital	Sustainable Economic Growth	Social Development and Poverty Reduction	Resource Efficiency	Climate Change Mitigation and Adaptation
TR 11	Develop a national electric mobility strategy and action plan	1,000,000	X			X	X
TR 12	Design and implement a public transport electric mobility pilot and capacity – building program in Amman	5,000,000	X			X	X
TR 13	Establish low – carbon municipal bus fleets for Irbid, Zarqa, and Madaba municipalities	22,000,000		X	X		X

Long-Term National Transport Strategy

Long-Term National Transport Strategy prepared by MoT focuses on policies

i) Creating a multimodal transport system that operates efficiently with adequate infrastructure strengthened with railways and effective operational systems

ii) Protecting the environment by increasing the share of public and non-motorized transport in trips and improving energy efficiency by using low-carbon technologies

iii) Increasing accessibility in public transport services

The vision statement of the Strategy was declared as

"to have a developed and sustainable transport sector, distinguished for competency, safety and environmental stability, enhancing the socio-economic development and making Jordan a regional hub for transport".

The Strategy is based on 8 policy pillars, as follows;

i. Complete the existing networks

ii. Make the best use of existing facilities

iii. Pursue a multimodal approach

iv. Combine infrastructure investments and policies

v. Make the best of private participation in the transport sector

vi. Protect the environment and reduce negative impacts

vii. Emphasize the regional dimension

viii. Have citizens at the core of the transport policy

In this context, measures are formulated in 6 themes, namely Road, Railways, Civil Aviation, Port and Maritime, Public Transport, Freight Transport and Logistics, and cross-cutting issues were also handled.

The proposed policies, measures and projects in the Strategy are in line with the national strategies and action plans prepared by the MoEnv as discussed above. The reduction of the environment-related negative externalities of the transport sector is the primary focus of the Strategy and it is planned to achieve by pursuing three main set of actions for all transport modes:

To begin with, there is a strong commitment for eliminating the dependency on road network for both passenger and freight transport and reaching a modal split favouring environment-friendly transport mode. This objective is planned to be achieved by the expansion and modernization of national railway network, improving public transport infrastructure and operation (i.e. operating according to timetables meeting transport demand, efficiently designed bus stops and interchanges, integrated fare systems).

Second set of actions include measures to renovate the private vehicles and public bus fleets and increasing the use of electric cars through financial, regulatory and enforcement incentives to decrease CO_2 emissions. Improving the efficiency of the freight logistics and passenger transport chains involves developing intramodality, interchanges, dry ports, and combining truck and public transport operators.

Finally, strong ownership, citizen participation and commitment are essential for ensuring that transport sector is sufficient in meeting social needs and environmental challenges for the economic and social development of Jordan.

C. Transport Sector Strategies and Plans at Local Level

Main local transport plans formulated for implementation of national green growth and sustainable transport policies are as follows:

- Greater Amman Master Plan 2025
- Amman Transport and Mobility Master Plan
- Zarqa Downtown Area Energy Efficient Urban Transport Plan
- Amman Resilient Strategy
- Amman Climate Plan, a Vision for 2050
- Green City Action Plan 2021

Other sectoral strategies and action plans related to environmental policies in transport sector are as follows:

- Second National Energy Efficiency Action Plan
- Master Strategy for Energy 2030 Ministry of Energy and Mineral Resources
- National Strategy and Action Plan for Sustainable Consumption and Production 2016–2025
- Green Growth National Action Plan 2021-2025, Energy Sector

5.2.2. Assessment of Environmental Impacts:

In Jordan, environmental protection measures and environmental impact assessment (EIA) preparation, screening, reviewing and monitoring processes are regulated by Environment Protection Law enacted in 2006 and revised in 2017, EIA Regulation No. 37 of 2005, secondary legislation and guidelines.

All infrastructure projects including transport projects as well as other public investment projects that has negative impacts for the environment need to be approved by MoEnv. EIA completed in the preliminary design stage of the project cycle is required to get the environmental clearance from the MoEnv.

In this context, firstly, a preliminary EIA should be submitted to MoEnv by the project holder. A preliminary EIA should include project description, project alternatives, impact assessments, mitigation measures and environmental, health and social management measures.

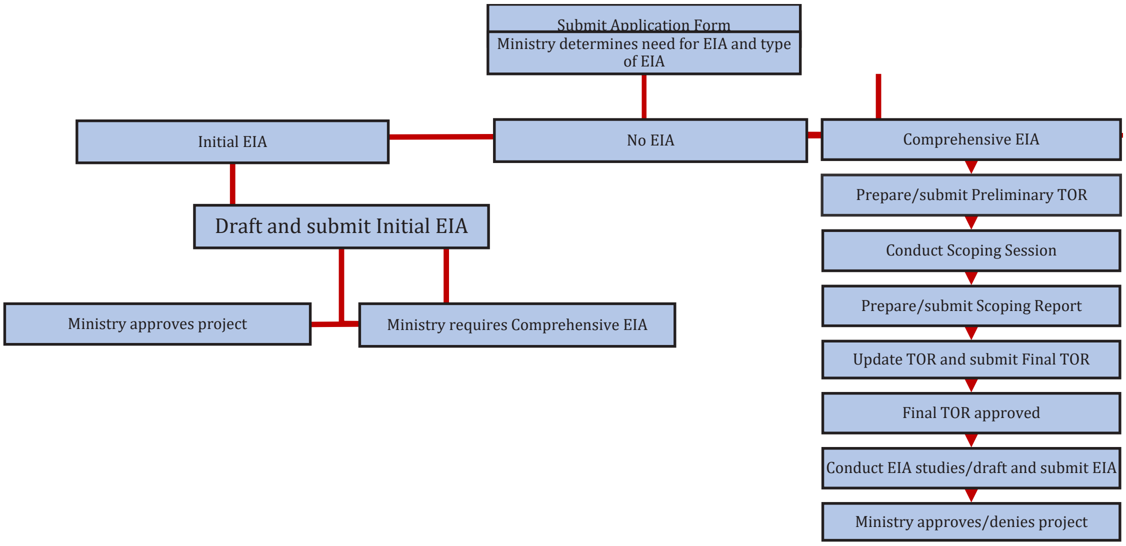
In the screening phase, following the evaluation of the "Initial EIA", if MoEnv comes to a conclusion that significant environmental impacts are expected a "Comprehensive EIA" is requested. For this purpose, a preliminary "Terms of Reference" (TOR) document should be prepared by the project holder. The TOR document should explain how the EIA will be conducted and should identify potential impacts and proposed mitigation measures,

In the preliminary TOR document how, the EIA will be carried out should be explained and potential consequences as well as proposed mitigation actions should be highlighted to be discussed at the scoping phase. Scoping is the process of communication and consultation between stakeholders to identify essential environmental concerns and discuss mitigation measures. Following the scoping phase, final TOR is approved by the MoEnv and EIA is conducted in conformity with the final approved TOR.

Finally, in the EIA Report Review phase, the report is evaluated by the Ministry of Environment to assess whether the project meets the conditions for environmental clearance.

The process as managed by MoEnv is summarized in Figure 5.5.

Figure 5.5: Environmental Clearance Process *(Ministry of Environment, 2014)*



A comprehensive EIA Report must include analysis and documentation of physical, biological and socio-economic environment baseline as well as impact analysis for these components, risk assessment and mitigation measures and project alternatives.

Field surveys, laboratory analyses, modelling, estimations are among assessment tools to be used in EIA. Life cycle assessment may be required depending on the project characteristics. Impacts should be quantified to the possible extent.

5.2.2.1. Environmental and Social Impact Assessment of Amman and Amman-Zarqa BRT Project

The Bus Rapid Transit (BRT) projects for Amman and Amman-Zarqa route were designed separately but the Government of Jordan and Greater Amman Municipality (GAM) decided to integrate the operations of the two systems. Therefore, a combined Environmental and Social Impact Assessment Report (ESIA) was prepared for the projects in 2017 (Greater Amman Municipality, 2017).

The analysed project consists of 3 BRT corridors. BRT 1 and BRT 2 corridors are in the city of Amman and BRT 3 corridor is the Amman-Zarqa corridor.

For the ESIA,

- Separate EIAs for Amman and Amman-Zarqa BRT Systems were reviewed.
- For air quality monitoring; a mobile station was established to monitor and assess the air quality by measuring the concentrations of sulfur dioxide (SO_2) nitrogen oxides (NO_x, NO, NO_2), carbon monoxide (CO) and particulate matter (PM_{10}) at three different locations.
- For noise monitoring; noise measurements are conducted at three locations.

- To estimate CO2 reductions; carbon foot print of the total traffic was calculated for the year 2018 for all the BRT routes both for baseline conditions assuming no BRT Project and for the implementation of BRT Project.
- Noise modelling was developed for baseline conditions and after BRT scenario.
- Socio-economic and cultural impacts were analysed.
- Impacts were calculated and assessed considering their magnitude, direction and duration.
- Mitigation methods were discussed.
- Environmental Management and Monitoring Plan was drafted.

Main outcomes can be summarized as follows:

- Improved public transportation which enables efficient and reliable service, time savings and comfortability is the main positive impact of the Project.
- Time savings and model shift from private cars to public transport would reduce the emissions of CO_2 and other air pollutants.
- Noise pollution arising from the new corridors should be mitigated by noise barriers, use of electric buses etc.
- Solid wastes generated during construction and operation phases should be managed effectively.
- Former public transport routes should be amended for efficiency gains.
- BRT routes and other routes should be integrated in terms of timetables and fare collection systems.
- Number of lanes reserved for private cars can stay unchanged if the width of lanes is revised which implies that reserving a lane for BRT would not induce capacity problems
- There would be no need for resettlement of displaced people in construction or operation periods.

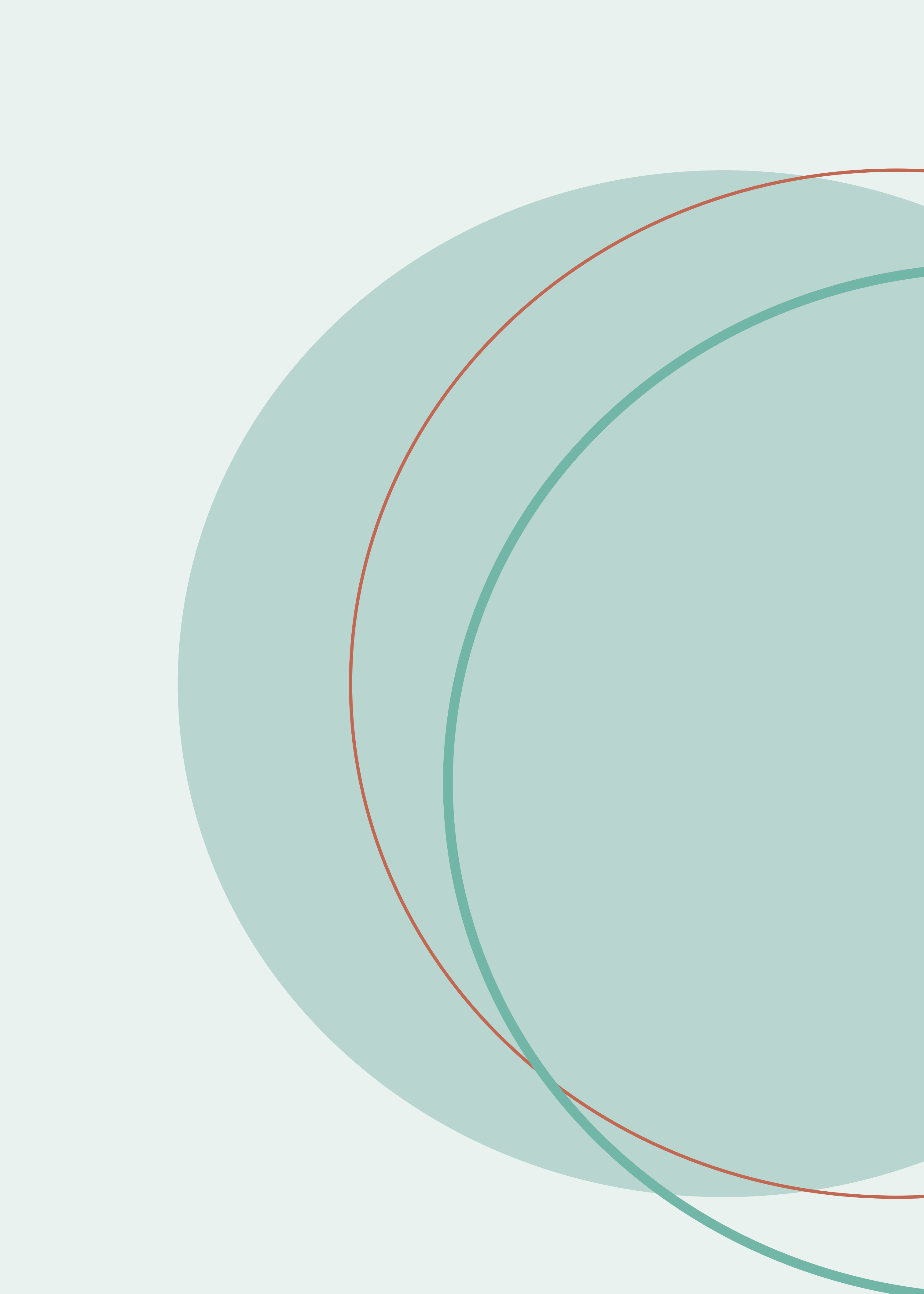
5.2.3 Public Participation and Stakeholder Engagement:

Engagement of stakeholders and public participation is critical in environmental decision-making processes in Jordan and MoEnv ensures that related parties take place in the drafting of EIA Reports.

At the scoping phase of the EIA process, after the submission of the preliminary TOR, MoEnv conducts a scoping session with stakeholders to confirm technical areas of concern, identify potentially significant issues and identify less significant issues to set the framework for EIA to ensure the EIA document can be prepared efficiently and clearly (Ministry of Environment, 2014). Potential stakeholders to be invited to the scoping session are

- Project owner(s)
- Municipal or other government officials
- Business owners
- Neighbourhood residents
- Stakeholder groups, i.e. women's groups
- Concerned individuals
- Regulatory agencies
- Institutional representatives (schools, religious) and
- Non-governmental Organization (NGO) representatives

At the scoping session, the project holder presents the preliminary TOR to the participants, explain the project, potential areas of concern, potential impacts, and plans for the Comprehensive EIA study. Upon the discussions in scoping sessions, a formal Scoping Session Report is drafted by the project holder. The report includes the scoping process as well as formulated recommendations for the final TOR.



CHAPTER 6

6. Survey Results

This chapter reports the findings of the questionnaire study implemented as a part of this research project. The purpose of the questionnaire is to assess the current practices within OIC Member countries related to the measurement of environmental impacts in transport infrastructure projects. It aims to gather insights into how these countries approach and measure the economic and social impacts of such projects, with a particular focus on environmental aspects.

The online questionnaire is implemented starting on the 28th of July 2023, and ending on the 7th of September 2023. The link to the online questionnaire is sent to a total of 1228 potential survey participants, who are experts on the topic of this report. Related survey questions are included in the "Appendix" section.

Our target population for the questionnaire consisted of:

- Ministries of transport and their affiliated bodies such as civil aviation authority, state highways administration, port administrations)
- Ministries of environment and other government agencies directly or indirectly working on sustainability
- Participants of the OIC Working Group Meeting
- Public and private transport service providers (railways, airlines, shipping companies, road transport operators)
- Sector organizations and associations regarding transportation and logistics
- Trade and industry unions
- NGOs
- Academicians working on transportation, logistics, public administration, public health, and environment/sustainability

Efforts were made to broaden the target group for the questionnaire, addressing the common issue of low response rates in similar research studies. Ultimately, 67 responses were received from OIC member nations. From an individual expert's perspective, the response rate is 5.45% (67 out of 1,228).

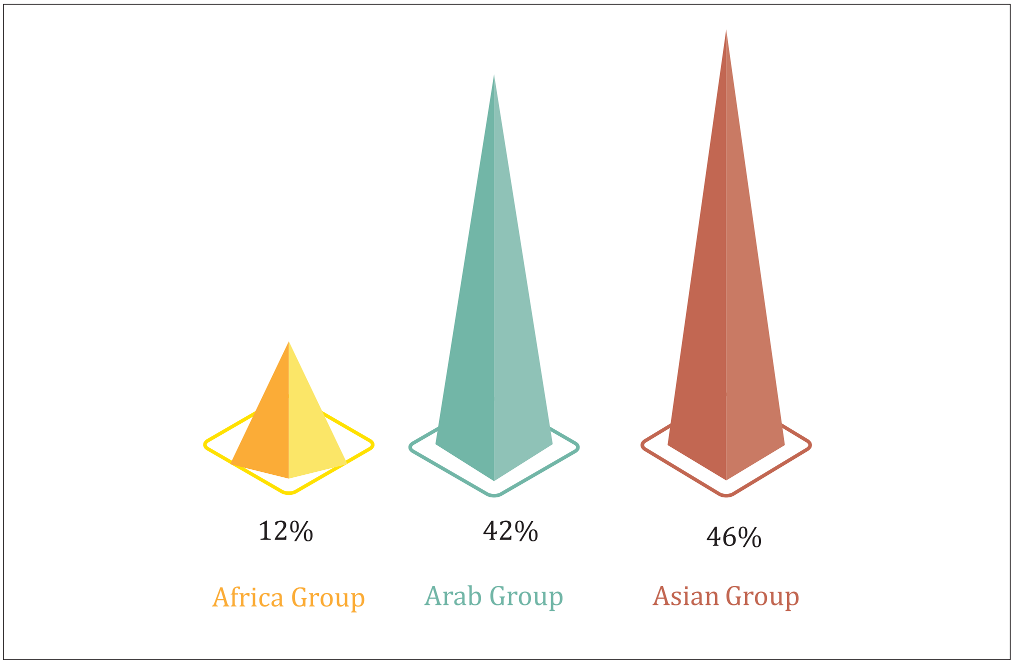
Despite the low response rate, the substantial number of responses received allows for comprehensive conclusions to be drawn. The OIC states represented in the questionnaire replies are shown in Table 6-1.

Table 6-1: The OIC Member States Covered in the Questionnaire

Afghanistan	Lebanon	Suriname
Albania	Maldives	The Gambia
Algeria	Nigeria	Tunisia
Azerbaijan	Palestine	Türkiye
Bangladesh	Republic of Guyana	Uganda
Bahrain	Republic of Yemen	United Arab Emirates
Iraq	Somalia	
Jordan	State of Libya	

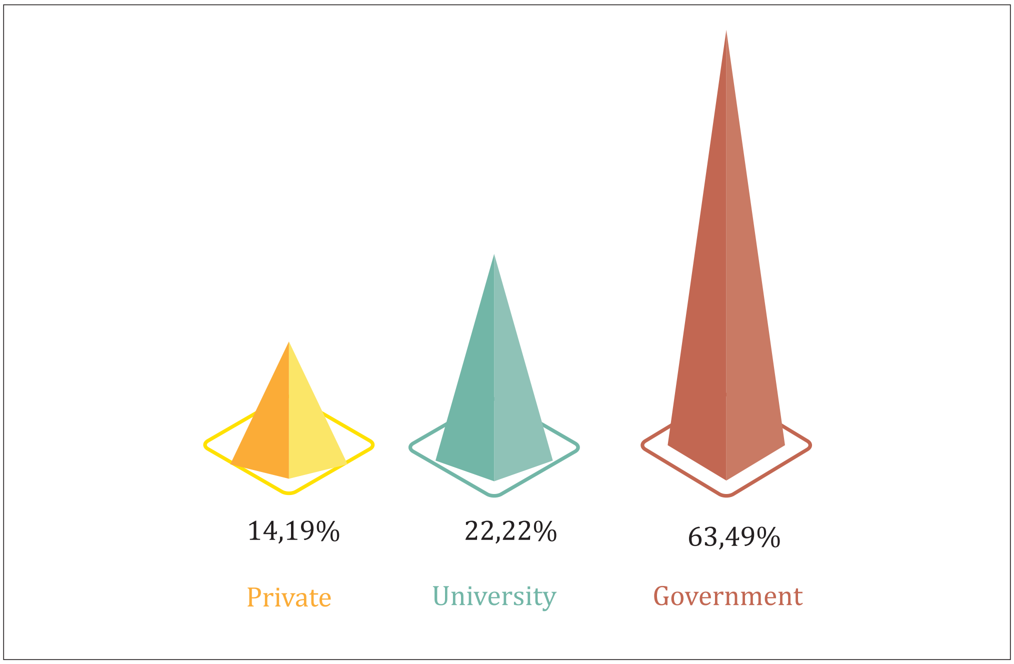
Figue 6.1 depicts the distribution of replies by OIC area. We have received 27, 30, and 8 responses from OIC Arab Group, OIC Asia Group, and OIC Africa Group, respectively. Countries with the highest number of responses include Türkiye, Jordan, Azerbaijan, Palestine, and Bangladesh.

Figure 6.1: Distribution of Responses by OIC Regions



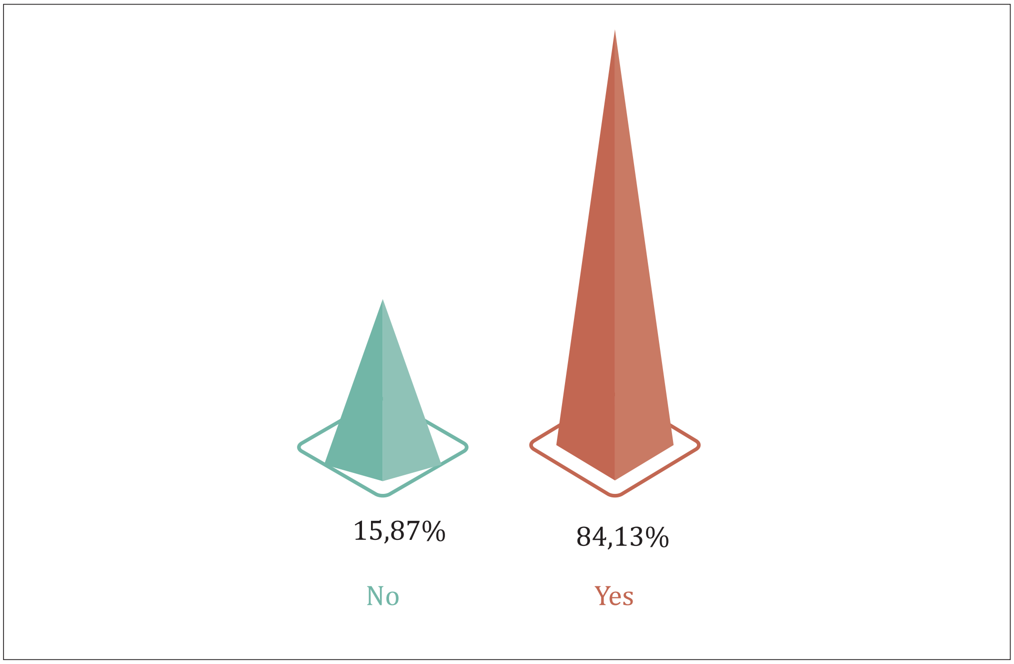
The questionnaire participants were also asked about their affiliation as a descriptive question. Figure 6.2 reveals that the majority of the respondents are from the government, which is followed by the university and private sector.

Figure 6.2: The Distribution of The Questionnaire Participants in Terms of Their Affiliation



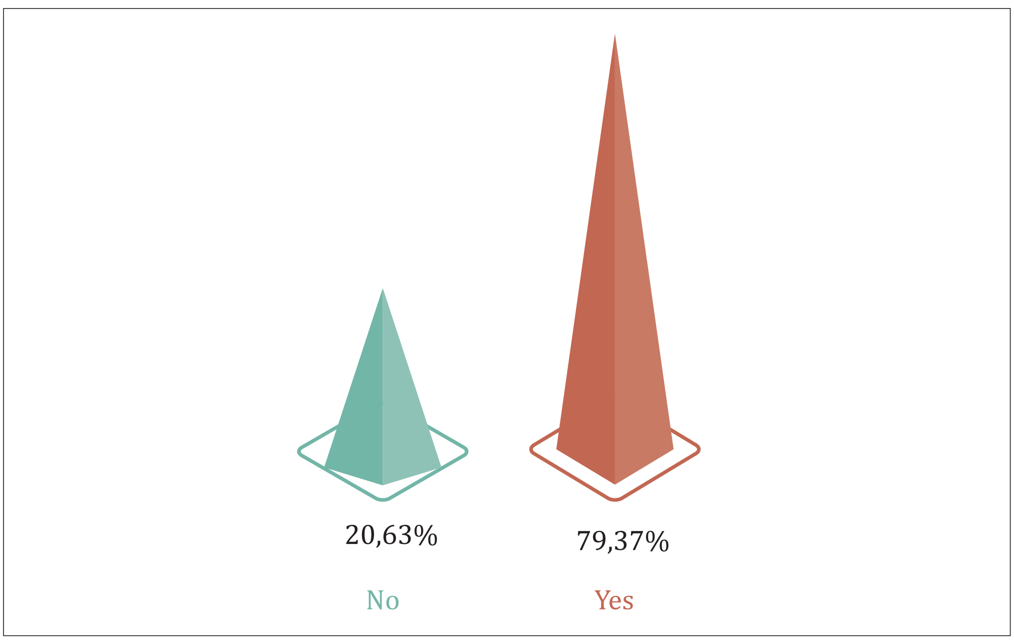
Following the descriptive questions, the subsequent section of the questionnaire centers on project appraisal methods in OIC countries. Initially, participants were inquired whether project appraisals for transportation infrastructure projects in their nations were mandatory. Fgure 6.4 presents the distribution of the responses. 53 out of 67 respondents (84.13%) marked that the preparation of project appraisal is mandatory for transport infrastructure projects.

Figure 6.3: Project Appraisal for Transport Infrastructure Projects Being Mandatory



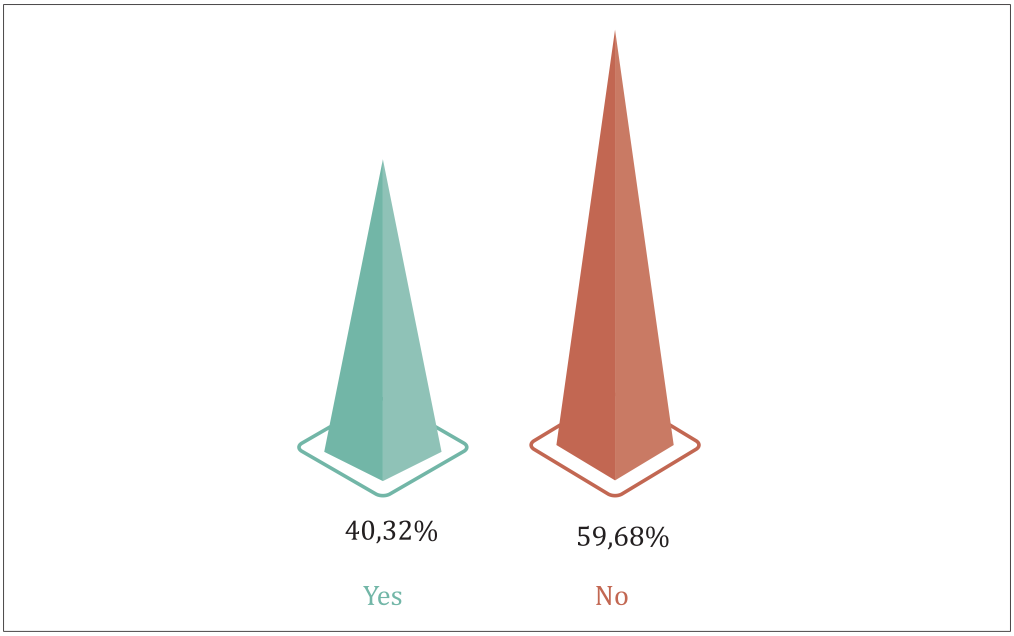
The next question in the survey asks whether environmental costs/benefits are included in the evaluation phases of transport infrastructure projects. Figure 6.4, which shows the relevant distribution of responses, indicates that 50 (79.37%) of the 67 participants emphasized that tenvironmental costs/benefits were included in the evaluation stages.

Figure 6.4: Inclusion of Environmental Costs/Benefits in Project Evaluation Phases



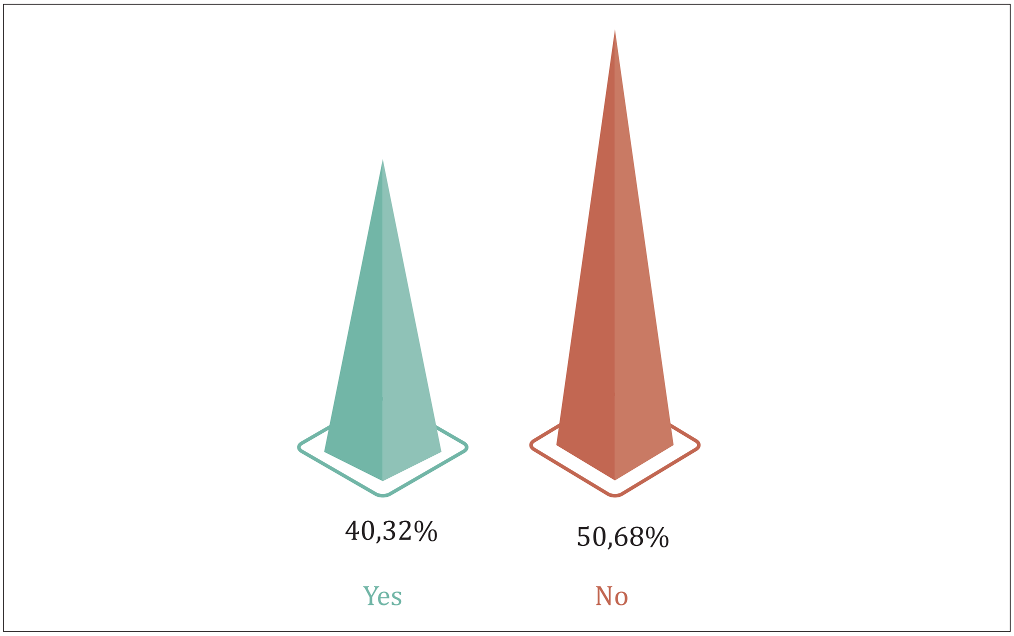
The next question is whether environmental impacts are monetized in project evaluations. The distribution of responses is shown in Figure 6.5. Nearly half of the respondents (50.82%) stated that environmental impacts were monetzed in their project evaluations no monetized.

Figure 6.5: Monetization of Environmental Impacts in Project Evaluations



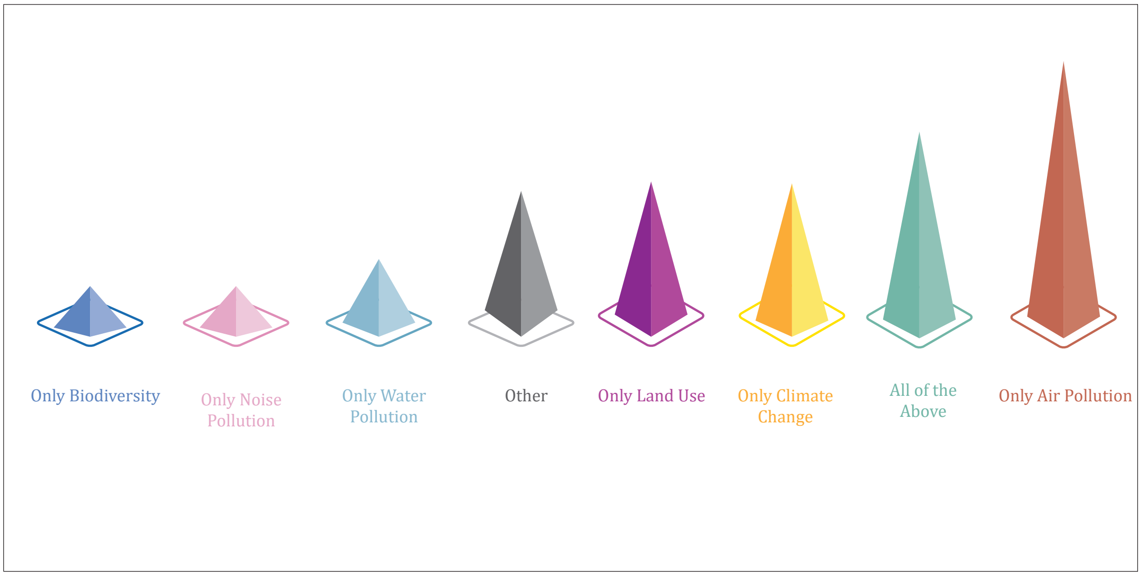
The methods used for evaluating environmental implications are critical. These approaches guarantee that all potential negative environmental consequences of a planned activity are identified ahead of time and that essential measures are implemented without impeding economic and social progress. The application of frameworks such as SEA, EIA, ESMF, EMP, and SUMP in this approach is equally critical for transportation infrastructures. Figure 6.6 shows the degree of adoption of such methodologies to measure the environmental impacts of transportation infrastructures. 49,21% of the participants stated that exemplary and similar methodologies were used. The respective responses suggest that EIA is the most widely used method among others.

Figure 6.6: Use of Specific Methodologies in Measuring the Environmental Impacts of Transport Infrastructures



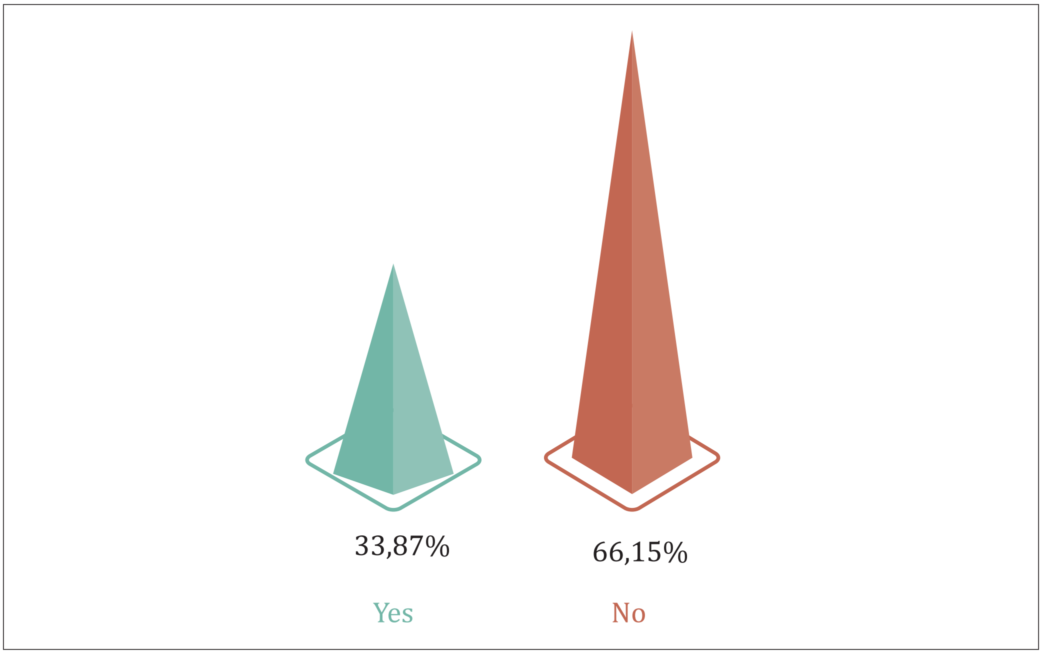
In another question, the survey participants were asked which environmental impacts were considered when assessing the effects of transportation infrastructures. Responses reveal that air and noise pollutions are the two most frequenly considered environmental impacts (Figure 6.7).

Figure 6.7: Environmental Issues Considered When Assessing the Impacts of Transportation Infrastructures



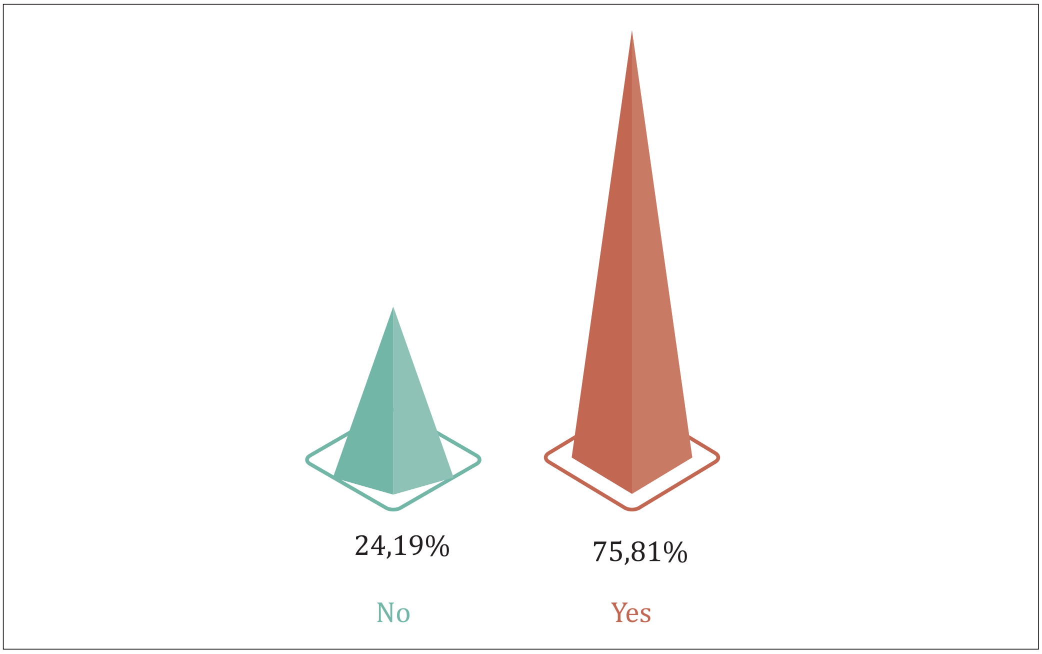
It is very important to analyse the consequences and alternative solutions of the permanent or temporary potential effects of new projects and developments on the environment. In the other question asked in this context, 41 of the survey participants stated that the environmental impacts of transport infrastructure projects during the construction phase were not measured (Figure 6.8).

Figure 6.8: Measuring the Environmental Impacts of Transportation Infrastructure Projects During the Construction Period



In the next question, it was aimed to determine whether the environmental impacts of transportation infrastructure projects were measured during the operation phase. 75.81% of the survey participants stated that environmental impacts were measured during the operation phase (Figure 6.9).

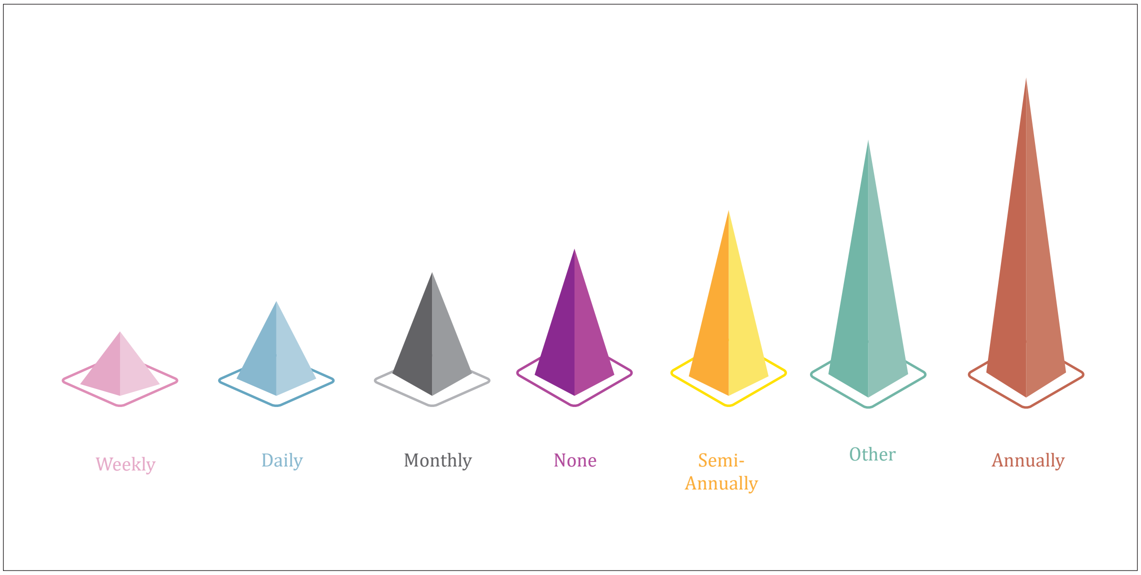
Figure 6.9: Measuring the Environmental Impacts of Transportation Infrastructure Projects During the Operation Phase



The following are the responses to another question posed to participants in order to evaluate how frequently environmental consequences are measured (Figure 6.10):

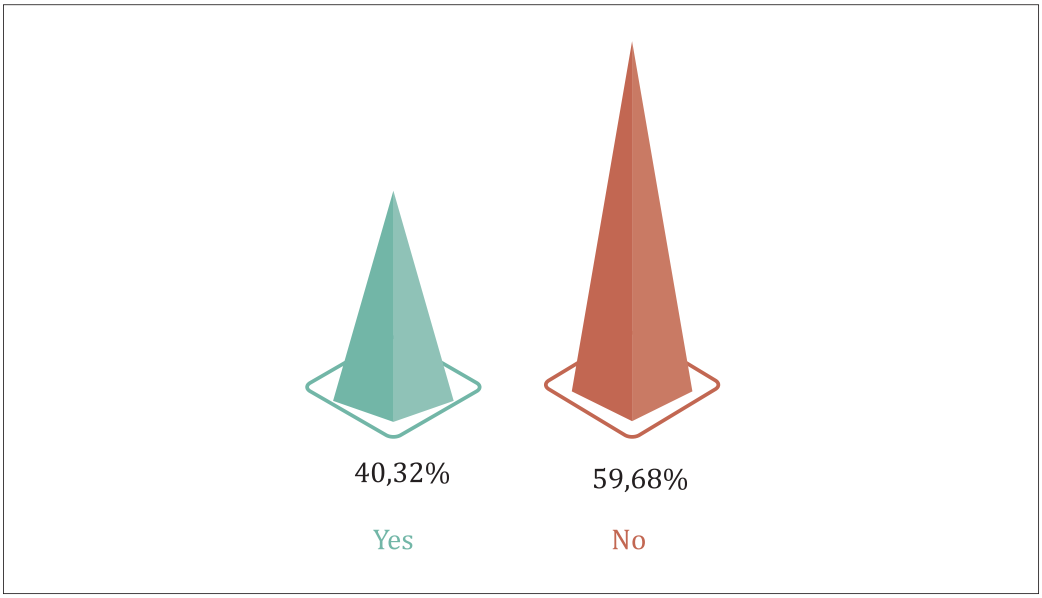
- Annually: 15 - 27.27%
- Semi-annually: 8 - 14.55%
- Monthly: 6 - 10.91%
- Daily: 3 - 5.45%
- Weekly: 2 - 3.64%
- Other: It differs regarding the transport model, Depends on project, Randomly observation, Depending on risk, According to the project, According the case, According to what specified in the environmental study, At the initiation of the project, Quarterly, At the EIA only, At the ESIA only, Per project term, Some project daily, some project weekly
- None: 7

Figure 6.10:Frequency of Measurement of Environmental Impacts



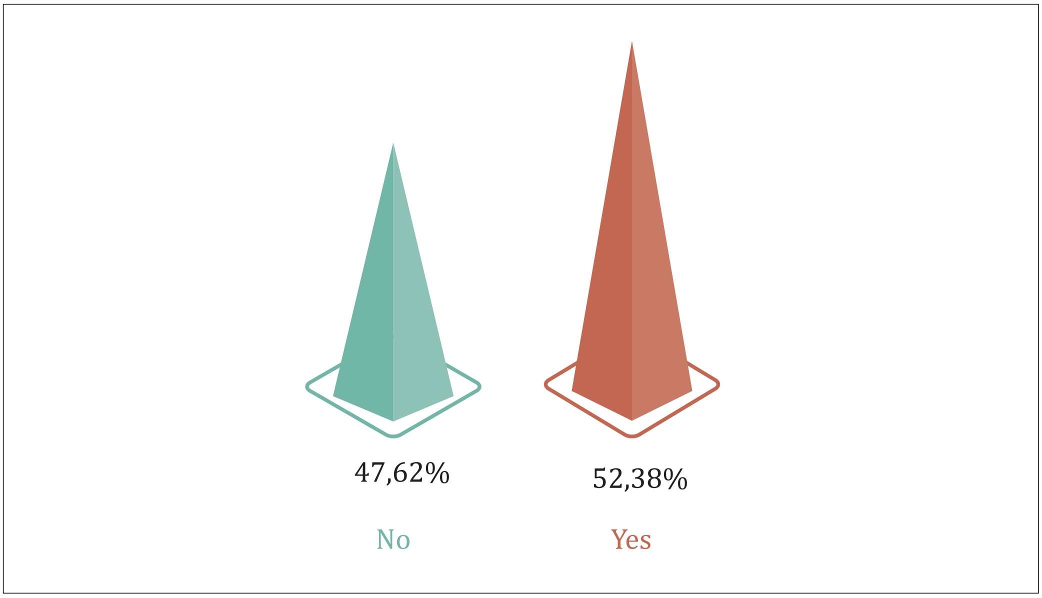
In the following question, the availability of standardized indicators or measures to measure environmental impacts are asked. 28 survey respondents indicated that standardized metrics existed, whereas 26 stated that they did not (Figure 6.11).

Figure 6.11: Existence of Standardized Measures for Measurement of Environmental Impacts



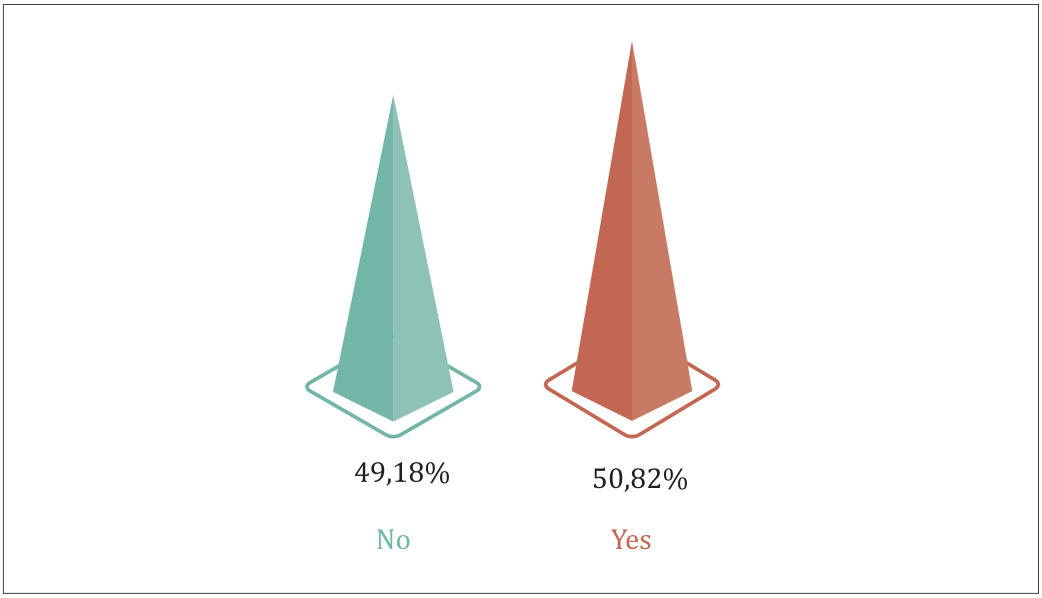
The following question of the survey aimed at determining the availability of a long-term plan/strategy for the measurement and monitoring of the environmental impacts of transportation infrastructure projects. The distribution of responses indicates that around 52% of the particiapnts stated that there was no such a plan/strategy (Figure 6.12).

Figure 6.12: The Availabilty of Long-Term Plans/Strategies to for the Measurement and Monitoring of Environmental Impacts of Transportation Infrastructure Projects



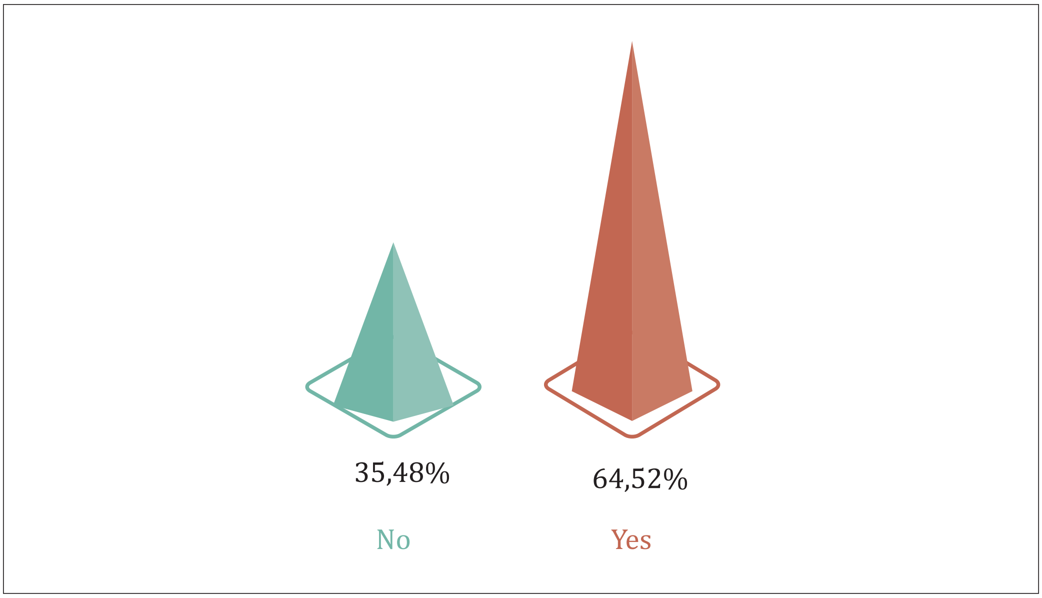
One important aspect of the measurement of environmental impacts is the public involvement (stakeholders affected) regarding the evaluation of such impacts. To focus on this issue, respondents were asked about the availability of such mechanisms/processes to receive public input and feedback on environmental concerns regarding transport infrastructures. The results depicted in Figure 6.13 imply that 30 individuals (out of 61) stated that such a system existed in their country.

Figure 6.13: Availablity of a Mechanism to Receive Public Perceptions on Environmental Concerns Related to Transportation Infrastructures



The next question asked participants if they had received financing from international finance institutions (IFIs) for transportation infrastructure projects in their country. In the next question, respondents were asked whether they had received financing from international financial institutions (IFI) for transport infrastructure projects in their country. 64.52% of the participants stated that their country received financial support from international financial institutions for transportation infrastructure projects (Figure 6.14). The participants noted that the IFIs requested from their institutions documentation such as EIA Regulations, EIA Procedures and Guidelines, ESIA studies, ESMF, ESMP, Stakeholder Engagement Plans, Labour Management Procedures, and Environmental and Social Safeguards Framework policy plans regarding the environmental impacts.

Figure 6.14: Financial Support from International Financial Institutions in Transportation Infrastructure Projects

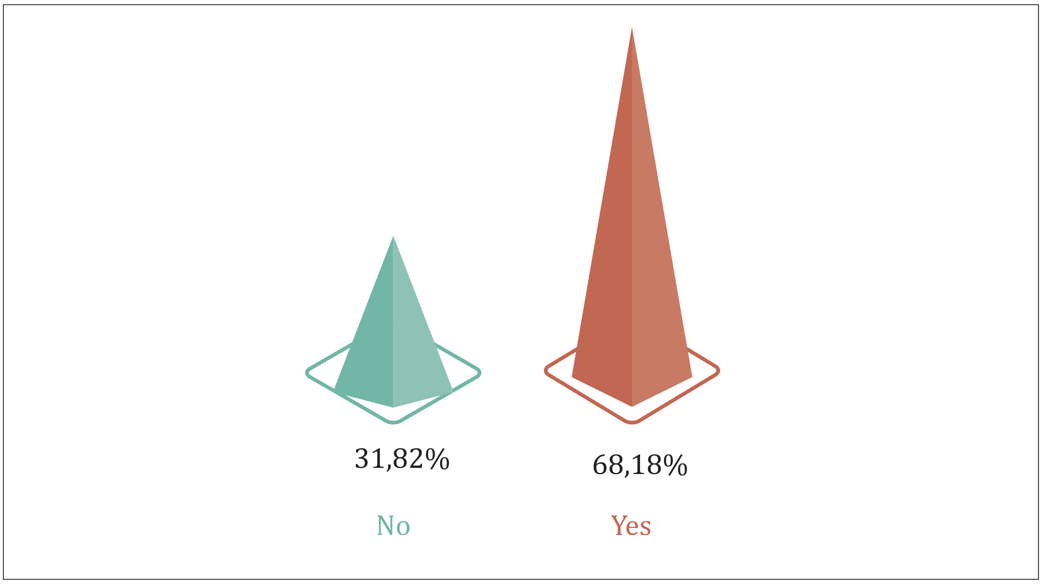


The question of whether there are any legislative or policy gaps preventing the effective measurement and mitigation of environmental impacts was also directed to the survey population. The findings suggest that there is a legislative or regulatory gaps that prevent the measurement and mitigation of environmental effects of transport infrastructure projects (Figure 6.15). The survey participants also pointed out that the following emerging thechnologies and innovative practices can improve the measurement and mitigation of such impacts:

- The use of GIS and Remote Sensing technologies
- Smart environmental monitoring system
- Advance GIS and drone technology
- Shifting to e-Mobility in Public Transport

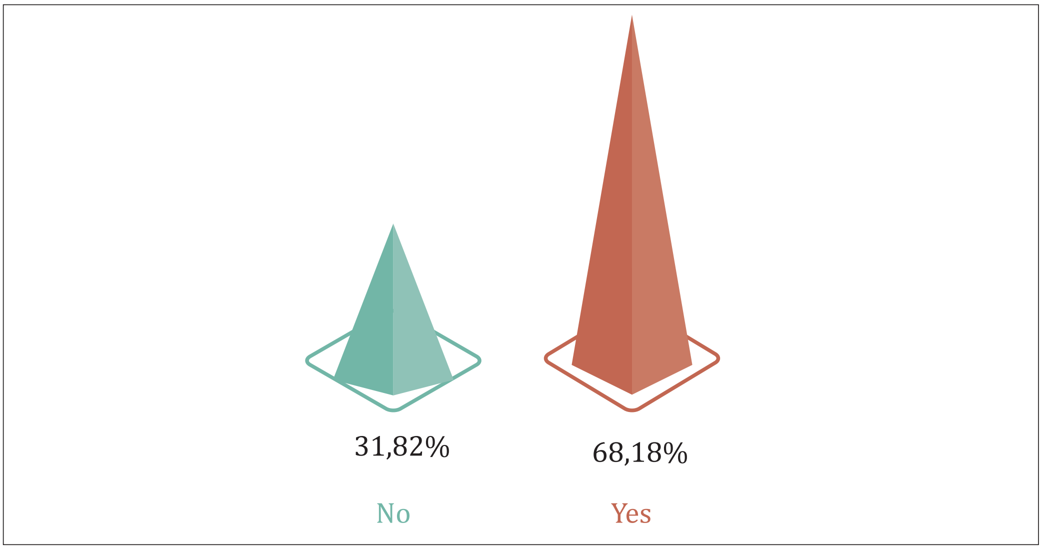
- Air quality/noise pollution monitoring equipment online real-time

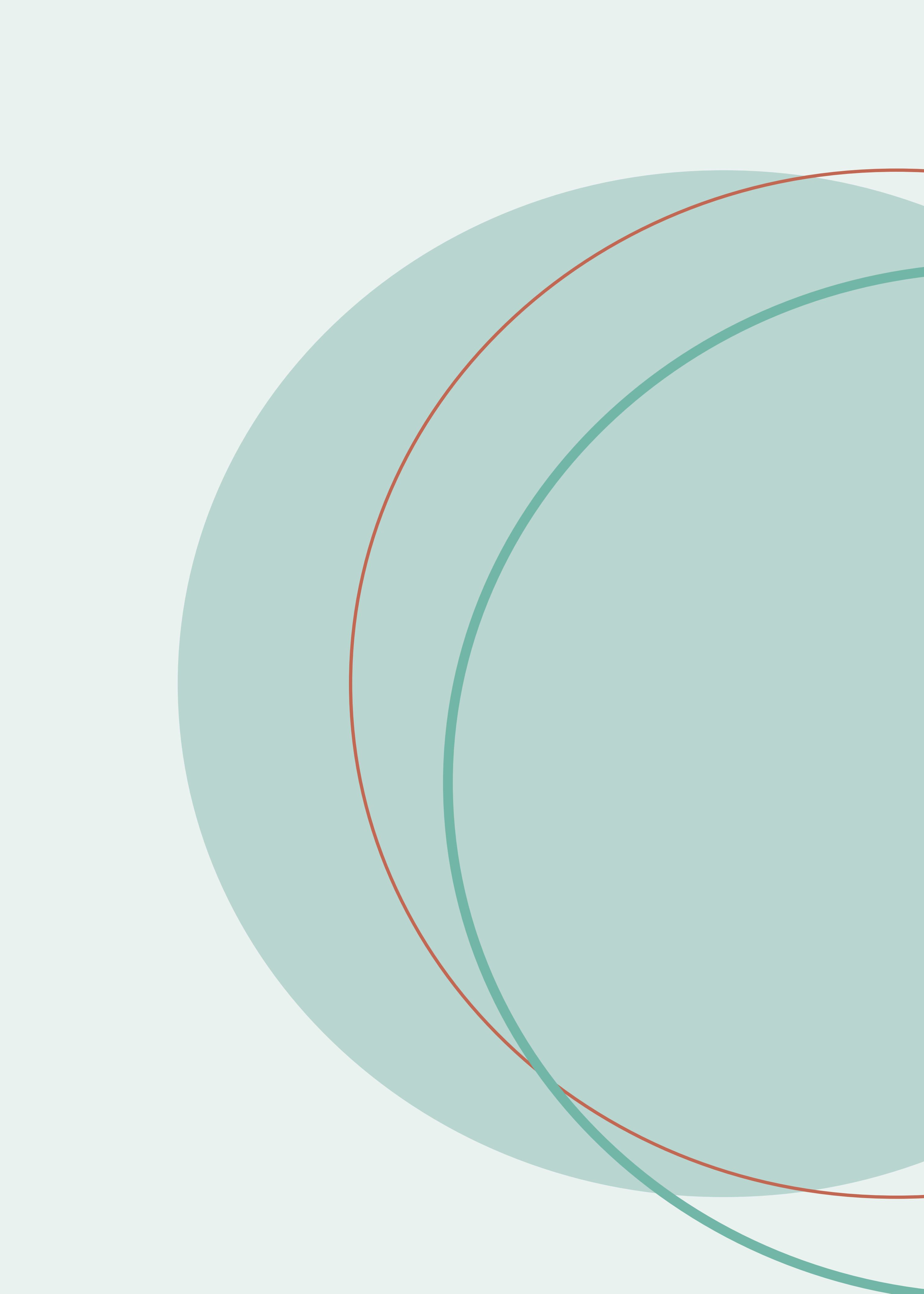
Figure 6.15: Existence of Legislative or Policy Gaps That Prevent Effective Measurement and Mitigation of Environmental Impacts of Transport Infrastructure Projects



In response to the last question of the survey, around 68% of the participants underlined that they evaluated the transport modes based on their environmental effects and that studies were conducted for the use of low-emission alternatives in new investments (Figure 6.16).

Figure 6.16: Evaluation of Modes According to Environmental Impacts and Use of Low Emission Alternatives in New Investments





CHAPTER 7

7. Measuring the Environmental Impacts of Transport Infrastructures

7.1. Fundamental Principles and Process Management

This section guides managing environmental impacts within transportation infrastructure investments and operations. The fundamental principles for assessing environmental impacts entail anticipating the potential environmental consequences of these investments/operations and determining mitigation strategies for addressing these impacts. Furthermore, this strategy introduces the essential concept of EIA and provides a concise overview of its key components, highlighting its significant role in evaluating the environmental implications of transportation infrastructure projects. It emphasizes its relevance, especially within OIC Member States (Walker, et al., 2019).

To ascertain environmental consequences accurately, it is essential to concentrate on key environmental factors. A best practice example involves the relevant decision-makers and stakeholders identifying environmental elements and integrating them into other planned investment/operation processes. Employing the correct methodologies is important for minimizing and eliminating the effects arising from the identified environmental factors, and the impact assessed using these methods should be documented (Naganathan & Chong, 2017).

Establishing a correct environmental management strategy requires having sufficient knowledge about the interactions among natural systems within the impact area of the investment projects and operations. This section outlines the steps to be taken, which are mentioned in Table 7-1. When viewed from the environmental management system approach of continuous improvement, the steps involve planning, doing, controlling, and acting.

Another issue to consider is the various phases of investment projects. Initially, it progresses with pre-feasibility and design processes in the planning phase. Subsequently, the feasibility study, economic and technical survey follows, leading to project evaluation and critical investment decisions. Finally, it continues with the process of implementing the plan. Simultaneously, the impact process requires to be examined.

The planning phase starts with preliminary measurements, followed by measurement and overall impact assessment. A report is prepared based on these findings, and monitoring is carried out to check that compliance is achieved. In projects created from scratch with an ecosystem approach, it is easily possible to monitor the effects on the environment (Teles & Sousa, 2014).

Table 7-1: Fundamental Impact Assessment Steps

Environmental Management System Approach for continuous improvement	Investment Project Phases	Impact Assessment Steps
Plan	Pre-feasibility/Design	Pre-Measurement/Baseline Studies
Do	Feasibility/ Economical & Technical Surveys	Measuring & Evaluating Impacts
Check	Project Assessment/ Investment Decision	Reporting Impacts
Action	Implementation	Compliance Monitoring

Transportation infrastructure serves as the foundation of modern societies, facilitating connectivity and driving economic growth. However, this advancement often comes at a cost to the environment. Acknowledging this reality, it is imperative to effectively manage the environmental impacts of transportation investments and operations. This approach is guided by key principles: anticipation, mitigation, the application of EIA, stakeholder engagement, employment of accurate methodologies, and understanding of natural systems and interactions. These principles form the basis of responsible environmental management in transportation (Fischer, 2023).

Anticipation stands as the initial step in this journey, wherein stakeholders assess potential environmental consequences comprehensively. This assessment is vital for understanding the scope and magnitude of potential impacts that a project might entail. By identifying these challenges proactively, stakeholders can prepare to address them with well-informed strategies. Mitigation lies at the core of responsible environmental management. After identifying potential consequences, it is imperative to formulate effective mitigation strategies. These strategies are designed to minimize or eliminate adverse environmental effects, ensuring that the project's environmental footprint remains as minimal as possible. Projects can proceed by integrating these strategies early on while minimizing their ecological impact (Holmatov & Hoekstra, 2020).

EIA is a systematic evaluation of the potential environmental impacts of a project, employing a multidisciplinary approach that examines factors such as air and water quality, noise levels, and ecological balance. This comprehensive assessment aids decision-makers in comprehending the full spectrum of environmental implications associated with a project and in identifying measures to mitigate these impacts. Engaging stakeholders enriches the environmental impact assessment process. This collaborative approach ensures that various perspectives, from local communities to decision-makers, are thoughtfully considered. Engaging stakeholders fosters a sense of ownership and responsibility for the project's environmental impact, promotes transparency, and builds public trust (Waheed, et al., 2018).

Applying correct assessment techniques is essential for understanding the severity of potential consequences. Implementing effective mitigation measures addressing identified environmental factors is equally vital, minimizing adverse effects. Employing proven methods empowers stakeholders to move forward confidently with their projects. Understanding the intricate interactions of projects with natural systems is fundamental. Comprehending the components that constitute the environment and the complex relationships between them enables stakeholders to develop strategies that support and enhance local ecosystems (Ong, Mahlia, & Masjuki, 2011).

In conclusion, effective environmental impact management in transportation infrastructure projects and operations demands a multifaceted approach guided by anticipation, mitigation, EIA, stakeholder engagement, accurate methodologies, and an understanding of natural systems and interactions. These principles form a comprehensive framework for responsible environmental management in transportation, ensuring that progress aligns harmoniously with the planet's well-being.

7.2. Legal and Administrative Arrangement

Effective environmental impact measurement and assessment is integral to responsible transportation infrastructure development. Several critical steps must be taken to ensure that the EIA process functions smoothly and adheres to legal and administrative requirements. These steps consist of these main topics: legislative framework analysis, environmental authorities' identification, setting out of the details of permitting procedures, and examination of transboundary considerations. A well-defined legislative framework lies at the foundation of a robust EIA process for transportation projects. This includes a detailed catalogue of legal statutes and regulations, both at the national and regional levels, that govern EIA processes. These legal frameworks specify the obligations and responsibilities of stakeholders involved in transportation projects and provide a clear roadmap for conducting EIAs. Transparency and adherence to these legal mandates are essential for sustainable transportation development (Gharehbaghi, Hosseinian-Far, & Hilletofth, 2022).

Identifying the relevant environmental authorities, which are government bodies or agencies responsible for enforcing EIA regulations, overseeing compliance, and ensuring that transportation projects align with environmental and sustainability goals, is a priority in maintaining accountability and promoting best practices in project execution. Effective collaboration between these authorities and project stakeholders is vital for the success of the EIA process (Jeon & Amekudzi, 2005).

Understanding and clearly outlining the permitting procedures is fundamental to EIA's success. This involves comprehensively detailing the application processes for permits related to transportation infrastructure projects. These procedures should be transparent, efficient, and accessible to all stakeholders. Furthermore, the prerequisites and conditions for obtaining project approvals must be well-defined. Clarity in permitting not only ensures compliance with environmental regulations but also facilitates responsible project planning and execution (Abdi & Daudén, 2021).

Transportation infrastructure projects often have impacts that extend beyond national borders. Therefore, it is essential to consider and address these transboundary impacts through legal agreements or mechanisms. These agreements should outline the procedures for evaluating and mitigating cross-border environmental effects. Cooperation with neighbouring countries is critical to maintaining harmonious relations and ensuring that the environmental consequences of transportation projects are appropriately managed (Baustert, et al., 2019).

In conclusion, the legal and administrative arrangement for EIA in transportation infrastructure projects is a multifaceted process. It involves establishing a robust legislative framework, identifying and engaging with environmental authorities, streamlining permitting procedures, and addressing transboundary considerations. These steps contribute to responsible, sustainable, and environmentally sound transportation development.

7.3. Roles and Responsibilities of Various Parties

The success of any transport infrastructure project depends on a clear definition of roles and responsibilities among key stakeholders. To ensure that EIA is effective in such projects, various parties play crucial roles, each with different tasks. These roles and responsibilities have significance at all levels, but the role of the party that wants the project to happen is primarily prominent. The regulatory authorities follow this with the decision-making power to authorize the project legally. In addition, the employees of the consulting firm that contributed to the creation of the project and the experts who were assisted. The local community of the region where the project is located is also very important in terms of social acceptance. The process continues with the approaches of the decision-making authorities and ultimately have been decisive in determining the roles and responsibilities in monitoring and implementation.

Project proponents are the entities responsible for initiating and proposing transportation projects. Their roles encompass not only envisioning and planning these projects but also conducting comprehensive EIAs. They are obliged to engage environmental consultants, gather baseline data, assess potential impacts, and formulate effective mitigation strategies. Furthermore, project proponents should ensure that all EIA procedures are meticulously followed during project implementation (Samberg, Bassok, & Holman, 2011).

Regulatory authorities hold the responsibility of overseeing the EIA process for transportation projects. This includes evaluating EIA reports submitted by project proponents, granting the necessary permits, and enforcing environmental regulations. These authorities serve as gatekeepers, ensuring that projects adhere to established environmental standards and pose minimal adverse effects. They must have the expertise to scrutinize EIA findings and make informed decisions based on their assessments (Steinemann, 2001).

Environmental consultants and experts contribute their specialized knowledge to the EIA process. Their roles encompass conducting thorough impact assessments, providing insights into potential environmental consequences, and offering expertise in specific domains. These professionals assist project proponents and regulatory authorities in understanding the complexities of environmental impact and devising effective mitigation strategies. Their input is invaluable in crafting well-informed and environmentally responsible transportation projects (Soria-Lara, et al., 2020).

Public participation is critical to EIA, ensuring that local concerns and perspectives are considered. Communities, non-governmental organizations (NGOs), and various stakeholders play essential. They offer valuable insights, highlighting potential environmental risks and advocating for sustainable practices. Their involvement fosters transparency and accountability, creating a sense of shared responsibility for the project's environmental impact (Nadeem & Fischer, 2011).

Government officials and policymakers hold decision-making roles in the EIA process. They are tasked with reviewing EIA findings, considering potential trade-offs, and making informed decisions regarding project approval or modification. These decision-makers must weigh the project's benefits against its environmental impact and align their choices with broader sustainability goals (Zhu & Ru, 2008).

An ongoing responsibility is ensuring that transportation projects adhere to the planned mitigation measures and minimize environmental harm. All involved parties, including project proponents, regulatory authorities, and environmental consultants, share in monitoring actual impacts. This includes assessing whether mitigation measures are effectively implemented and, if necessary, taking corrective actions to rectify unforeseen environmental consequences (Hands & Hudson, 2006).

In the context of OIC member countries, these roles and responsibilities are the turning point for achieving sustainable transportation infrastructure development. Comprehensive guidance, including explanatory text, diagrams, flowcharts, case studies, and relevant data tables, can be added to provide a well-structured guidebook on measuring the environmental impact of transport infrastructures. Clear delineation of these roles ensures that transportation projects align with environmental objectives and promote sustainability.

7.4. Types of Transport Infrastructure and Their Environmental Impacts

This section offers a comprehensive overview of the various environmental impacts that arise from transport infrastructure and services. It explores the methods and parameters used to assess these impacts, providing policymakers, researchers, and practitioners with valuable insights to make informed decisions and develop strategies that promote environmentally responsible transportation practices.

7.4.1 Air Transport Infrastructure

The significance of air transport infrastructure goes beyond regional connectivity, economic growth and global mobility. However, it is essential to recognize and address the environmental issues associated with air transport, encompassing both airports and aircraft operations. By comprehending these environmental issues and employing effective assessment techniques, stakeholders can steer the aviation sector toward sustainable practices.

This section delves into key concepts to provide a comprehensive understanding of the environmental impacts and assessment methods relevant to air transport infrastructure. Its aim is to equip individuals involved in the evaluation and management of environmental impacts in the realm of transport infrastructures with the necessary knowledge and tools. Through a systematic exploration of these concepts, this section offers valuable insights for promoting sustainable practices within the aviation sector.

Air Pollution from Airports and Aircraft Emissions: To promote sustainable and environmentally sound practices in the aviation sector, it is critical to understand and address the issue of air pollution from airport and aircraft emissions (Masiol & Harrison, 2014). Air transport infrastructure, including airports and aircraft, is associated with various types and sources of emissions. These emissions include NOx, VOCs, PM, and SOx. The sources of emissions are diverse and include aircraft engines, ground support equipment, and airport infrastructure (Tang & Zhang, 2018) . To quantify air pollution from airports and aircraft, several assessment methods are utilized. These methods encompass measurement techniques and monitoring systems to assess emissions from aircraft and airport operations. Air quality modelling and dispersion modelling approaches are implemented to estimate the spread and concentration of pollutants. Additionally, the collection and analysis of air samples near airports are conducted to measure pollutant levels accurately (Kurniawan & Khardi, 2011).

The impacts of air pollution from airports and aircraft may lead to reduced local ambient air quality in the vicinity of airports. Nearby communities may experience adverse health effects due to elevated levels of pollutants (Schlenker & Walker, 2016). Environmental justice considerations also arise from disproportionate exposure to air pollution, impacting certain communities more severely (Maantay, 2007) .

Efforts to mitigate these environmental impacts involve technological advancements and improvements in aircraft engines to minimize emissions (Ranasinghe, Guan, Gardi, & Sabatini, 2019). Additionally, the R&D of cleaner fuels and alternative energy sources is explored as a means of reducing the environmental footprint of aviation. Operational measures, such as optimizing flight routes, reducing taxiing time, and minimizing aircraft idling, are also implemented (Evertse & Visser, 2017). Upgrades in airside and landside infrastructure support sustainable and energy-efficient operations.

Regulatory frameworks and standards govern emissions from aviation, ensuring compliance and accountability. International agreements and organizations, such as the International Civil Aviation Organization (ICAO), actively work towards reducing aviation-related air pollution on a global scale (Lyle, 2018). Moreover, national and regional policies and initiatives are developed to improve air quality around airports, fostering sustainability and environmental stewardship.

Noise Pollution from Airports and Aircraft Operations: The effects of aircraft noise on nearby communities and human well-being are substantial. Managing noise emissions effectively is essential for promoting sustainable and community-friendly aviation practices. Noise pollution in airport environments stems from multiple sources and is influenced by various factors. These sources include aircraft engines, ground operations, and airport infrastructure (Ozkurt, Sari, Kutukoglu, & Gurarslan, 2014). Factors such as aircraft types, flight patterns, and operational procedures also contribute to noise levels. Additionally, the design and layout of airports play a role in noise dispersion and the potential for mitigation (Postorino & Mantecchini, 2016).

Various methods, including sound level meters and noise dosimeters, are used to measure and quantify noise levels (Sittig, Nesbitt, Krageschmidt, Sobczak, & Johnson, 2011). Standardized metrics such as weighted decibels (dBA) and community annoyance indices help in asses noise levels and community reactions (More, 2010). Compliance with noise regulations and guidelines set by regulatory authorities is essential to ensure adherence to acceptable noise limits.

Technological advancements and engineering solutions, such as quieter engines and aerodynamic modifications, aim to minimize noise emissions (Hall & Crichton, 2007). Ground-based measures like noise barriers, sound insulation, and land-use planning considerations also contribute to noise reduction. Operational strategies, including flight route optimization and night-time restrictions, help to minimize noise impacts (Zachary, Gervais, & Leopold, 2010).

Addressing aircraft noise impacts requires community engagement and the implementation of relevant policies. Involving communities in decision-making processes related to noise management is vital to ensure their concerns are considered. Collaborative approaches involving airports, airlines, and local residents help to address noise concerns effectively. National and international policies, regulations, and guidelines are established to reduce aircraft noise and protect affected communities (Netjasov, 2012).

By understanding the sources and factors influencing noise pollution, assessing its impacts, implementing measurement techniques and standards, applying mitigation measures and technologies, and engaging communities while adhering to relevant policies, airports and aviation stakeholders can work towards reducing noise pollution and fostering harmonious relationships with surrounding communities.

Climate Change Impacts of Aviation and GHG Emissions: Aviation plays a significant role in global GHG emissions, making it imperative to address its impact on climate change (Gossling & Upham, 2012). Understanding and mitigating the climate change impacts of aviation are fundamental for promoting sustainability and low-carbon practices within the industry. Aviation contributes to GHG emissions through the release of CO_2, N_2O, and water vapor. Quantifying aviation's share of global GHG emissions and understanding its growth trajectory is important (Gossling & Upham, 2012). Comparisons with emissions from other sectors provide insight into the relative importance of aviation in climate change mitigation efforts.

Climate change affects weather patterns and atmospheric conditions relevant to air travel. Understanding the impacts of climate change on weather systems and their influence on flight operations, airport infrastructure, and flight safety is utmost importance. Adapting aviation practices to mitigate climate-related risks and challenges is necessary for maintaining safe and efficient air travel (David & Giordano-Spring, 2021).

Sustainable Aviation Fuels (SAF) have the potential to reduce GHG emissions. Ongoing technological advancements and research efforts aim to develop and implement SAF (Chiaramonti, 2019). Additionally, exploring alternative propulsion systems and energy sources in aviation contributes to carbon emissions reduction. Operational measures, including improved air traffic management and flight planning, optimize fuel efficiency and help in reducing emissions (Ryerson, Hansen, & Bonn, 2011) .

Mitigating aviation's climate impact involves policy frameworks and international initiatives. Agreements such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) focus on reducing aviation emissions (ICAO, 2020). National and regional policies, regulations, and incentives support carbon reduction in aviation. Market-based measures and carbon pricing mechanisms play a role in addressing aviation's climate impact. Collaborative efforts between stakeholders, including airlines, airports, and regulators, are essential for achieving emission reduction targets.

By considering the contribution of aviation to global GHG emissions and climate change effects on air travel; implementing the assessment methods for quantifying aviation's carbon footprint, exploring sustainable aviation fuels and emission reduction strategies, and implementing policy frameworks and international initiatives, the aviation industry can work towards reducing its climate impact and promoting a more sustainable future.

Methods for Assessing Air Quality and Pollutant Dispersion Near Airports: Assessing air quality and understanding the dispersion of pollutants near airports is essential for evaluating the potential impacts on local communities and developing effective mitigation strategies. Monitoring techniques for assessing air quality in airport vicinities involve the selection of appropriate monitoring sites and strategically placing air quality monitoring stations (Vardoulakis, Gonzalez-Flesca, Fisher, & Pericleous, 2005). Various measurement parameters and instruments are utilized to monitor air pollutants, including gases and particulate matter. Considerations are made between continuous monitoring systems and periodic sampling approaches. Rigorous data collection and quality assurance methods ensure accurate and reliable air quality measurements (Liu, Li, & Li, 2016).

Dispersion modelling plays a significant role in evaluating the spread of pollutants from airports (Popescu, Ionel, & Talianu, 2011). Atmospheric dispersion models are employed to simulate the transport and dispersion of pollutants from airport sources. These models require input data such as emission rates, meteorological conditions, and land-use information. The outputs of these models provide interpretations, and analyses of pollutant concentrations in various receptor locations (Jerrett, et al., 2005). Validation of dispersion models is carried out through comparison with field measurements to ensure their accuracy. Commonly monitored pollutants near airports include NOx, VOCs, and PM (Ionel, et al., 2011). Air quality indices and standards are used to assess and communicate air pollution levels to the public.

The impacts of airport emissions on surrounding communities involve the assessment of potential health effects associated with exposure to pollutants emitted from airports. Spatial distribution of pollutant concentrations aids in identifying areas with higher exposure rates. Community perception surveys and participatory approaches are applied to assess the impact of airport emissions on residents' well-being (Andersson, Nässén, Larsson, & Holmberg, 2014). Site-specific considerations and challenges in assessing air quality near airports are considered as best practices for conducting air quality assessments in these areas (Yang, Gu, Zhang, & Zhang, 2019). Collaboration between airport authorities, regulatory agencies, and local communities is emphasized in monitoring and assessment efforts.

Evaluation of Noise Levels and Community Exposure to Aircraft Noise: Measuring aircraft noise levels involves the use of various techniques and equipment to quantify noise emissions (Zaporozhets, Attenborough, & Tokarev, 2011). Temporal factors considered in noise measurement include average noise levels, peak noise events, and night-time noise restrictions. Compliance monitoring is the common way in order to assess noise levels against regulatory limits and guidelines.

To assess community exposure to aircraft noise, noise contour modelling is utilized (Jarup, et al., 2005). Techniques like the Integrated Noise Model (INM) or the Aviation Environmental Design Tool (AEDT) are also employed for noise contour modelling (Kim, Lim, & Lee, 2018). Input parameters such as flight data, aircraft types, airport layout, and topography are used in these models. Noise contours provide visual representations of the spatial distribution of aircraft noise (Emir, Fiona, & Nico, 2023). Gathering information through community surveys and perception studies help assess community perceptions of aircraft noise, including annoyance levels, sleep disturbances, and other noise-related impacts on well-being.

To minimize community exposure to aircraft noise, effective land use planning and noise mitigation strategies are key items (Girvin, 2009). Noise zoning and land use planning principles are implemented to reduce noise impacts in sensitive areas. Physical measures like noise barriers and building insulation, are useful in mitigating noise effects. Additionally, aircraft operational measures, including flight procedures, curfews, and preferential runway use, are considered as noise abatement strategies. These strategies are considered during airport design, such as runway orientation, taxiway routing, and terminal location (Prats, Puig, & Quevedo, 2011).

Assessment of Carbon Footprint and Emissions Inventories for Aviation: Calculation methodologies for aviation emissions provide an overview of international guidelines and protocols such as the ICAO's carbon footprint methodology (Postorino & Mantecchini, 2014). Various factors influencing emission calculations are fuel consumption, aircraft type and age, operational efficiency, and cargo and passenger loads (Morrell, 2009). Conversion factors and emission factors are changeable for different fuel types and emission sources.

ICAO's CORSIA and other national and international reporting systems are applicable for emissions inventories in aviation (Strouhal, 2020). Monitoring, reporting, and verification requirements for airlines and other aviation stakeholders are outlined within the reporting systematics (Matthes, et al., 2022). Challenges and best practices in data collection and reporting for emissions inventories may be addressed along with the use of standardized reporting formats like the ICAO Carbon Emissions Calculator to facilitate consistent reporting (Prussi, Lee, Wang, Malina, & Valin, 2021).

Policy frameworks and international cooperation efforts are evolving with highlighted global agreements and initiatives targeting emissions reduction in aviation. National policies and regulations promote emissions reduction in aviation, including emission trading schemes and tax incentives, are discussed by policy makers (ICAO, 2020). Collaborative efforts among airlines, airports, manufacturers, and regulatory bodies to develop industry-wide emission reduction strategies are emphasized, showcasing the importance of cooperation in addressing aviation emissions (Chiaramonti, 2019).

7.4.2. Land Transport Infrastructures

Land transport infrastructures are important in facilitating the movement of people and goods, but also have significant environmental impacts that need to be carefully managed. This section focuses on the air pollution generated by road and rail traffic and the emissions from vehicles and explores the impacts, assessment methods, and potential mitigation strategies.

Air Pollution from Road Traffic and Vehicle Emissions: Road traffic and vehicle emissions have a significant impact on air pollution, leading to significant environmental and health concerns. Pollutants emitted from road traffic, including PM, NOx, CO, and VOCs causing wide range of impacts like smog formation, acid rain, and contribution to climate change (Hung-Lung, et al., 2007). Exposure to these pollutants can pose health risks such as respiratory problems, cardiovascular diseases, and increased mortality rates (Lee, Kim, & Lee, 2014) .

Factors influencing emission levels may vary according to vehicle-related factors such as fuel type, engine efficiency, emission control systems; the age of the vehicle fleet and traffic-related factors such as traffic volume, congestion, driving patterns, and road conditions.

To mitigate road traffic emissions, the promotion of clean and alternative fuel technologies is necessary. This can be achieved through the implementation of emission standards and regulations for vehicle manufacturers and the enforcement of fuel quality control. Additionally, traffic management strategies and urban planning approaches can prioritize sustainable transport modes, such as public transportation, cycling infrastructure, and pedestrian-friendly designs to reduce congestion and optimize traffic flow and improve air quality.

Noise Pollution from Roads and Railways: Road traffic noise generated by vehicles' engines, tire friction, aerodynamic effects and railway noise arise from train engines, wheels on tracks, braking systems are major sources of noise pollution (Asensio, et al., 2021).

The residents' exposure to noise from nearby roads affects their well-being and may cause sleep disturbance, stress, cardiovascular issues, and cognitive impairment. In addition to this, wildlife may also be affected by noise emissions; disruption of animal communication, habitat disturbance, and altered behaviour of animals may be observed (Kawada, 2011).

Sound level meters and noise dosimeters are used to measure noise levels accurately (The Institute of Noise Control Engineering of the USA, 2023). After measurement of sources, computer models and geographical information systems create noise maps, identify noise hotspots, and assess noise exposure in specific areas (Mishra, Kumar, Nair, & Shukla, 2021).

Traffic management measures such as speed limits, traffic calming techniques, and intelligent transportation systems to reduce noise from road traffic are some applicable noise mitigation strategies (Brink, Mathieu, & Rüttener, 2022). In construction phases of roads and railways, infrastructure design is supposed to consist noise reduction structures like noise barriers, low-noise pavement etc. Regulations and guidelines related to noise pollution covered in national and local regulations aim to limit noise levels from roads and railways.

Assessment of GHG Emissions from Road and Rail Networks: GHG emissions from road and rail networks contribute significantly to climate change, making their assessment and reduction crucial in mitigating environmental impacts. When GHG emissions from road transport are discussed, the main sources are defined as CO2, CH4, and N2O. Factors influencing GHG emissions explored as vehicle type, fuel efficiency, traffic congestion, and driving behaviour (Bharadwaj, Ballare, Rohit, & Chandel, 2017). Vehicle emission factors, fuel consumption data, and activity-based modelling, are important data for quantifying GHG emissions.

The sources of GHG emissions in rail transport listed as diesel locomotives, electric traction systems, and infrastructure-related emissions. Train speed, load capacity, electrification, and maintenance practices are the factors that affect emission levels. Methods for estimating GHG emissions from rail operations are considered as energy consumption, distance travelled, and infrastructure characteristics (Pritchard & Preston, 2018). The development of comprehensive emission inventories is used in data collection and estimation, gathering information on vehicle fleets, fuel consumption, traffic volume, and infrastructure characteristics. GHG emissions are accurately estimated by calculation methods, utilizing emission factors, emission models, and statistical data. Temporal and spatial considerations are accounted for variations in emission factors based on vehicle age, technology, driving cycles, and regional-specific factors.

Some mitigation strategies for reducing GHG emissions in road and rail networks are given below (Cochrane, Saxe, Roorda, & Shalaby, 2017);

- The adoption of low-emission and zero-emission vehicles
- Vehicle technology advancements
- Encouraging the use of cleaner fuels, including biofuels, H and CNG
- Promoting the use of rail and other sustainable transport modes, intermodal transportation

Infrastructure improvements, such as enhancing traffic management systems, optimizing routes, and improving road and rail network efficiency to minimize fuel consumption and emissions, are also discussed as mitigation strategies.

Methods for Evaluating Traffic Congestion and Its Environmental Effects: Traffic congestion is a significant issue in urban areas, leading to various environmental impacts and affecting the overall efficiency of transportation systems (Chin & Rahman, 2011).

Traffic flow measurement techniques include traffic volume counting methods such as manual counting, automated traffic counters, and video-based technologies (Toth, et al., 2013). The estimation of travel times and identification of congested areas using techniques like loop detectors, GPS devices, and Bluetooth technology are efficient ways in measuring vehicle speeds, traffic density, and lane occupancy to assess congestion levels.

Traffic congestion indicators are presented as the Level of Service (LOS) metrics such as the Highway Capacity Manual (HCM) guidelines (Zuniga-Garcia, Machemehl, & Ross, 2018). Congestion indices such as the Travel Time Index (TTI) and the Congestion Index (CI) are used to quantify the severity of congestion in specific areas or road segments (Aftabuzzaman, 2007).

The environmental effects of traffic congestion including its impact on air quality, fuel consumption, noise pollution, and the urban heat island effect may rise emissions of pollutants such as CO, NOx, and PM. Traffic simulation software are beneficiary for assessing traffic congestion and interactions between transportation systems, land use patterns, and travel behaviour (Hidas, 2005).

Mitigation strategies for alleviating traffic congestion and improving traffic flow are presented as traffic management measures such as signal optimization, intelligent transportation systems (ITS), and dynamic traffic assignment (Balakrishna, Koutsopoulos, & Ben-Akiva, 2005). The promotion of public transportation, cycling, and walking alternate private vehicle use to reduce traffic congestion and similarly associated environmental impacts.

Analysis of the Impacts of Road Construction and Maintenance Activities: During the construction phases of roads and highways, land disturbance and habitat fragmentation occur as a result of clearing land, excavation, and the fragmentation of natural habitats. Soil erosion and sedimentation are potential issues due to land grading, excavation, and inadequate erosion control measures. Discharge of construction-related pollutants, including sediment, construction materials, and chemicals, into water bodies poses risks to water quality. Noise and vibration generated by construction equipment can affect nearby communities and sensitive receptors. Additionally, the release of dust, particulate matter, and emissions from construction machinery and vehicles can impact local air quality.

In the operational phase, noise pollution from vehicles using the road can affect nearby residential areas and sensitive receptors. Air pollution from vehicle emissions, including CO, nitrogen oxides (NOx), and PM, is another concern. Road surfaces and drainage systems influence water runoff, flood risk, and water quality in surrounding areas. The effects of roads on wildlife populations, migration patterns, and habitat connectivity, such as roadkill, barrier effects, and fragmentation, should be evaluated. (Underhill & Angold, 1999) The visual intrusion of roads on the landscape and their impact on scenic views and cultural heritage sites should also be considered.

Assessment methods and tools for evaluating the environmental impacts of road construction and maintenance projects include Environmental Impact Assessment (EIA), Life Cycle Assessment (LCA), Geographic Information Systems (GIS), and monitoring and measurement techniques. EIA methodologies predict, evaluate, and mitigate environmental impacts, while LCA frameworks assess the overall environmental footprint of road infrastructure throughout its lifecycle. GIS tools analyse spatial data and model potential impacts, while monitoring and measurement techniques track noise levels, air quality, water quality, and soil erosion during and after construction (World Bank, 2023).

Mitigation measures and best practices for road construction and maintenance involve sustainable practices, such as using eco-friendly construction materials, implementing erosion control measures, and adopting techniques that minimize environmental impacts. Integrating ecological design principles, such as wildlife crossings, vegetation buffers, and habitat restoration, can mitigate negative effects on biodiversity. Sustainable maintenance practices include optimized schedules, efficient resource use, and proper disposal of waste. Stakeholder engagement and public consultation are crucial to involve local communities, environmental organizations, and relevant stakeholders in decision-making, planning, and implementation processes.

7.4.3. Maritime Transport Infrastructures

Maritime transport infrastructure, including ports, harbours, and shipping routes, is an important connection way for global trade and transportation. However, it is essential to recognize and address the environmental impacts associated with sea transport activities to ensure sustainable and responsible maritime practices. This section focuses on exploring the environmental impacts and assessment methods specific to maritime transport infrastructure.

Water Pollution from Shipping Activities and Port Operations: Shipping activities and port operations have the potential to lead to water pollution, posing risks to marine ecosystems and water quality. It is essential to understand and mitigate water pollution from these sources to promote sustainable maritime practices.

Ballast water management inevitably requires the most attention. Ballast water, which is taken on board by ships to maintain stability and balance, can pose environmental risks if discharged without proper treatment (Endresen, Behrens, & Brynestad, 2004) The introduction of invasive species and pathogens through ballast water discharge can have detrimental impacts on native ecosystems. Effective ballast water management practices, including physical disinfection, chemical treatment, and ballast water exchange, help reduce the transfer of harmful organisms and pathogens.

Oil spills and pollutant releases are significant concerns in maritime operations and infrastructure. Oil spills can occur during fuel transfer, ship accidents, or port operations, leading to severe environmental consequences for marine ecosystems and coastal areas (Periáñez, 2007). Response strategies, such as the use of containment booms, skimmers, dispersants, and shoreline protection measures, are crucial for mitigating the impacts of oil spills. Port-based pollution prevention measures, including spill prevention equipment, regular inspections, and strict safety protocols, are essential to prevent and minimize oil and chemical spills in port areas.

Marine debris and wastes are need to be managed for ships that generate various types of solid waste, including plastics, packaging materials, and non-biodegradable items. International and national regulations govern waste disposal from ships, emphasizing the need for garbage management plans, waste reception facilities in ports, and proper disposal methods. Recycling and waste reduction initiatives, such as recycling programs, waste segregation, and the use of eco-friendly materials, help promote sustainable practices in shipping and port operations.

Required efforts should be made to ensure the continuity of environmental monitoring and compliance. Monitoring water quality parameters including nutrient concentrations and dissolved oxygen levels helps assess the impacts of shipping activities and port operations on water ecosystems. Adherence to international and regional regulations, like the International Convention for the Prevention of Pollution from Ships (MARPOL), is vital to minimize water pollution from shipping activities (Fitzmaurice, 2022). Inspection and enforcement by port authorities, maritime organizations, and regulatory agencies ensure compliance with environmental regulations and impose penalties for non-compliance.

Assessment of Underwater Noise Pollution and Its Effects on Marine Life: Various sources contribute to underwater noise pollution. Ship noise encompasses engine noise, propeller cavitation, and machinery vibrations. Port-related noise includes sources such as ship maneuvering, cargo handling, and construction activities. Additional anthropogenic activities, including pile driving, dredging, and seismic surveys, also cause to underwater noise pollution.

Underwater noise pollution generated by shipping activities and port operations can have significant impacts on marine life, including marine mammals, fish, and other aquatic species (Markus & Sánchez, 2018). High-intensity noise can cause hearing impairment and physiological effects in marine animals, potentially leading to temporary or permanent hearing loss. It can also alter the behaviour of marine species, disrupting feeding, mating, communication, and migration patterns. Excessive noise can mask important biological sounds, such as communication calls and prey detection signals, thereby affecting the survival and ecological interactions of marine organisms.

Various techniques are employed to assess underwater noise pollution. Passive acoustic monitoring involves the use of hydrophones and other acoustic sensors to monitor and record underwater noise levels over time, enabling the identification of noise hotspots and temporal patterns (Van Parijs, Clark, & Sousa-Lima, 2009). Acoustic modelling and mapping tools are used to predict and visualize underwater noise propagation, facilitating the assessment of noise impacts in specific areas and on sensitive marine habitats. Bioacoustics monitoring techniques, such as passive acoustic monitoring of vocalizations and behaviour, help assess the response of marine species to underwater noise pollution. EIAs for maritime projects integrate underwater noise assessments, ensuring that potential noise impacts on marine life are considered and addressed.

Mitigation measures as noise reduction technologies, including quieter ship designs, propeller modifications, and hull coatings, help reduce underwater noise emissions from ships (Audoly, Gaggero, & Baudin, 2017). Implementing speed limits and vessel routing measures can minimize noise impacts on marine habitats and sensitive areas. During port construction activities, best practices such as the use of noise barriers, bubble curtains, and scheduling restrictions help mitigate noise. Regulatory frameworks and guidelines, such as the International Maritime Organization's (IMO) Guidelines on the Reduction of Underwater Noise from Commercial Shipping, aim to minimize underwater noise pollution and its impacts on marine life (Rayegani, 2021).

Evaluation of GHG Emissions from Maritime Transport: Maritime transport plays a significant role in GHG emissions, which have a substantial impact on climate change. Evaluating and addressing these emissions are essential for promoting sustainable maritime practices and reducing the industry's carbon footprint. This section focuses on the evaluation of GHG emissions from maritime transport.

GHG emitted by maritime transport include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and hydrofluorocarbons (HFCs) (Garg, Shukla, & Kapshe, 2006). CO_2 is the primary GHG emitted by ships and has a long-term impact on climate change. CH_4 and N_2O are potent GHG emitted from maritime activities and contribute to global warming. SF_6 and HFCs are synthetic GHG emitted from specific maritime operations, such as refrigeration systems and firefighting equipment.

Several factors influence GHG emissions in maritime transport such as vessel type and size (including their design and engine characteristics), influence fuel consumption, and subsequent GHG emissions. The type of fuel used and its sulfur content also play a role in emissions, with heavy fuel oil, marine gas oil, and LNG having different emissions profiles. Vessel speed, operational practices, and port-related activities, such as cargo handling and ship-to-shore power supply, further contribute to emissions.

Various methodologies are used to assess GHG emissions from maritime transport. International guidelines and protocols, such as the International Maritime Organization's (IMO) guidelines and the ISO 14064 standard, provide established methodologies for calculating and reporting emissions. Activity-based emissions estimation considers factors such as fuel consumption, distance travelled, and vessel characteristics. Both bottom-up and top-down approaches are used, with bottom-up methodologies considering detailed vessel-specific data and top-down approaches utilizing global emission inventories and statistical data. Emission factors and comprehensive emission inventories serve as valuable tools for assessing and monitoring emissions.

Energy efficiency measures, including improved hull designs, engine upgrades, waste heat recovery systems, and hybrid propulsion systems, can mitigate fuel consumption and emissions with a contribution to decrease in emission levels (Buchwald, Christensen, & Larsen, 1979). The use of alternative fuels such as LNG, biofuels, and hydrogen, as well as electric propulsion systems, helps minimize GHG emissions. Market-based measures such as carbon pricing, emission trading schemes, and environmental levies incentivize emission reductions in the maritime industry. Regulatory frameworks, including the IMO's Initial IMO Strategy on Reduction of GHG Emissions from Ships, and international initiatives focus on decarbonizing maritime transport.

Methods for Assessing the Environmental Effects of Port Infrastructure: In countries that apply an EIA methodology, the flow follows the same headings for port infrastructures too. EIA is introduced as a process for identifying, predicting, and evaluating potential environmental impacts of port infrastructure projects. Baseline data collection is emphasized to establish a baseline against which potential impacts can be assessed, including factors such as water quality, air quality, biodiversity, and socio-economic aspects. Methods for impact identification and prediction are explored, including screening tools, impact matrices, and predictive models. The inclusion of mitigation measures and monitoring programs in the EIA process is highlighted for effective management and reduction of adverse environmental impact.

Water quality and marine ecosystem assessments are primarily the assessment of sediment quality and potential impacts associated with dredging activities. The evaluation of marine biodiversity and habitat (coral reefs, seagrass beds, mangroves etc.) impacts is possible with measurement of parameters in water such as dissolved oxygen, nutrient levels, contaminants, and marine litter.

Air quality assessments encompass methods for quantifying and modelling air pollutant emissions from port operations. The use of dispersion models to assess the spatial distribution and potential impacts of air pollutants is discussed, considering meteorological conditions and local topography. The significance of monitoring ambient air quality in and around ports to assess actual pollutant levels and evaluate potential impacts on human health and the environment is highlighted (Wiley, 2018).

Noise and vibration assessments cover methods for modelling and mapping noise levels generated by port infrastructure. The importance of on-site noise measurements and community surveys to validate model predictions and assess the community's perception of noise impacts is discussed. Monitoring and assessing vibrations generated by port activities, such as pile driving and heavy machinery operation, are emphasized to evaluate potential impacts on structures and sensitive receptors.

Socio-economic assessments explore methods for assessing the economic benefits and costs associated with port infrastructure, including job creation, trade facilitation, and revenue generation. The social implications of port infrastructure, such as community disruption, changes in land use patterns, and impacts on cultural heritage and local lifestyles, are discussed. The evaluation of potential health impacts, such as air pollution-related health risks, noise-related stress, and the overall well-being of communities living near port infrastructure, is highlighted.

Analysis of Ballast Water Management and Its Impact on Invasive Species: Ballast water is a fundamental component of ship stability and safety during voyages, but it also carries the risk of introducing invasive species to new environments. This section focuses on the analysis of ballast water management and its impact on invasive species (Bailey, 2015). Ballast water exchange, ballast water treatment systems, and alternative methods are the ways to manage ballast water. IMO's Ballast Water Management Convention and other relevant guidelines aimed to stop the expansion of invasive species through ballast water (Gollasch, David, Voigt, Dragsund, & Hewitt, 2007).

The adverse ecological effects of invasive species are defined as competition with native species, alteration of habitats, and disruption of ecological balance with their ability to establish and spread rapidly in new ecosystems. The existing of invasive species may have consequences on industries like fisheries, aquaculture and tourism.

The process of exchanging ballast water in open oceans creates the chance to reduce the concentration of potentially harmful organisms before entering new ports or coastal areas. Various treatment technologies are used such as filtration, disinfection, and deoxygenation, used to eliminate or control the transfer of organisms in ballast water. The importance of monitoring and verifying the effectiveness of ballast water management systems through sampling, analysis, and certification processes is emphasized.

In conclusion, with emerging trends and future directions in ballast water management ongoing research efforts aimed to improve the understanding of invasive species and developing new tools and strategies for ballast water management. Collaborative initiatives and platforms for sharing best practices, data, and experiences related to ballast water management and invasive species prevention are explored as important aspects of international cooperation and knowledge sharing.

7.4.4. Freight Transport Infrastructures

Unlike air, land, and maritime transport (which are discussed above), freight transport is a horizontal topic. Freight transport infrastructure, which integrates different modes of transportation such as road, rail, and maritime, plays an important role in facilitating efficient and sustainable freight and passenger transportation. However, it is essential to understand and mitigate the environmental impacts associated with freight transport infrastructure to promote environmentally responsible practices.

Transportation systems often involve the integration of multiple modes, such as air, land, and sea transport, to facilitate efficient movement of people and goods. The combined environmental impacts of these different transport modes need to be considered to gain a comprehensive understanding of the overall environmental footprint of a transportation system. The combined environmental impacts of different transport modes are investigated in the next paragraphs.

Assessment Methods for Freight Transport Hubs and Terminals: Freight transport hubs and terminals are important in facilitating the seamless transfer of passengers and goods between different modes of transport (Ližbetin, 2019). Assessing the environmental impacts of these hubs and terminals is vital for promoting sustainable and efficient intermodal transportation systems.

EIAs for freight hubs and terminals help identify and assess potential environmental impacts throughout the life cycle of these facilities. Key factors considered in the EIA process include land use, air quality, noise, water resources, waste management, and socio-economic aspects. The significance of mitigation measures and monitoring programs in the EIA process is aimed to minimize identified environmental impacts.

Sustainable site selection and design for freight hubs and terminals demand some conditions such as environmental sensitivity, accessibility, proximity to population centers, and transportation network connectivity. Sustainable design practices for intermodal facilities, including energy-efficient buildings, use of renewable energy sources, stormwater management, green spaces, and integration with public transportation systems, are the main research topics to prove the validity of the considered effects (City of Melbourne, 2023).

Energy and resource efficiency in freight hubs and terminals are surveyed in this document. The energy consumption patterns of these facilities, including lighting, heating, ventilation, and cooling systems, as well as vehicle electrification infrastructure, carry importance. Water conservation measures, wastewater treatment, and sustainable water besides waste reduction, recycling, and proper disposal practices, within freight hubs and terminals are improving with current legislation.

Connectivity and multimodal integration are key aspects of intermodal transport. The efficiency and effectiveness of intermodal connections within the hub or terminal are evaluated, considering factors such as transfer times, ease of access, and multimodal integration. The design and functionality of facilities enable seamless transfers between different modes, including passenger terminals, cargo handling areas, and intermodal transfer points.

Engaging stakeholders is important including local communities, in the planning and development of freight hubs and terminals to address potential social and environmental concerns. Social impact assessment covers changes in local traffic patterns, noise pollution, and disruptions to nearby communities. Accessibility and inclusivity aspects need to be assessed in order to provide priorities for people with disabilities, elderly populations, and vulnerable groups.

By employing comprehensive assessment methods tailored for intermodal transport hubs and terminals, decision-makers can identify and address potential environmental challenges, optimize resource utilization, minimize negative impacts on surrounding communities, and promote sustainable and integrated transportation systems.

Evaluation of Emissions Reduction Strategies for Freight Logistics: Reducing emissions in freight logistics is carrying importance for achieving sustainable and environmentally responsible transportation systems. As freight logistics involve the seamless coordination of multiple modes of transport, implementing effective emissions reduction strategies can significantly minimize the environmental footprint of freight transportation. In this section, the evaluation of various emissions reduction strategies is explored which are specifically designed for freight logistics.

Modal shift and optimization are key considerations. The benefits of shifting freight from road transport to more sustainable modes such as rail and maritime are highlighted, as they can significantly reduce emissions and congestion (Islam, Ricci, & Nelldal, 2016). The importance of optimizing freight routes and schedules to minimize empty miles, reduce fuel consumption, and enhance overall efficiency in freight logistics.

Alternative fuels and technologies play a significant role. The feasibility and adoption of electric and hybrid vehicles in freight logistics are evaluated, considering infrastructure requirements, range limitations, and technological advancements. The use of alternative fuels, such as biofuels, hydrogen, and natural gas, in freight logistics and their potential to reduce GHG emissions and air pollutants provides the tendency to establish a greener transport system (Hoefnagels, Wetterlund, Pettersson, & Faaij, 2017).

Implementing eco-driving training programs aims to promote fuel-efficient driving behaviours and reduce emissions within the realm of freight logistics. (Kontovas & Psaraftis, 2011). Strategies to optimize vehicle maintenance practices and improve aerodynamics, such as tire maintenance, regular engine tune-ups, and the use of aerodynamic technologies, are explored to enhance fuel efficiency and minimize emissions.

Evaluating collaborative efforts among stakeholders in the supply chain, such as shared warehousing, consolidated shipments, and collaborative distribution centers, can reduce unnecessary transportation and emissions. Efficient inventory management and demand planning are discussed to minimize stockouts, optimize shipment sizes, and reduce overall transportation requirements and associated emissions in freight logistics.

The implementation of monitoring and reporting systems for tracking emissions in freight logistics, including the use of telematics, onboard sensors, and digital platforms, is explored. Relevant key performance indicators (KPIs) for evaluating emissions reduction efforts in freight logistics, such as GHG intensity, fuel consumption per unit of cargo, and emissions per kilometre travelled.

By evaluating and integrating tailored emissions reduction strategies for freight logistics, stakeholders can make significant progress in reducing the environmental impact of freight transportation. Through a combination of modal shift, adoption of alternative fuels and technologies, eco-driving practices, supply chain optimization, and robust monitoring systems, freight logistics can become more sustainable, efficient, and aligned with global emission reduction targets.

Integrated Approaches to Assess the Sustainability of Intermodal Transportation: Assessing the sustainability of intermodal transportation requires a comprehensive and integrated approach that considers environmental, social, and economic factors. As intermodal transportation involves the coordination of multiple modes and stakeholders, evaluating its sustainability helps identify opportunities for improvement and supports informed decision-making.

A triple-bottom-line assessment is a key consideration (Wilcox, Nasiri, Bell, & Rahaman, 2016). The environmental impacts of intermodal transportation, including GHG emissions, air and water pollution, noise pollution, and habitat fragmentation, are evaluated using established assessment methods and indicators. The social aspects of intermodal transportation, such as impacts on local communities, accessibility, safety, and equity, are assessed through stakeholder engagement, surveys, and participatory approaches. Economic analysis, including cost-benefit analysis and economic valuation, is conducted, considering factors such as infrastructure investment, operational costs, savings in fuel consumption, and job creation.

LCA methodology may be applied to evaluate the environmental impacts of intermodal transportation throughout its entire life cycle, from the extraction of raw materials to manufacturing, operation, maintenance, and end-of-life disposal or recycling. Comparative analysis is conducted to compare the environmental performance of intermodal transportation with other modes, such as road-only or air-only transport, to identify potential environmental benefits and areas for improvement.

Sustainable performance indicators specific to intermodal transportation are developed and which also consider key environmental, social, and economic dimensions are defined and utilized. Robust data collection and monitoring systems are established to track and measure the performance of intermodal transportation against sustainability indicators, enabling regular assessment and benchmarking.

Multi-criteria decision analysis (MCDA) is the key point and the related stakeholders, including government agencies, transport operators, logistics providers, and local communities, are engaged in a participatory process to identify and prioritize sustainability criteria for intermodal transportation (Macharis, Meers, & Lier, 2015). MCDA techniques are applied to assess the performance of different intermodal transportation scenarios or projects against multiple sustainability criteria, considering the trade-offs and synergies among environmental, social, and economic factors.

Policy and regulatory frameworks form the main structure and the integration of sustainability considerations in transportation policies, plans, and regulations at regional, national, and international levels are analysed to ensure alignment with sustainable development goals and targets. The effectiveness of incentive mechanisms, such as grants, subsidies, tax incentives, and emissions trading schemes, in promoting sustainable practices and investments in intermodal transportation.

By adopting these integrated approaches, assessment of the sustainability of intermodal transportation, decision-makers and stakeholders can gain a holistic understanding of its environmental, social, and economic performance. This understanding enables the identification of areas for improvement, the formulation of effective policies and strategies, and the promotion of sustainable and resilient intermodal transportation systems that support economic growth while minimizing negative environmental and social impacts.

7.5. Urban Transport Infrastructures

Urban transport, which is also a horizontal topic like the freight transport, creates opportunities in shaping the sustainability and liveability of cities. It is necessary to inspect the environmental impacts associated with urban transport systems, as they can significantly affect the air quality, the energy consumption, the GHG emissions, and overall urban well-being.

Air Pollution and Noise Pollution in Urban Areas from Transportation: Urban areas face challenges related to air pollution and noise pollution caused by transportation activities. The concentration of vehicles, high population density, and extensive transport networks contribute to elevated levels of air pollution and noise in cities. Developing effective strategies for the impacts, and assessment methods of air and noise pollution sources are the key steps to mitigate their effects.

In terms of air pollution, road traffic is a primary source, releasing pollutants such as NOx, PM, and VOCs from exhaust fumes. Industrial emissions from facilities in urban areas and dust generated by construction activities and unpaved roads also contribute to air pollution.

The impacts of air pollution are wide-ranging. High levels of air pollution can lead to respiratory problems, cardiovascular diseases, allergies, and other health issues, particularly affecting vulnerable populations (D'Amato, Cecchi, D'Amato, & Liccardi, 2010). Additionally, air pollution has detrimental effects on ecosystems, including damage to vegetation, soil, and water bodies, and contributes to climate change by increasing GHG concentrations.

Air quality monitoring stations equipped with sensors measure pollutant concentrations in urban areas to assess air quality levels and identify pollution hotspots. Air dispersion modelling uses computer models to simulate the dispersion and transport of pollutants in the atmosphere, providing insights into pollutant distribution and predicting air pollution levels. Emission inventories compile comprehensive data on pollutant emissions from transportation sources and other sectors, aiding in assessing the contribution of different sources to air pollution.

Moving on to noise pollution, road traffic noise is a significant contributor, especially during peak hours. Rail and transit noise generated by trains and trams, as well as aircraft noise near airports, also impact nearby communities. The consequences of noise pollution encompass health implications like stress, disruptions in sleep patterns, cardiovascular issues, and diminished overall well-being. Overwhelming noise pollution can also hinder effective communication, disturb regular routines, lower the quality of urban environments, and undermine the sense of community unity.

Assessing noise pollution involves techniques such as noise mapping, which visualizes noise levels in urban areas and identifies areas where noise mitigation measures are necessary. Noise monitoring through the deployment of sensors and on-site measurements helps assess noise levels in specific locations and evaluate compliance with noise regulations. Noise impact assessments analyse the potential impacts of transportation projects on noise levels and consider noise mitigation measures during project planning and design phases.

By understanding the sources, impacts, and assessment methods for air pollution and noise pollution in urban areas from transportation, policymakers, urban planners, and stakeholders can develop effective strategies and interventions to improve air quality, reduce noise levels, and create healthier and more liveable urban environments. Mitigating these environmental impacts is essential for enhancing the quality of life and promoting sustainable urban development.

Assessment of GHG Emissions from Urban Transportation Systems: GHG emissions from urban transportation systems contribute significantly to climate change and global warming. As cities strive to achieve sustainability goals and reduce their carbon footprint, assessing and understanding the GHG emissions from urban transport becomes important.

The sources of GHG emissions in urban areas primarily come from road transport, including cars, buses, motorcycles, and trucks. These vehicles emit CO_2 and other GHGs during fuel combustion. Mass transit systems, such as buses and trains, also contribute to GHG emissions, although them per-passenger emissions are typically lower than individual vehicles. Additionally, GHG emissions may arise from non-road transportation sources in urban areas, such as construction and maintenance equipment, off-road vehicles, and waterborne vessels (Browne, Allen, & Woodburn, 2014).

The impacts of GHG emissions are far-reaching. GHG emissions, particularly CO_2, contribute to the accumulation of greenhouse gases in the atmosphere, leading to global warming and climate change. Elevated GHG concentrations can exacerbate the urban heat island effect, leading to temperature increases in urban areas compared to surrounding rural regions. Climate change, influenced by GHG emissions, can also have indirect health impacts such as increased heat-related illnesses, changes in disease vectors, and worsening air quality.

Assessing GHG emissions from urban transportation systems involves various methods. Developing comprehensive inventories of GHG emissions from urban transportation sources is essential for quantifying the contribution of different modes and sectors (Li, 2011). Analysing the composition and characteristics of the urban vehicle fleet, including fuel types, age, and efficiency, helps estimate GHG emissions. Utilizing transport models and simulation tools allows for the estimation of GHG emissions under different scenarios, aiding in policy analysis and decision-making. Gathering data on fuel consumption, vehicle kilometres travelled, and modal shares supports the calculation and monitoring of GHG emissions from urban transport.

To reduce GHG emissions, cities can implement various mitigation strategies. Promoting the use of sustainable modes such as public transport, cycling, and walking can help reduce GHG emissions from urban transport. Shifting towards electric vehicles (EVs), hybrids, and low-carbon fuels can significantly reduce GHG emissions and improve air quality. Integrated land use and transport planning, which coordinates urban development with efficient transport networks and promotes compact cities, can minimize the need for motorized travel and associated GHG emissions. Policy and regulatory measures such as emission standards, congestion pricing, and incentives for sustainable transport choices can also drive emissions reduction in urban transport.

By assessing and monitoring GHG emissions from urban transportation systems, cities can identify areas for improvement, implement targeted interventions, and track progress towards sustainable and low-carbon urban mobility. Taking effective measures to reduce GHG emissions not only contributes to global climate change mitigation efforts but also improves air quality, promotes public health, and enhances the overall sustainability of urban areas.

Evaluation of Sustainable Urban Mobility Solutions and Low-Carbon Transport Options: Achieving sustainable urban mobility is essential for creating liveable cities and mitigating the environmental impacts of transportation (Lam & Head, 2012). Evaluating and implementing sustainable urban mobility solutions and low-carbon transport options play a major role in reducing congestion, improving air quality, and enhancing accessibility and mobility for urban residents.

Sustainable urban mobility solutions encompass various aspects that need evaluation. Public transportation, including buses, trams, metros, and light rail, needs to be assessed for its effectiveness, coverage, frequency, and affordability in meeting the mobility needs of urban populations. The infrastructure, safety, and promotion of walking, cycling, and other non-motorized modes also need evaluation as sustainable and healthy transportation options. Additionally, the potential of car-sharing and ride-sharing services should be examined to reduce private vehicle ownership, decrease traffic congestion, and promote efficient use of vehicles. Assessing the integration of different transport modes, such as park-and-ride facilities, seamless transfers between modes, and multi-modal journey planning, is critical for providing seamless and efficient urban mobility options.

Low-carbon transport options include assessing the adoption and deployment of EVs in private cars, public transport, and shared mobility services to reduce GHG emissions and promote clean transportation. The feasibility and impact of alternative fuels such as biofuels, hydrogen, and CNG as low-carbon alternatives for urban transport should also be evaluated. Furthermore, the integration of electric scooters, bicycles, and other micro-mobility options into the urban transport system needs assessment to provide convenient, emission-free alternatives for short-distance trips (Bozzi & Aguilera, 2021).

When evaluating sustainable urban mobility, accessibility and connectivity are important factors, including ease of access to transportation options, connectivity between different modes, and the availability of inclusive transport services for all segments of the population. Affordability and equity are essential, encompassing the affordability of transport services, equitable access to mobility options for all socio-economic groups, and addressing transportation-related social inequalities. The environmental impact should be quantified, considering GHG emissions, air pollution, and noise pollution resulting from different transport options. Health and well-being should also be considered, considering the benefits of sustainable transport modes in terms of physical activity promotion, improved air quality, and reduced noise exposure. Safety and security aspects, such as safety measures, infrastructure design, and policies aimed at enhancing the safety and security of urban transport users, need evaluation as well.

To facilitate evaluation, various tools and methodologies can be involved. Transport modelling and simulation using advanced tools allow for evaluating the impacts of different urban mobility scenarios, forecasting travel demand, and assessing the effectiveness of interventions. Cost-benefit analysis can be conducted to compare the economic, social, and environmental costs and benefits of sustainable urban mobility solutions and low-carbon transport options. Furthermore, stakeholder engagement and public participation are carrying importance and involving key stakeholders such as residents, transport operators, and local communities in the evaluation process ensure their perspectives and needs.

By evaluating sustainable urban mobility solutions and low-carbon transport options, cities can identify the most effective strategies to improve urban mobility, reduce environmental impacts, and enhance the overall quality of life for residents (Canitez, Alpkokin, & Kiremitci, 2020). Implementing these solutions requires collaboration among policymakers, urban planners, transport operators, and community members to create a truly sustainable and people-centric urban transport system.

Methods for Analysing the Environmental Benefits of Public Transportation Systems: Public transportation promotes sustainable and environmentally friendly urban mobility. Analysing the environmental benefits of public transportation systems helps assess their contribution to reducing GHG emissions, improving air quality, and mitigating the environmental impacts of urban transportation.

One method for analysing the environmental benefits of public transportation is LCA. LCA involves conducting a thorough evaluation of the environmental outcomes linked to all stages of the public transportation system's life cycle, from material extraction and manufacturing to operation and disposal. It deals with a group of environmental indicators such as GHG emissions, energy consumption, air and water pollution, and resource depletion to provide a holistic evaluation of the system's environmental performance.

Emission Inventory Analysis is another method used to assess the environmental benefits of public transportation. It involves developing emission inventories specific to public transportation systems, quantifying the GHG emissions, air pollutants, and other pollutants generated by different modes of public transport (D'Avignon, Carloni, La Rovere, & Dubeux, 2010). This analysis helps identify the major sources of emissions within the public transportation system and provides a baseline for evaluating emission reduction strategies and comparing the environmental performance of different modes. Modal Shift Analysis involves analysing the environmental benefits resulting from a shift in travel behaviour from private vehicles to public transportation. This analysis quantifies the reduction in vehicle kilometres travelled, energy consumption, GHG emissions, and congestion that occur when individuals switch to using public transportation (Batty, Palacin, & González-Gil, 2015). Evaluation of the potential environmental impact of encouraging greater public transportation usage and informs policies and strategies aimed at promoting modal shift and reducing private vehicle dependency are the proofs of it. Air Quality Monitoring is an essential method for assessing the environmental benefits of public transportation. Monitoring air quality in and around public transportation corridors provides real-time data on pollutant concentrations. With this information, it could be understandable that the air quality benefits of public transportation systems and identifies areas where further improvements may be demanded. Dispersion modelling can also be used for gaining an analysis of the spatial distribution of pollutants and their potential health impacts in the vicinity of public transportation routes and stations. Additionally, conducting passenger surveys and travel behaviour studies helps understand the travel patterns, preferences, and motivations of public transportation users. It provides the estimation of the environmental benefits resulting from mode shift and identify opportunities for further improving the environmental performance of public transportation systems.

The existence of the environmental benefits of public transportation systems, policymakers, urban planners, and transport operators can make informed decisions, prioritize sustainable mobility strategies, and demonstrate the positive environmental impacts of investing in and promoting public transportation as a key component of urban transportation systems.

The issues discussed above are summarized in Table 7.2, in the form of key environmental impacts, pollutant types, indicators and their relationship with the mode of transportation (European Commission, 2020).

Table 7-2: Possible Environmental Targets and Indicators

Objects and Targets	Indicators	Modes of Transport
Air pollution	• Concentrations of particulate matter (PM) • Emissions or concentrations of air pollutants (NO_X, PM, SO_X, VOCs) • Exposure of the population to air pollutant concentration • Emissions of ozone precursors (NO_X, NMVOC, CO, CH_4) • Sulfur hexafluoride (SF_6) and hydrofluorocarbons (HFCs)	• Air Transport (Airport and Aircrafts) • Land Transport • Maritime Transport • Freight Transport • Urban Transport
Landscape, biodiversity, heritage and townscape	• Infrastructure Dimension • Land take and land dividing of ecologically sensitive areas • Serious negative impacts on Natura 2000 regions • Distance from ecologically sensitive areas • Potential impacts on key species population • Variations in traffic (pass-km) as a proxy of the likelihood of impacts from road run-off • Risk of traffic accidents involving wild animals	• Land Transport • Freight Transport

Objects and Targets	Indicators	Modes of Transport
Water resources	• Infrastructure Dimension (+impact of traffic) in densely populated areas • Distance from sensitive sites • Levels of nutrients, oxygen, and pollutants in surface and groundwater • Changes in ecological status of surface waters as assessed under Water Framework Directive • Risks to water bodies from accidents during transport of dangerous goods • Impacts on flood risk • Ballast water (Invasive species and pathogens) • Oil spills and pollutant releases (Oil spill response and containment, Port-based pollution) • Marine debris and waste (Solid waste generation)	• Maritime Transport
Soil pollution	• Risk of soil contamination • Adverse impacts on the hydrological and/or ecological functions of soil • Soil erosion and sedimentation	• Land Transport
Resource depletion	• Energy use • Material use • Resource intensity • Use of non-renewable sources	
Acidification	• Emissions of SO_2 and NO_X	

Objects and Targets	Indicators	Modes of Transport
Climate change	• GHG emissions (CO_2, CH_4, N_2O, H_2O) • Avoided GHG emissions (tonnes of CO_2e) • Fuel consumption per passenger kilometre • Share of zero and low-emission vehicles in national fleet • Vulnerability (exposure and sensitivity) of infrastructure to climate change impacts • Contribution of infrastructure to climate resilience (Train tracks and roads (in kilometres) with upgraded heat resilience measures; Bridges with upgraded flood protection; Roads (in kilometres or as a percentage of total) with upgraded stormwater run-off drainage; Annual kilometre-hours of transport infrastructure non-availability due to extreme weather events)	• Air Transport • Land Transport • Maritime Transport • Freight Transport • Urban Transport
Noise	• Population disturbed by noise • Surface area affected by noise pollution • Noise level (sound pressure level (SPL), weighted decibel (dBA)) • Vibrations from construction, road traffic and railway noise (engines, tire friction, and aerodynamic effects) • Aircraft engines and ground operations • Influence of airport design and layout on noise dispersion • Underwater noise pollution (Ship noise, Port-related noise, Anthropogenic activities)	• Air Transport • Land Transport • Maritime Transport
Human health	• Impacts on physical activity • Impacts on road safety: number of accidents, fatalities and injuries	

7.6. A Step-by-Step Guide to Measuring Environmental Impacts of Transport Infrastructures in OIC Member Countries

7.6.1. Pre-Measurement Stages

Recognizing the diverse environmental, social and cultural contexts within OIC member countries, this Step-by-Step Guide is designed to address the specific challenges and opportunities that these nations face in measuring and managing the environmental impacts of transport infrastructures. Before initiating the task of measuring the environmental impact of transport infrastructures in OIC member countries, it is important to meticulously prepare during the pre-measurement stages. These stages serve as the cornerstone of a comprehensive, scientifically sound, and ethically responsible assessment of the environmental effects of transportation infrastructure projects. They are not merely procedural but are integral to ensuring the accuracy and effectiveness of environmental assessments.

Step 1: Understanding OIC-Specific Needs and Priorities:

- *Project Identification:* Identify the specific transportation infrastructure projects within OIC member countries that require environmental impact assessment.
- *Related Parties Identification:* Identify relevant stakeholders, including government agencies, environmental organizations, and local communities, to not to be overlooked their concerns and priorities.
- *Islamic Consideration:* Encourage a holistic approach that integrates environmental conservation with socio-economic development in accordance with Islamic teachings.

Step 2: Regulatory Compliance

- *Local Regulatory Review:* Conduct a thorough review of existing local and national regulations, policies, and standards related to transport infrastructure and environmental impact assessment first in the country where the project will take place and then the OIC member countries. Ensure that your assessment complies with all applicable laws and regulations.
- *International Regulatory Review:* Assess how local regulations align with international environmental standards and best practices. Determine if there are specific measurement methods, impacts, approaches that are realized in examples around the world for the project.
- *Permits and Licenses:* Identify the necessary permits and licenses required for the assessment and engage with regulatory authorities.

Step 3: Determination of Boundaries and Impact Area

- *Scope Clarification:* Begin by precisely defining the scope of the assessment. Identify the geographical boundaries of the project area, considering all relevant elements.
- *Ecosystems and Communities:* Recognize and map out the receiving environment. This includes identifying the ecosystems, communities, and sensitive habitats that may be impacted by the project.
- *Direct and Indirect Impact Areas:* Clearly distinguish between the areas directly affected by the transport infrastructure projects (direct impact areas) and those indirectly influenced by their presence (indirect impact areas).

- *Socioeconomic Considerations:* Assess the socio-economic factors of the receiving environment, such as Islamic approach, local communities, cultural heritage, and economic activities that might be affected.

Step 4: Definition of Environmental Parameters

- *Parameter Selection:* Carefully select the environmental parameters that are most relevant to the assessment. Consider air quality, water quality, noise levels, soil conditions, biodiversity, and other country specific factors.
- *Thresholds and Standards:* Establish clear environmental quality thresholds and standards, aligned with both international norms and local regulations, against which impacts will be measured.

Step 5: Selection of Sampling Points and Measurement Techniques

- *Research:* Review existing environmental impact assessments and research relevant to similar projects, drawing upon best practices and lessons learned.
- *Strategic Sampling:* Choose sampling points strategically to ensure that they represent the diversity of the project area. These points should be located in both direct and indirect impact areas.
- *Scientific Techniques:* Implement scientifically rigorous measurement techniques that are not only appropriate for the environmental parameters being assessed but are also culturally and technologically suitable for the region.

Step 6: Establishment of Monitoring Intervals and Follow-Up

- *Monitoring Schedule:* Set clear monitoring intervals, considering seasonal variations and project timelines. Regularly scheduled monitoring helps track changes over time.
- *Follow-Up Assessments:* Ensure that follow-up assessments are conducted systematically, allowing for the continuous evaluation of evolving environmental conditions throughout the project's lifecycle.

Step 7: Stakeholder Engagement

- *Stakeholder Involvement:* Engage with all relevant stakeholders, including local communities, indigenous groups, governmental agencies, non-governmental organizations, and project developers.
- *Whistleblowing Mechanism:* Conduct open and transparent public consultations to gather local insights, concerns, and cultural considerations. Establish mechanisms for addressing conflicts and disputes among stakeholders.

Step 8: Environmental Impact Assessment (EIA) Planning

- *EIA Outline:* Create a detailed plan outlining the entire EIA process, encompassing timelines, milestones, responsibilities, and monitoring and evaluation mechanisms.

- *Expert Selection:* Foster collaboration among diverse experts, including ecologists, geologists, engineers, social scientists, and economists, to provide a holistic assessment.

Step 9: Diligent Record-Keeping

- *Data Documentation:* Maintain detailed records at every stage of the assessment process. Document data, observations, methodologies, and outcomes meticulously.
- *Traceability:* Establish a robust system for data traceability, ensuring that all information can be linked back to its source and verified as needed.

Step 10: Baseline Data Establishment

- *Baseline Dataset:* Establish a comprehensive and accurate baseline dataset for environmental conditions, enabling the precise measurement of changes caused by the transportation infrastructure project.
- *Data Quality:* Implement data quality assurance protocols to validate the reliability and accuracy of baseline data.

Step 11: Knowledge Sharing and Collaboration:

- *Collaboration:* Promote collaboration among OIC member countries to foster a regional approach to addressing environmental impacts of transportation infrastructure.
- *Sharing:* Encourage the knowledge sharing of best practices and experiences in sustainable transportation and environmental management.

These pre-measurement stages represent a formidable commitment to setting the stage for a rigorous and inclusive environmental assessment. Through meticulous preparation and a steadfast commitment to environmental stewardship, it can be paved the way for sustainable and responsible transportation infrastructure development in OIC member countries, safeguarding their ecosystems and communities for generations to come.

For a clearer understanding of the above steps and to provide a solid understanding, the steps will be explained with an illustration of a port project in a coastal province of Türkiye (Box 7.1).

Box 7.1: Explanation of Pre-Measurement Stages for an Imaginary Port Project

Step 1: Understanding OIC-Specific Needs and Priorities

This port is located on the coastline, away from settlements but in a naturally and culturally rich area. It will contribute to the Turkish economy as a container port and will have a cargo handling capacity of 1.500.000 Twenty-Foot Equivalent Units (TEU). Within the scope of the project, filling will be done with dump trucks from land to sea, and pile driving will be done from the sea with piling barges for the docks and piers. The areas where the dock ropes will be connected will be constructed with bored piles over the fill.

Ministry of Transport and Infrastructure, Ministry of Environment, Urbanization and Climate Change, public living in the region where the project will be implemented, social organizations related to the project region, project owner and project contractor were identified as stakeholders. In alignment with Islamic teachings, special attention is given to preserving and protecting the natural environment as a trust from Allah. Mitigation measures need to implemented to minimize harm to the ecosystem.

Step 2: Regulatory Compliance

This project is within the scope of EIA Regulation that is effectively implemented in Türkiye. Commercial ports and offshore infrastructures where marine vehicles of a certain weight can dock are subject to the obligations specified in this regulation. The evaluation at this step should proceed with competent/authorized people and institutions to ensure that all applicable laws and regulations are covered.

The most important permits to be obtained are; It is the Coastal Facilities Operation Permit to be obtained from the Ministry of Transport and the environmental permit to be obtained from the Ministry of Environment, Urbanization and Climate Change. In addition, in case there is a need for regulation in the areas of responsibility of competent authorities such as the General Directorate of Highways and State Hydraulic Works, the necessary permits must be followed.

Step 3: Determination of Boundaries and Impact Area

The distance of the area where the port construction will take place to the nearest settlement is 2 km. The state highway passes 100 m away from the project area. In environmental impact assessment reports prepared in Turkey, the area within a circle with a diameter of 3 km is considered as the impact area.

In the 3 km diameter area determined as the project impact area, there are local settlements, agricultural lands, highway, fisherman's shelter and public beach. In the port project, the direct impact area is considered as the boundaries of the project site. It is important that the project coordinates at sea and on land are applied to the field. Indirect impact area is the regions outside the project boundaries and counted within the 3 km impact area. Traffic load, emissions and social changes in these regions are evaluated within the cumulative impact assessment.

Social impact analysis and evaluation should be carried out by sociologists to evaluate socio-economic factors. For example, it should be reported how the people engaged in fishing activities in this region will be affected by the port project.

Step 4: Definition of Environmental Parameters

It is important to identify the existing environmental characteristics of the project area in baseline measurements. In this imaginary project area, it is envisaged to make sea water, soil, air quality and background noise measurements and to report biological species diversity.

In this step, the limit values within the scope of the legislation of the country where the project is located should be checked. If the project owner receives financing from international financial institutions, the conditions of the financing agreement must be followed.

Step 5: Selection of Sampling Points and Measurement Techniques

With the online EIA system in Türkiye, environmental impact assessment reports of projects similar to this imaginary project can be accessed through the website of the Ministry of Environment, Urbanization and Climate Change. In addition, aspects of the port operation subject to the project that require improvement in terms of international good practices can be obtained from the sectoral guides of international financial institutions.

Sampling points were chosen strategically to ensure they were representative of the diversity of the project area. For example, the air quality measurement station located close to the site will be used to determine the current status of air quality. Samples were taken from designated points inside and outside the port area and analysed to determine the level of marine pollution. Background noise measurements were carried out day and night in the two buildings closest to the project area. All measurements will be made by authorized laboratories according to internationally accepted standards.

Step 6: Establishment of Monitoring Intervals and Follow-Up

The construction works of the project are planned to be completed within 2 years after the start of construction. Operational activities will be carried out for 40 years, which is the operating life, together with the technological improvements to be made. Planning should be made to follow environmental measures throughout the construction and operation processes.

Step 7: Stakeholder Engagement

In Turkish EIA legislation, local people are informed about the project through a public participation meeting, and if they have any comments regarding the project, they are provided to the project owner. A public participation meeting was also held in this imaginary project. At this meeting, opinions were expressed on biodiversity, transportation routes and traffic management. After this stage, the project owner must take these opinions into account when determining his stakeholders and create an action plan from the outputs of the public participation meeting. Stakeholders' opinions, suggestions and complaints will be monitored periodically and necessary measurements will be made; their dimensions, risk situations, and probability of occurrence will be evaluated. All these elements will be recorded and presented to the relevant authorities when requested.

Step 8: Environmental Impact Assessment (EIA) Planning

It is planned that the Dock/Pier, Excavation, Embankment construction and Dredging Operations will take 18 months, the construction of the Dock/Pier Superstructures will take 10 months, obtaining operating permits will take 2 months at the end of the construction period, and the port will be put into operation in approximately 2 years in total. Comments were received from environmental engineers, civil engineers, geological engineers, survey engineers, biologists and economists in determining and monitoring the environmental impacts during construction and operation processes.

Step 9: Diligent Record-Keeping

Many scientific studies were carried out both at sea and on land during the planning phase of this port project. Some of those; hydrographic and oceanographic reports, geological and geotechnical study reports, port turbulence analysis, ecosystem assessment report, air quality data, water quality data.

Step 10: Baseline Data Establishment

The data of all reports mentioned in the previous step must be under the control and knowledge of the competent authority regarding its subject. In this context, all scientific reports have been approved by the competent authority. For example, the oceanography report was approved by the naval forces command.

Step 11: Knowledge Sharing and Collaboration

Experienced professionals and environmental experts from Türkiye collaborate to provide technical assistance and advice on environmental impact assessment methodologies for OIC member countries. Lessons learned from this and previous projects in various locations are shared to inform best practices and improve the effectiveness of the assessments.

7.6.2. Measurement and Evaluation of Impacts

In consideration of the environmental and social approaches advocated by international financial institutions and recognizing the significance of adhering to globally recognized environmental standards, OIC member countries should prioritize a risk-based perspective when assessing the environmental impacts of infrastructure projects. Therefore, the adoption of a risk-based audit format emerges as the most prudent and effective approach for OIC member countries in evaluating and managing environmental risks associated with such projects.

The Table 7-3 below is given as an example of the criteria to be used in risk-based assessments. The criteria listed in this table are the elements that pose an environmental risk.

Table 7-3: Environmental Impact Measurement Topics and Related Reports

Environmental Impacts and Risks		Checkpoints (documents and commitments to ensure impact management)
Resource Efficiency and Pollution Prevention	**Climate Change** Risks that may develop as a result of the project's location being exposed to extreme weather events such as floods, droughts, and hurricanes.	• Specified Emergency Response Plan for Extreme Weather Events • Meteorological Data Analysis • EIA or ESIA Report
	Energy and Water Consumption High resources consumption during operation and construction of the project. Potential of negative impact on water resources (high water consumption, changing water temperature, changing river bed, etc.).	• Water and Energy Management Plan • Hydrological Data Analysis • Groundwater Modelling • EIA or ESIA Report
	Raw Material Consumption Status of the use of natural resources (raw materials, geothermal resources, etc.) in the construction phases of transportation infrastructures.	• Raw Materials Management Plan • EIA or ESIA Report
	Solid Waste High risk of hazardous and/or non-hazardous waste generated by the project during the construction/operation phase.	• Solid Waste Management Plan • EIA or ESIA Report
	Air Quality and Emission The negative impact on air quality and/or the risk of increasing greenhouse gas emissions and causing climate change due to the effects of the project.	• Air Quality Management Plan • Air Quality Modelling • EIA or ESIA Report
	Noise and Vibration The high level of noise generated by the project and the level of risk in the interaction area of the project.	• Noise Management Plan • Noise Modelling • EIA or ESIA Report
	Wastewater High amount of waste water generated by the project or the waste water generated has high pollution levels. Different forms of wastewater may dispose from transportation modes.	• Wastewater Management Plan • EIA or ESIA Report
	Soil Risk of soil contamination and/or large amount of soil displacement due to the project at the project site or in the impact area.	• Soil Conservation Plan • EIA or ESIA Report

Environmental Impacts and Risks		Checkpoints (documents and commitments to ensure impact management)
Land Acquisition and Involuntary Resettlement	**Land Acquisition** The risk of land being expropriated for the project. Risk of social impacts due to the size of the private lands.	• Land Acquisition Plan • ESIA Report
	Involuntary Resettlement Risk of physical or economic displacement in the region due to land expropriation for the project, risk of negative impacts on vulnerable groups.	• Resettlement Plan and Framework • Land Acquisition List • Stakeholder Engagement Plan • ESIA Report
	Land Use The degree of negative impact caused by the land (agricultural, forest, pasture, etc.) where the project is implemented, the risk of changing and degrading the habitat of the region.	• Biodiversity Management Plan • Restoration Plan • EIA or ESIA Report
Biodiversity Conservation	**Flora** Risk of negative impact on flora (vegetation, wetlands and endemic plants, etc.) due to project activities.	• Biodiversity Management Plan • EIA or ESIA Report
	Fauna The risk of negative impacts on fauna (especially endangered species) in the project area or impact area.	• Biodiversity Management Plan • EIA or ESIA Report
	Natural Park and Protected Areas The risk of the project being located in areas protected by national or international conventions (protected wetlands, Ramsar area, etc.) or affecting these areas due to its proximity to these areas.	• EIA or ESIA Report
Cultural Heritage	**Cultural Heritage** The risk of the project being located near cultural heritage sites (historical, cultural and archaeological structures/settlements, etc.), as defined by national/international legislation, and adversely affecting these structures.	• EIA or ESIA Report
	Cultural Values The risk of the project affecting the cultural values (intangible commercial / non-commercial assets identified with handicrafts, places of worship, etc.) in the region or in the vicinity. in the region or its surroundings that are important to the local population.	• EIA or ESIA Report

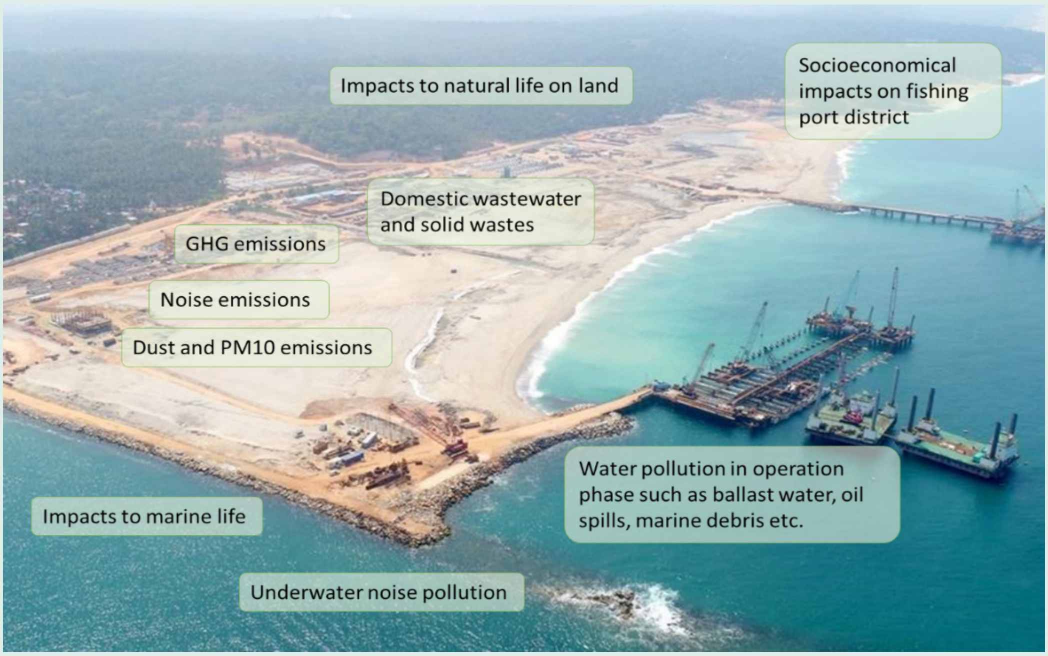
Environmental Impacts and Risks		Checkpoints (documents and commitments to ensure impact management)
Stakeholder Engagement	**Social Organizations and Groupings** Risk of influence/interest of 3rd parties like environmental and social organizations due to the project (Are certain populations discri-mated by the project (elderly, poor, disabled, young), Are human rights being affected or discriminated by the project).	• Stakeholder Engagement Plan • Grievance Mechanism • EIA or ESIA Report
	Stakeholder Engagement and External Communications Risk of adverse impact due to the reasons that stakeholders (affected people and other stake-holders, NGOs, etc.) who will be affected by investment cannot obtain information about the investment and cannot give an opinion about the investment.	
	Grievance Mechanism The risk that stakeholders (affected people and other stakeholders, NGO, etc.) who will be affected by the investment will not be able to deliver their complaints about the investment to the investor.	

Box 7.2: Explanation of Environmental Impacts for an Imaginary Port Project

The project owner will put in place measures to increase efficiency in its use of energy, water, other resources, and material inputs that are both technically and financially possible and cost-effective. During the Project's design and operation, the alternatives and most affordable choices will be considered to reduce project-related GHG emissions. Adoption of renewable or low-carbon energy sources and sustainable management techniques are just two examples of these possibilities.

Some GHG emissions are estimated in the prepared EIA Report. It is calculated that 20 trucks, 4 excavator, 1 dozer, 2 loader, 2 barges, 2 service boats, one bored pile machine, 1 concrete pump, 1 concrete mixed and 2 generators will generate 1,271 kg/hr CO and 0,851 kg/hr SO_2. However, there is no estimation of GHG generation within the EIA Report, for construction and operation phases. An Air Quality Modelling has been performed within the EIA Report. It was concluded that at the closest receptor, both PM and settled dust emissions are below the limit values given in Regulation on Control of Industrial Air Pollution.

In case of soil pollution, there is a minimum risk of any spillage to soil and impact on soil quality since all ground will be covered with concrete and no refueling service for ships. Port construction and operation phases generate different kinds of wastes. In operation phase, as a result of processes of the wastewater treatment plant, the sludge will be generated. Both treatment sludge and concentrated sludge will be sent to a licensed facility. This is a good practice for recycling of waste. In the construction phase, as a result of elevation reduction Works; excavated material will be generated. It is planned to be used for sea filling once it complies with the filling material requirements. If it is not compliance to use, this material will be sent to excavated material sites of municipality.



Potable water is planned to be supplied from groundwater well located in the project area. Analysing water from each system end points is a good practice to adequate control of water quality. There will be a wastewater treatment plant in line with requirements of Regulation on Water Pollution and Control.

The Project area does not coincide with any national and international naturally protected areas. In accordance with the EIA Report, 37 terrestrial flora species were detected in the project area and their immediate vicinity and 17 of them have low risk. A great number of sea flora species were detected. In accordance with results, some are near threatened and *Neophron percnopterus* is endangered. A lot of sea fauna species were detected with both literature and observation. As a result of study, 101 fish species are detected. One of them are tagged as endangered, three are vulnerable and four near threated. It is important issue that dredging in spawning area or development area for fish and other marine animals. It can be resulted in damage eggs and larvae.

Even if the construction site is on the sea, the region is considered rich in cultural assets. The nearby fishing shelters are considered one of the cultural riches of the region, as they have existed since ancient times.

Outcomes and Recommendations for Planned Port Project:

- All documents should be applicable for sub-contractors and a Sub-Contractor Management Plan will also be beneficial for project owner.

- Resource and Energy Efficiency Management Plan should be prepared and implemented.

- GHGs inventory and reporting processes should be followed.

- Emergency Response Plan should be implemented as an umbrella document for environmental and occupational health issues.

- Environmental Control and Management Plans for each environmental impact should be prepared and implemented (i.e. Waste Management, Noise and Vibration, Air Quality, Resource and Energy Efficiency, Hazardous Materials Control and Management Plans)

- This applications and limit values in Turkish regulations should be compared with international standards like EBRD's sectoral guidebooks, IFC's sectoral guidelines and EU's Best Available Techniques.

- Work plan should be applicable according to spawning time and duration of sensitive species.

- Ecosystem Assessment Report should be prepared periodically.

- Cultural Heritage Management Plan and Chance Find Procedure should be developed for the Project construction phase.

- Stakeholders should be stated and a Stakeholder Engagement Plan should be prepared and implemented.

7.6.3. Preparation of the Report

In light of the substantial financial investments associated with transportation infrastructure projects in OIC member countries, it is strongly recommended to commission an environmental and social due diligence report prepared by domain experts. This comprehensive, site-specific environmental report encompasses several critical components, including a detailed project description, an assessment of the project's adherence to relevant national environmental and social regulations as well as international standards, an exhaustive risk analysis, and a meticulously structured action plan for post-assessment actions.

This phase signifies the culmination of extensive efforts dedicated to the evaluation of the environmental impacts of transportation infrastructure projects. The report, meticulously crafted by seasoned experts in the field, serves as an indispensable guiding document for key decision-makers and stakeholders intricately involved in the project. It serves to encapsulate indispensable information, gauge the project's compliance with regulatory frameworks, evaluate potential risks, and lay out a well-defined action plan for the path ahead. In doing so, this report is instrumental in ensuring that transportation infrastructure development in OIC member countries aligns with sustainability objectives and adheres to ethical and environmental principles.

Project Description: To begin the report, it is suggested that to provide a thorough presentation of the transportation infrastructure project. This section should offer an exhaustive overview of the project's purpose, scope, geographical location, design specifics, and construction methodologies. It should strive for a presentation accessible to readers with both technical and non-technical backgrounds.

Compliance with Applicable National E&S Regulations and International Standards: Integral to the report is analyzing the project's alignment with pertinent national environmental and social regulations and international standards. It would be beneficial to highlight instances where the project complies with these regulations and pinpoint areas where deviations or additional measures may be necessary for conformity.

Risk Assessment Outputs: For clarity and comprehensibility, the risk assessment outcomes should be represented in an orderly manner. This should encompass an in-depth analysis of the project's potential environmental and social risks. Utilizing risk matrices or similar tools to illustrate the level of risk, considering factors like severity and likelihood, is recommended. Identifying areas of high risk that warrant immediate attention and mitigation strategies is advisable.

Action Plan for Follow-Up: The action plan is a critical report segment. This plan is suggested to articulate precise steps and measures to address identified risks and secure compliance with environmental and social standards. It should provide lucid directives on mitigating risks, preventing negative consequences, and enhancing positive ones. The action plan should also comprise well-defined timelines, designated responsible parties, and performance indicators for monitoring progress.

Engagement and Consultation: It is required to shine a spotlight on the engagement and consultation process with stakeholders, inclusive of local communities, governmental bodies, non-governmental organizations, and project developers. Sharing insights gleaned during this process, including concerns, recommendations, and commitments to address stakeholder input, is highly recommended.

Conclusion and Recommendations: To wrap up the report, a brief recap of the key findings is advisable, underscoring the significant issues requiring attention. Furnishing practical recommendations for decision-makers' consideration ensuring their alignment with sustainability objectives and environmental preservation, is encouraged.

Appendices: For transparency and credibility enhancement, it is suggested to include supplementary documents, data, maps, and references in the appendices. This would allow readers to delve deeper into specific facets of the assessment if needed.

Executive Summary: Incorporating an executive summary at the outset of the report is recommended to facilitate swift comprehension for busy decision-makers. This summary should encapsulate the most crucial findings, compliance status, and recommended courses of action.

Public Access: By principles of transparency and accountability, making the report accessible to the public is advisable. Ensuring that it is readily available to all stakeholders, including the local community, for reference and scrutiny should be considered.

Review and Update: Recognizing that the environmental and social due diligence report is a dynamic document, it is suggested that it be subject to regular review and updating. This would enable it to reflect changes in project status, evolving risks, and the effectiveness of mitigation measures.

The creation of this report represents a significant stride toward promoting responsible and sustainable transportation infrastructure development. It equips decision-makers with the essential information and guidance needed to make informed choices that safeguard the environment, protect communities, and contribute to the long-term well-being of OIC member countries. This report is a testament to our unwavering commitment to preserving ecosystems and communities for future generations.

7.6.4. Review and Evaluation of the Report

After the preparation of the environmental and social due diligence report, the subsequent imperative step is the 'Review and Evaluation' phase. This pivotal stage is instrumental in guaranteeing that the report attains the utmost comprehensiveness and adheres to the highest standards of precision, dependability, and transparency. This process aligns with the commitment of OIC member countries to meticulous and accountable environmental assessment.

Independent Expert Review: An independent team of experts, well-versed in environmental and social assessments, is recommended to conduct a thorough review of the report. This review should encompass a comprehensive evaluation of the methodologies used, the data's accuracy, and the conclusions' soundness. The goal is to create an unbiased and comprehensive report that withstands rigid scrutiny.

Alignment with Regulations and Standards: The report should be meticulously evaluated for its alignment with national environmental and social regulations and international standards. Any discrepancies or areas where the report falls short of these requirements should be identified and addressed. Confirming that the report's recommendations are consistent with legal and ethical standards is essential.

Stakeholder Input and Concerns: A critical aspect of the review process is considering stakeholder input and concerns. Feedback from local communities, governmental agencies, non-governmental organizations, and other stakeholders should be thoroughly examined. Ensuring the report adequately addresses these concerns and incorporates valuable stakeholder insights is paramount.

7.6.5. Implementation, Monitoring and Auditing of Report Results

This phase bridges the gap between the findings and recommendations outlined in the environmental and social due diligence report, transforming them into concrete, actionable steps. These steps are instrumental in steering the project's execution and guaranteeing its sustained adherence to environmental and social standards. In line with the principles of responsibility and sustainability upheld by OIC member countries, this phase plays a crucial role in ensuring the alignment of project activities with ethical and environmental guidelines.

Implementation of Recommendations: The recommendations outlined in the report should be systematically implemented. This entails incorporating the proposed mitigation measures, environmental safeguards, and social responsibility actions into the project's design, construction, and operation phases. The recommendations must be adhered to with unwavering commitment.

Stakeholder Engagement and Communication: Open and transparent communication must be maintained with stakeholders, including local communities, governmental bodies, non-governmental organizations, and project developers. Stakeholder engagement should be ongoing, and their concerns and suggestions should be addressed promptly. Regular updates and consultations help build trust and ensure the project meets societal expectations.

Monitoring and Compliance: Continuous monitoring of the project's environmental and social performance is paramount. This includes assessing whether mitigation measures effectively reduce and enhance negative impacts. Compliance with national regulations, international standards, and the report's recommendations should be rigorously upheld.

Auditing and Verification: Independent experts should conduct periodic audits and verification processes to ensure the project's adherence to the report's findings and recommendations. These audits should verify data accuracy, assess the effectiveness of mitigation measures, and confirm compliance with legal and ethical standards.

Reporting and Documentation: The monitoring, auditing, and compliance process should be well-documented at every stage. Regular reports should be generated to provide transparency and accountability to stakeholders. These reports should be made accessible to the public and relevant authorities.

Conflict Resolution Mechanisms: Mechanisms for conflict resolution among stakeholders should be established. These mechanisms should provide a structured process for addressing disputes or disagreements related to environmental and social aspects of the project. Prompt resolution helps maintain project continuity and community relations.

Capacity Building: Capacity building among project stakeholders, including local communities and project staff, is encouraged. Training and awareness programs should be conducted to enhance understanding of environmental and social responsibilities and to ensure the effective implementation of mitigation measures.

Continual Improvement: The implementation, monitoring, and auditing process should be viewed as a cycle of continual improvement. Lessons learned from previous projects and ongoing assessments should inform future transportation infrastructure endeavour, fostering a responsible and sustainable development culture.

The "Implementation, Monitoring, and Auditing of Report Results" phase ensures that transportation infrastructure projects align with environmental and social objectives. It fosters accountability, transparency, and adaptability, ultimately contributing to responsible and sustainable development in OIC member countries.

CHAPTER 8

8. Lessons Learned and Policy Recommendations

Transportation sector is one of the leading sources of environmental impacts in terms of air quality and noise. Therefore, governments all around the world attempts at adopting measures to mitigate such negative impacts. These measures include increasing the use of electric vehicles, energy-saving technologies and operational practices, the increased utilization of low-carbon fuels, and the enactment policies that encourage the adoption of transportation modes with reduced carbon emission.

Connecting environmental factors is essential for comprehending the environment impact of transportation. Environmental issues span from local concerns like noise pollution and CO_2 emissions to global problems like climate change. These effects manifest at various geographic scales, including continental, national, and regional levels. It is of utmost importance to establish design guidelines for transportation infrastructure that prioritize the minimizing harmful effects on the environment and protecting ecosystems. The transport sector ranks third, following power generation and industrial activities regarding its contribution to climate change. This contribution is primarily due to air pollution and GHG emissions. Effective GHG mitigation initiatives in many countries depend on addressing these emissions.

Transportation policies and regulations are enacted by societies to address environmental impacts. Government agencies are responsible for enforcing these standards, while advocacy groups promote and defend environmental concerns. The extent and effects of these policies vary significantly depending on their level of implementation and geographic scope.

The **European Green Deal** sets a bold target of reducing GHG emissions from the transportation sector by 90% by 2050. Achieving this goal necessitates substantial investments in low-emission transportation modes. Across the globe, regulatory laws and measures are being implemented to address the environmental impacts of transport infrastructure and services.

The Strategic Environmental Assessment (SEA) play a central role in this regard. SEA is a systematic approach designed to evaluate the potential impacts of draft laws, public plans, and programs across various sectors, including transportation, infrastructure, energy, private sector development, agriculture, rural development, water, and sanitation. The European Union (EU) Directive (2001/42/EC) underscores the importance of developing sustainable plans that consider a multitude of factors, including biodiversity, water, air, soil, climate factors, cultural heritage, human health, population, migration, and economic impacts. SEA offers the potential to significantly enhance transport planning by integrating these critical environmental factors into the decision-making process.

This document includes a guidebook developed to identify and assess the environmental impacts of transportation infrastructure in OIC member countries. The methodology includes desk-based case studies and field trips to gain insights into best practices, challenges, and sustainable development pathways. The study covers five countries known for their advanced environmental awareness and measurement practices.

A web-based questionnaire was designed to measure the impacts of transport infrastructure investments and services in OIC countries. This questionnaire systematically collected information from various stakeholders, encompassing government officials, experts, practitioners, and communities. It consisted of twenty questions were prepared to obtain measurable data on key metrics included project management, policy framework, assessed environmental impacts, energy consumption, emission reduction, emerging technologies, standardized indicators, investment allocation, and modal split.

Based on the case studies and the OIC-wide survey study, this study underlines the following issues as policy recommendations.

Environmental costs and benefits should be incorporated into the costs-benefit analyses.

Cost-benefit analyses for transport infrastructure projects are implemented based on financial and economic costs and benefits. However, the exclusion of environmental benefits and costs to such studies can lead to wrong project decisions. For example, a transport project having significant negative impacts can be approved or a transport project, which brings crucial reductions in negative environmental impacts but financially unfeasible can be rejected. Therefore, environmental costs and benefits should be incorporated into the costs-benefit analyses to better guide the decision makers.

Integration of stakeholder requirements and contributions

Considering the negative impacts associated with transport projects, the inclusion of the stakeholders to the decision-making processes is necessary. This can be done through data-gathering process, household and dedicated surveys, project-based public consultation and public participation meetings. It is crucial to inform public about future scenarios, assumptions and forecast on the environmental impacts after the completion of the investments.

Transparency in information disclosure about transportation projects

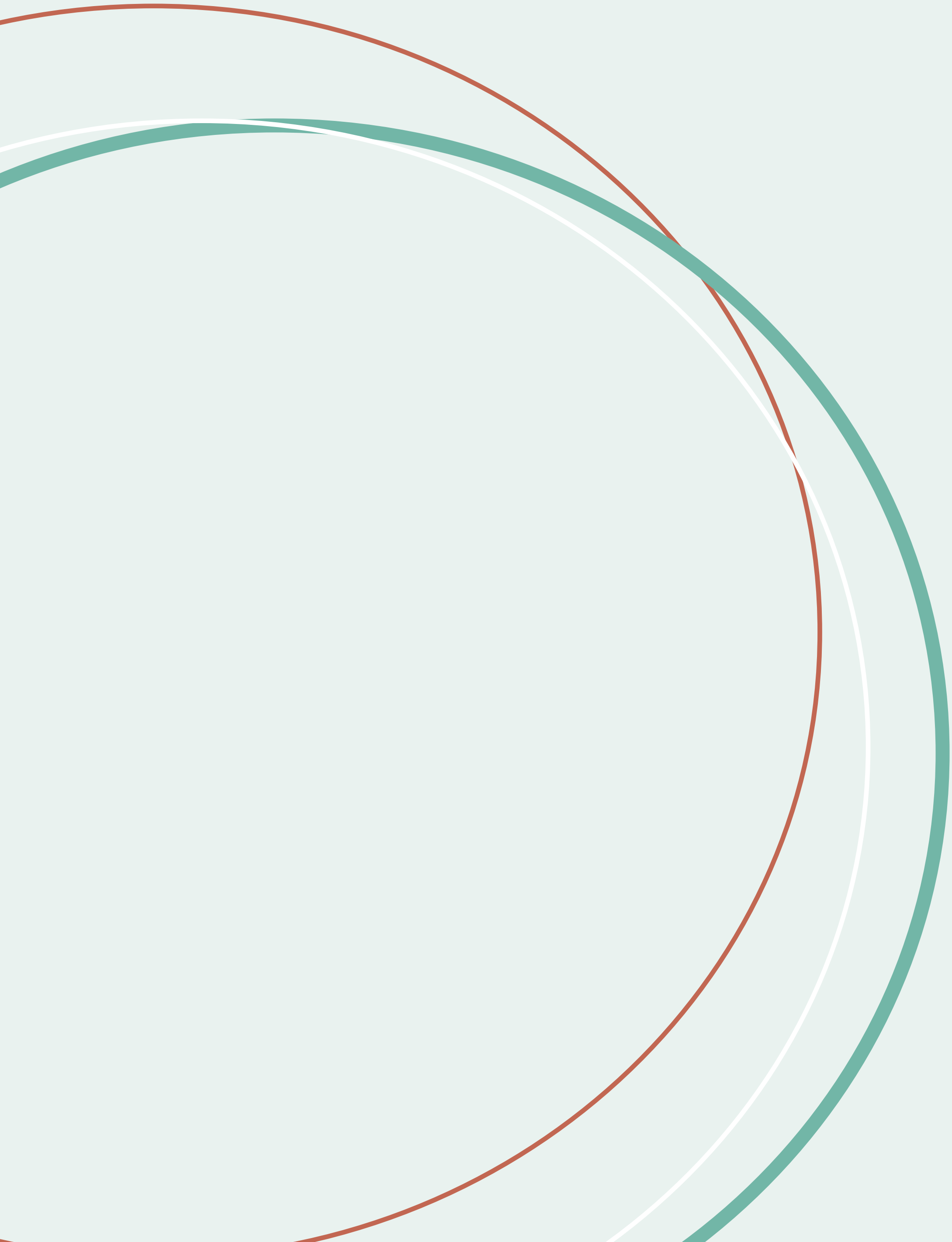
The EIAs and other related studies on the expected environmental impacts must be shared with the public.

Quality of relevant statistics

Accurate forecasts and EIAs necessitate accurate statistics. Therefore, relevant statistics on the transport and environment linkage should be produced and published regularly.

Ex-post Analysis

To determine if the transport projects have led to expected environmental impacts (both positive and negative) as was forecasted before realizing the project, the real environmental impact of the projects should be measured and analyzed after the start of the operations. This will enable decision makers to make a comparison and determine to what extent forecasts deviated from actual numbers. The possible deviations can later be used as an input to improve the forecasts of the environmental impacts for future EIAs.



Appendix

Survey Questions

1. Please write your country.
2. Please specify your affiliation.
3. Is it mandatory to prepare a project appraisal for transport infrastructure projects in your country?
4. Do you include environmental costs/benefits in your project appraisals?
5. If your answer is yes to the above question, do you monetize the environmental impacts in the project appraisals?
6. In your country, do you have specific methodologies or frameworks (such as SEA, EIA, ESIA, ESMF, EMP, SUMP, etc.) for measuring the environmental impacts of transport infrastructures?
7. Which environmental aspects do you consider when assessing the impacts of transport infrastructures? (you can select more than one)
8. Are the environmental impacts of transport infrastructure projects predicted/measured only during the construction phase?
9. Are the environmental impacts of transport infrastructure projects predicted/measured during the operational phase?
10. If your answer is Yes to Question 8 above, please indicate how often are they measured? Please select the closest option below.
11. Do you have standardized indicators or metrics to quantify the environmental impacts?
12. Does your organization regularly report the environmental impact of transport infrastructure projects?

13. In your country, is there a long-term plan or strategy to continuously measure and monitor the environmental impact of transport infrastructure projects throughout their lifecycle?
14. In your country, do you have any specific mechanisms or processes for soliciting public input and feedback regarding environmental concerns related to transportation infrastructures?
15. In your country, do you borrow international financing institutions (IFI) (e.g., WB, IBRD, EBRD, EIB, AIIB, GEF etc.) for transport infrastructure projects?
16. If your answer is yes to the above question, please indicate which documents IFIs request from your government/organization specific to environmental impacts.
17. Are there any regulatory or policy gaps that hinder the effective measurement and mitigation of environmental impacts?
18. Are there any emerging technologies or innovative practices that could improve the measurement and mitigation of environmental impacts?
19. Do you evaluate modes according to their environmental impact and conduct studies to use low-emission alternatives in new investments?

References

A Maguire, S. I. (2010). Relieving congestion at intermodal marine container terminals: review of tactical/operational strategies.

Abdi, M. H., & Daudén, F. J. (2021). Understanding transportation prerequisites to be integrated with urban development in developing countries: Iran as a Case. *Transportation Research Procedia*, 370-376.

Aftabuzzaman, M. D. (2007). *Measuring traffic congestion-a critical review.* London: 30th Australasian transport research forum.

Airport Cooperative Research Program. (2023). *NCHRP WebResource 1: Reducing Greenhouse Gas Emissions: A Guide for State DOTs.* Retrieved from https://crp.trb.org/nchrpwebresource1/wp-content/uploads/sites/23/2020/11/Table_B-1.pdf

Akhtar, N., Syakir Ishak, M. I., Bhawani, S. A., & Umar, K. (2021). Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. *Water*. doi:http://dx.doi.org/10.3390/w13192660

Anderson, S. T. (2011). *Automobile fuel economy standards: Impacts, efficiency, and alternatives. Review of Environmental Economics and Policy.*

Andersson, D., Nässén, J., Larsson, J., & Holmberg, J. (2014). Greenhouse gas emissions and subjective well-being: An analysis of Swedish households. *Ecological Economics*, 75-82.

ASEAN. (2023). *ASEAN Sustainable Urban Mobility Plans.* Retrieved from https://smmr.asia/topics/sustainable-urban-mobility-plans/

ASEAN Secretariat . (2016). *Masterplan on ASEAN Connectivity 2025*.

Asensio, C., Pavón, I., Ramos, C., López, J. M., Pamiés, Y., Moreno, D., & Arcas, G. d. (2021). Estimation of the noise emissions generated by a single vehicle while driving. *Transportation Research Part D: Transport and Environment*.

Associated British Ports. (2022). *Southampton*. Retrieved from Associated British Ports: https://www.abports.co.uk/locations/southampton/

Audoly, C., Gaggero, T., & Baudin, E. (2017). Mitigation of underwater radiated noise related to shipping and its impact on. *IEEE Journal of Oceanic Engineering*, 373-387.

Babisch, W. (2014, February 26). Updated exposure-response relationship between road traffic noise and coronary heart diseases: A meta-analysis. *Noise Health*, 1-9. Retrieved from Updated exposure-response relationship between road traffic noise and coronary heart diseases: A meta-analysis.: https://www.noiseandhealth.org/text.asp?2014/16/68/1/127847

Bailey, S. A. (2015). An overview of thirty years of research on ballast water as a vector for aquatic invasive species to freshwater and marine environments. *Aquatic Ecosystem Health & Management*, 261-268.

Balakrishna, R., Koutsopoulos, H. N., & Ben-Akiva, M. (2005). Calibration and validation of dynamic traffic assignment systems. *Transportation and Traffic Theory. Flow, Dynamics and Human Interaction*.

Batty, P., Palacin, R., & González-Gil, A. (2015). Challenges and opportunities in developing urban modal shift. *Travel Behaviour and Society*, 109-123.

Baustert, P., Gutiérrez, T. N., Gibon, T., Chion, L., Ma, T.-Y., Mariante, G. L., . . . Benetto, E. (2019). Coupling Activity-Based Modeling and Life Cycle Assessment—A Proof-of-Concept Study on Cross-Border Commuting in Luxembourg. *Geographic Data Science and Sustainable Urban Developments*.

Bharadwaj, S., Ballare, S., Rohit, & Chandel, M. K. (2017). Impact of congestion on greenhouse gas emissions for road transport in Mumbai metropolitan region. *Transportation Research Procedia*, 3538-3551.

Bickel, P., Friedrich, R., Link, H., Stewart, L., & Nash, C. (2006). Introducing Environmental Externalities into Transport Pricing: Measurement and Implications. *Transport Reviews*, 389–415.

Biennial Update Report to the UNFCCC. (2015). *Prepared by the outhors using data presented at Malaysia.*

Bosch, D. (2022, 10 25). *California's Zero Emissions Vehicle Rule and Its Nationwide Impacts*. Retrieved from https://www.americanactionforum.org/insight/californias-zero-emissions-vehicle-rule-and-its-nationwide-impacts/#:~:text=The%20California%20Air%20Resources%20Board,under%20the%20Clean%20Air%20Act.

Bozzi, A., & Aguilera, A. (2021). Shared E-scooters: A review of uses, health and environmental impacts, and policy implications of a new micro-mobility service. *Sustainability*.

Brink, M., Mathieu, S., & Rüttener, S. (2022). Lowering urban speed limits to 30 km/h reduces noise annoyance and shifts exposure–response relationships: Evidence from a field study in Zurich. *Environment International*.

Browne, M., Allen, J., & Woodburn, A. (2014). The potential for non-road modes to support environmentally friendly urban logistics. *Procedia-Social and Behavioral Sciences*, 29-36.

Buchwald, P., Christensen, G., & Larsen, H. (1979). Improvement of citybus fuel economy using a hydraulic hybrid propulsion system—A theoretical and experimental study. *SAE Transactions*, 1042-1056.

Bureau of Transportation Statistics. (2013). Retrieved from https://www.bts.gov/archive/publications/transportation_statistics_annual_report/2013/figure8_6

Bureau of Transportation Statistics. (2017). *U.S. Energy Use by Sector: 2015*. Retrieved from https://www.bts.gov/archive/publications/transportation_statistics_annual_report/2016/tables/ch7/fig7_1

Cahill, M. (2010). *Transport, Environment and Society.* New York: Open University Press.

Canitez, F., Alpkokin, P., & Kiremitci, S. (2020). Sustainable urban mobility in Istanbul: Challenges and prospects. *Case studies on transport policy*, 1148-1157.

Census of Population. (2020). Retrieved from https://www.singstat.gov.sg/-/media/files/publications/cop2020/sr1/cop2020sr1.pdf

Cheah, L., & Heywood, J. (2011). Meeting US passenger vehicle fuel economy standards in 2016 and beyond. Energy Policy.

Chiaramonti, D. (2019). Sustainable Aviation Fuels: the challenge of decarbonization. *Energy Procedia*, 1202-1207.

Chin, H. C., & Rahman, M. H. (2011). An impact evaluation of traffic congestion on ecology. *Planning Studies and Practice*, 20.

City of Melbourne. (2023). *City of Melbourne*. Retrieved from https://www.melbourne.vic.gov.au/parking-and-transport/transport-planning-projects/Pages/transport-planning-projects.aspx

Clark, C., & Stansfeld, S. (2016). The effect of transportation noise on health and cognitive development: A review of recent evidence. . *International Journal of Comparative Psychology*, 29.

Clean Water Action Council. (2023). *Environmental Impacts of Transportation*. Retrieved from Clean Water Action Council of Northeast Wisconsin: https://www.cleanwateractioncouncil.org/issues/resource-issues/transportation/

Cochrane, K., Saxe, S., Roorda, M. J., & Shalaby, A. (2017). Moving freight on public transit: Best practices, challenges, and opportunities. *International Journal of Sustainable Transportation*, 120-132.

COMCEC. (2023). Retrieved from www.comcec.org

D Muravev, H. H. (2021). Multi-agent optimization of the intermodal terminal main parameters by using AnyLogic simulation platform: Case study on the Ningbo-Zhoushan Port. *International Journal of Information Management*.

Daley, B. (2010). *Air Transport and the Environment.* London: Ashgate.

D'Amato, G., Cecchi, L., D'Amato, M., & Liccardi, G. (2010). Urban air pollution and climate change as environmental risk factors of respiratory allergy: an update. *Journal of Investigational Allergology and Clinical Immunology*, 95-102.

David, B., & Giordano-Spring, S. (2021). Climate reporting related to the TCFD framework: An exploration of the air transport sector. *Social and Environmental Accountability Journal*, 18-37.

D'Avignon, A., Carloni, F., La Rovere, E., & Dubeux, C. B. (2010). Emission inventory: An urban public policy instrument and benchmark. *Energy Policy*, 4838-4847.

Deloitte. (2022). Retrieved from https://www2.deloitte.com/uk/en/pages/consumer-business/articles/sustainable-consumer.html

Deloitte. (2022). *How consumers are embracing sustainability?* Retrieved from Deloitte: https://www2.deloitte.com/uk/en/pages/consumer-business/articles/sustainable-consumer.html

Denmark Ministry of Transport. (2018). *National Cycling Strategy 2018-2025.* Retrieved from https://www.trm.dk/da/trafik/cykling/national-cykelstrategi

Dora, C., & Phillips, M. (2000). *Transport, environment and health.* Regional Office for Europe: World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/326582

EC. (2020). *EU Biodiversity Strategy for 2030*. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380.

EEA. (2001, Jan 1). *Traffic noise exposure and annoyance*. Retrieved from European Environment Agency: https://www.eea.europa.eu/data-and-maps/indicators/traffic-noise-exposure-and-annoyance

EEA. (2013). *Green Infrastructure (GI) — Enhancing Europe's Natural Capital.* Retrieved from EEA: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0249

EEA. (2016). *Urban adaptation to climate change in Europe 2016: Transforming cities in a changing climate.* Luxembourg: Publications Office of the European Union.

EEA. (2021, May 11). *Aviation and shipping emissions in focus*. Retrieved from EEA: https://www.eea.europa.eu/articles/aviation-and-shipping-emissions-in-focus

EEA. (2021, Nov 18). *Emissions of air pollutants from transport*. Retrieved from European Environment Agency: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-8

EEA. (2023, April 27). *Greenhouse gas emissions from transport in Europe*. Retrieved from European Environment Agency (EEA): https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport

Ellison, R. B., Greaves, S. P., & Hensher, D. A. (2013). Five years of London's low emission zone: Effects on vehicle fleet composition and air quality. Transportation Research Part D: Transport and Environment. 23, 25-33.

Eltis. (2019, 11 28). *What is a Sustainable Urban Mobility Plan?* Retrieved from https://www.eltis.org/mobility-plans/11-what-sustainable-urban-mobility-plan

Eltis. (2022). *Barcelona*. Retrieved from Eltis - The Urban Mobility Observatory: https://www.eltis.org/content/barcelona

Emir, G., Fiona, R., & Nico, V. O. (2023). New perspectives on spatial and temporal aspects of aircraft noise: Dynamic noise maps for Heathrow airport. *Journal of Transport Geography*.

Endresen, Ø., Behrens, H., & Brynestad, S. (2004). Challenges in global ballast water management. *Marine pollution bulletin*, 615-623.

Energy Council of Canada. (2019). Retrieved from https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2019-total-system-electric-generation

Energy Market Authority. (2021). *Energy Consumption.*

EPA. (2000). *The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance.* Washington: EPA.

EPA. (2023). *NAAQS Table*. Retrieved from https://www.epa.gov/criteria-air-pollutants/naaqs-table

EU. (2000, 9 18). *Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles - Commission Statements.* Retrieved from Eur-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0053

EU. (2000). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.* Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32000L0060

EU. (2001). *Strategic Environmental Assessment*. Retrieved from European Comission (EU): https://environment.ec.europa.eu/law-and-governance/environmental-assessments/strategic-environmental-assessment_en

EU. (2008). *Natura 2000.* Retrieved from European Comission: https://ec.europa.eu/environment/nature/natura2000/index_en.htm

EU. (2011). *Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.* Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011L0092

EU. (2013). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Green Infrastructure (GI) — Enhancing Europe's Natural Capital.* Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52013DC0249

EU. (2013). *Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU.* Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013R1315-20190306

EU. (2014). *Directive 2014/94/EU of the European Parlimant and the Council of 22 October 2014 on the deployment of alternative fules infrastructure.* Retrieved from eUR-lEX: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0094

EU. (2019). Retrieved from The European Alternative Fuels Observatory (EAFO): https://alternative-fuels-observatory.ec.europa.eu/

EU. (2019). Retrieved from The European Alternative Fuels Observatory (EAFO): https://alternative-fuels-observatory.ec.europa.eu/

EU. (2021). *EU Emissions Trading System (ETS).* Retrieved from https://ec.europa.eu/clima/policies/ets_en

EU. (2023, 02 21). *circabc.europa.eu.* Retrieved from https://circabc.europa.eu/ui/group/3f466d71-92a7-49eb-9c63-6cb0fadf29dc/library/7b9cd7e5-c064-45db-acdf-5c87f5b76f70/details?download=true

EU. (2023, 02 21). *circabc.europa.eu.* Retrieved from https://circabc.europa.eu/ui/group/3f466d71-92a7-49eb-9c63-6cb0fadf29dc/library/7b9cd7e5-c064-45db-acdf-5c87f5b76f70/details?download=true

EU. (2023). *https://alternative-fuels-observatory.ec.europa.eu/*. Retrieved from European Commision: https://alternative-fuels-observatory.ec.europa.eu/

EU. (n.d.). *Clean Vehicles Directive*. Retrieved from European Commission: https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/clean-and-energy-efficient-vehicles/clean-vehicles-directive_en

EU. (n.d.). *Sustainable Urban Mobility Plans (SUMPs) and Cycling*. Retrieved from https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/cycling/guidance-cycling-projects-eu/policy-development-and-evaluation-tools/sustainable-urban-mobility-plans-sumps-and-cycling_en

European Commission. (2019). *EU*. Retrieved from The European Alternative Fuels Observatory (EAFO): https://alternative-fuels-observatory.ec.europa.eu/

European Commission. (2020). *Mapping good practices in strategic environmental assessment for transport plans and programmes: Final report.*

European Commission. (2021). *Zero Pollution Action Plan*. Retrieved from European Commission: https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en#:~:text=The%20zero%20pollution%20vision%20for,creating%20a%20toxic%2Dfree%20environment.

European Commission. (2021). *Zero Pollution Action Plan.*

European Commission. (2023, May 22). *Turkey*. Retrieved from European Alternative Fuels Observatory: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/turkey

European Commission Joint Research Centre. (2022). *Zero pollution : outlook 2022.* Publications Office of the European Union.

European Commission. (n.d.). *THE SEA MANUAL.* Retrieved from https://ec.europa.eu/environment/archives/eia/sea-studies-and-reports/pdf/beacon_manuel_en.pdf

European Commission, D.-G. f., McGuinn, O'Brien, Oulès, L., & J. (2020). *Mapping good practices in strategic environmental assessment for transport plans and programmes : final report.* Publications Office.

European Environment Agency. (2016). Urban adaptation to climate change in Europe 2016: Transforming cities in a changing climate.

European Environment Agency. (2023, March 14). *Noise pollution and health*. Retrieved from European Environment Agency: https://www.eea.europa.eu/publications/zero-pollution/health/noise-pollution

European Parliament. (2022, 05 10). *Revision of the Eurovignette Directive*. Retrieved from European Parliament: https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2017)614625

Evertse, C., & Visser, H. G. (2017). Real-time airport surface movement planning: Minimizing aircraft emissions. *Transportation Research Part C: Emerging Technologies*, 224-241.

Fairhurst. (2022). *PORT OF DUNDEE*. Retrieved from Fairhurst - Consulting Structural and Civil Engineers: https://www.fairhurst.co.uk/consultation/marine-licence-application-port-of-dundee/

Federal Aviation Administration. (2015). Retrieved from https://www.faa.gov/air_traffic/environmental_issues/ared_documentation#Optimization_of_Airspace_in_the_Metroplex_OAPM

Federal Highway Administration. (2018). *Noise Measurement Handbook Final Report.*

Federal Highway Administration. (2022). *Transportation Alternatives Program (TAP).* Retrieved from https://www.fhwa.dot.gov/environment/transportation_alternatives/program_overview/

Federal Highway Administration. (2023). Retrieved from Congestion Mitigation and Air Quality Improvement Program: https://www.fhwa.dot.gov/environment/air_quality/cmaq/

Federal Highway Administration. (2023). *Environmental Review Toolkit*. Retrieved from Federal Transportation Authorizations: https://www.environment.fhwa.dot.gov/legislation/federal_transportation_auth.aspx

Federal Interagency Committee. (2023). *Federal Agency Review of Selected Airport Noise Analysis Issues.*

Federal Ministry of Transport and Digital Infrastructure. (2019). *Electric Mobility Act*. Retrieved from https://www.bmvi.de/SharedDocs/EN/Publications/G/electric-mobility-act.html

Federal Ministry of Transport and Infrastructure. (2016). *The 2030 Federal Transport Infrastructure Plan.*

First Sustainable Urban Mobility Plan for Turkey. (n.d.). Retrieved from https://www.globalfuturecities.org/news/first-sustainable-urban-mobility-plan-turkey-announced-istanbul

Fischer, T. B. (2023). Strategic Environmental Assessment in Transport and Land Use Planning.

Fitzmaurice, M. (2022). *The International Convention for the Prevention of Pollution from Ships (MARPOL).* Research Handbook on Ocean Governance Law.

Garg, A., Shukla, P., & Kapshe, M. (2006). The sectoral trends of multigas emissions inventory of India. *Atmospheric Environment*, 4608-4620.

General Directorate Of State Airports Authority. (2023). Retrieved from https://www.dhmi.gov.tr/Lists/SsdHavacilikBilgiYnetimiSbMd_KurumsalBilveDoc/Attachments/7/Havac%C4%B1l%C4%B1k%20haritalar%C4%B1.pptx

Gharehbaghi, K., Hosseinian-Far, A., & Hilletofth, P. (2022). The predicaments of environmental impact assessment (EIA) for transport infrastructure: an examination of policy stagnation and progress. *Transforming Government: People, Process and Policy*.

Giles-Corti, B., Vernez-Moudon, A., Reis, R., Turrell, G., Dannenberg, A. L., Badland, H., . . . Owen, N. (2016). City planning and population health: a global challenge. *Lancet*, 2912–2924. doi:https://doi.org/10.1016/S0140-6736(16)30066-6

Giles-Corti, B.-M. A. (n.d.).

Girvin, R. (2009). Aircraft noise-abatement and mitigation strategies. *Journal of air transport management*, 14-22.

Gollasch, S., David, M., Voigt, M., Dragsund, E., & Hewitt, C. (2007). Critical review of the IMO international convention on the management of ships' ballast water and sediments. *Harmful algae*, 585-600.

Gossling, S., & Upham, P. (2012). *Climate Change and Aviation: Issues, Challenges and Solutions.* New York: Earthscan.

GOV.UK. (2019). Retrieved from https://www.gov.uk/guidance/measuring-and-reporting-environmental-impacts-guidance-for-businesses#reporting-transport-emissions

GOV.UK. (2023). Retrieved from https://www.gov.uk/government/statistics/provisional-uk-greenhouse-gas-emissions-national-statistics-2022

GOV.UK. (2023). Retrieved from https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env#pollutants-emissions-and-noise-env03

GOV.UK. (2023). *Additional information on assumptions used to develop decarbonising transport scenarios.*

Greater Amman Municipality. (2017). *Environmental and Social Impact Assesment Report for the Amman and Amman-Zarqa Bus Rapid Transit (BRT) Systems.*

Gyllenbögel, A. (2021). *A new law has now come into force: Up to half of Finnish municipalities' vehicle capacity must soon be covered by electric vehicles*. Retrieved from Vedia: https://www.vedia.fi/a-new-law-has-now-come-into-force-up-to-half-of-finnish-municipalities-vehicle-capacity-must-soon-be-covered-by-electric-vehicles/

Hall, C. A., & Crichton, D. (2007). Engine design studies for a silent aircraft. *Journal of Turbomachinery*, 479-487.

Hands, S., & Hudson, M. D. (2006). Incorporating climate change mitigation and adaptation into environmental impact assessment: a review of current practice within transport projects in England. *Impact Assessment and Project Appraisal* , 330-345.

Heathcote, C. (2017). *Forecasting infrastructure investment needs for 50 countries, 7 sectors through 2040*. (Global Infrastructure Outlook) Retrieved from World Bank Blogs: https://blogs.worldbank.org/ppps/forecasting-infrastructure-investment-needs-50-countries-7-sectors-through-2040

Hester, R., & Harrison, R. (2004). *Transport and the Environment.* Cambridge: The Royal Society of Chemistry.

Hidas, P. (2005). A functional evaluation of the AIMSUN, PARAMICS and VISSIM microsimulation models. *Road & Transport Research*, 45.

Hoefnagels, R., Wetterlund, E., Pettersson, K., & Faaij, A. (2017). Cost optimization of biofuel production–The impact of scale, integration, transport and supply chain configurations. *Applied energy*, 1055-1070.

Holman, C., Harrison, R., & Querol, X. (2015). Review of the efficacy of low emission zones to improve urban air quality in European cities. 111, 161-169.

Holmatov, B., & Hoekstra, A. Y. (2020). The Environmental Footprint of Transport by Car Using Renewable Energy. *Earth's Future*.

Humphreys, I. (1999). Privatisation and commercialisation: changes in UK airport ownership patterns. Journal of Transport Geography. In I. Humphreys.

Hung-Lung, C., Ching-Shyung, H., Shih-Yu, C., Ming-Ching, W., Sen-Yi, M., & Yao-Sheng, H. (2007). Emission factors and characteristics of criteria pollutants and volatile organic compounds (VOCs) in a freeway tunnel study. *Science of The Total Environment*, 200-211.

ICAO. (2020). Carbon Offsetting and Reduction Scheme for International Aviation. *Magazine of Aviation Development*, 23-28.

ICCT. (2016, 06). *A technical summary of Euro 6/VI vehicle emission standards.* Retrieved from The International Council on Clean Transportation: https://theicct.org/sites/default/files/publications/ICCT_Euro6-VI_briefing_jun2016.pdf

IEA. (2021). *Final consumption*. Retrieved from World total final consumption by source: https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

IEA. (2023). *Global CO2 emissions by sector, 2019-2022*. Retrieved from https://www.iea.org/data-and-statistics/charts/global-co2-emissions-by-sector-2019-2022

Illinois Environmental Council. (2023). Retrieved from https://ilenviro.org/energy/#:~:text=Energy%20in%20Illinois,nation)%20and%2010%25%20renewables

Institute for Transportation & Developement Policy [ITDP]. (2016). *China's Shared Mobility Strategy*. Retrieved from ITDP: http://www.itdp-china.org/itdpweb/ensharemobility/

International Energy Agency [IEA]. (2022). *Global Energy and Climate Model Documentation.* International Energy Agency (IEA).

Intertek. (2015). *Intertek supports National Grid on UK-Norway Interconnector*. Retrieved from Intertek: https://www.intertek.com/news/2015/06-11-national-grid-uk-norway-interconnector/

Ionel, I., Nicolae, D., Popescu, F., Talianu, C., Livio, B., & Apostol, G. (2011). Measuring air pollutants in an international Romania airport with point and open path instruments. *Romanian Journal of Physics*, 507-519.

IPCC. (2007). *Transport and its infrastructure In Climate Change Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Islam, D., Ricci, S., & Nelldal, B. (2016). How to make modal shift from road to rail possible in the European transport market, as aspired to in the EU Transport White Paper 2011. *European transport research review*, 1-14.

Istanbul Metropolitan Municipality. (2017). *Istanbul Metropolitan Municipality.* Retrieved from https://tuhim.ibb.gov.tr/media/2172/%C4%B0bb-ula%C5%9Fim-raporu-2017-eng_son.pdf

ITDP. (2020, 1). *Non-Motorized Transport Policy Guideline for Mid-Size Cities in Indoesia.* Retrieved from http://airqualityandmobility.org/STR/Indonesia_NMT_PolicyGuideline_English.pdf

Jaramillo, P., Ribeiro, S. K., & Newman, P. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK, UK: Cambridge University Press,. doi:10.1017/9781009157926.012

Jaramillo, P., Ribeiro, S. K., & Newman, P. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK, UK: Cambridge University Press. doi:10.1017/9781009157926.012

Jarup, L., Dudley, M.-L., Babisch, W., Houthuijs, D., Swart, W., Pershagen, G., . . . Vigna-Taglianti, F. (2005). Hypertension and exposure to noise near airports (HYENA): study design and noise exposure assessment. *Environmental health perspectives*, 1473-1478.

Jeon, C. M., & Amekudzi, A. (2005). Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics. *Journal of Infrastructure Systems*.

Jerrett, M., Arain, A., Kanaroglou, P., Beckerman, B., Potoglou, D., Sahsuvaroglu, T., . . . Giovis, C. (2005). A review and evaluation of intraurban air pollution exposure models. *Journal of Exposure Science & Environmental Epidemiology*, 185-204.

Kawada, T. (2011). Noise and health—Sleep disturbance in adults. *Journal of occupational health*, 413-416.

Kim, S., Lim, D., & Lee, K. (2018). Reduced-order modeling applied to the aviation environmental design tool for rapid noise prediction. *Journal of Aerospace Engineering*.

Köllinger, C. (2022, 11 2). *Barcelona updates its Urban Mobility Plan 2024.* Retrieved from eltis.org: https://www.eltis.org/in-brief/news/barcelona-updates-its-urban-mobility-plan-2024

Kontovas, C., & Psaraftis, H. (2011). Reduction of emissions along the maritime intermodal container chain: operational models and policies. *Maritime Policy & Management*, 451-469.

Kurniawan, J. S., & Khardi, S. (2011). Comparison of methodologies estimating emissions of aircraft pollutants, environmental impact assessment around airports. *Environmental impact assessment review*, 240-252.

Lam, D., & Head, P. (2012). Sustainable urban mobility. *Energy, Transport, & the Environment: Addressing the Sustainable Mobility Paradigm*, 359-371.

Land Transport Authority. (2023). Retrieved from Singapore Rail Network: https://www.lta.gov.sg/content/ltagov/en/getting_around/public_transport/rail_network.html

Lee, B.-J., Kim, B., & Lee, K. (2014). Air pollution exposure and cardiovascular disease. *Toxicological research*, 71-75.

Lee, N., & Walsh, F. (1992). Strategic environmental assessment: an overview. *Project Appraisal 7:3*, 126-136.

Li, J. (2011). Decoupling urban transport from GHG emissions in Indian cities—A critical review and perspectives. *Energy policy*, 3503-3514.

Liu, J., Li, W., & Li, J. (2016). Quality screening for air quality monitoring data in China. *Environmental pollution*, 720-723.

Ližbetin, J. (2019). Methodology for determining the location of intermodal transport terminals for the development of sustainable transport systems: A case study from Slovakia. *Sustainability*, 1230.

Lyle, C. (2018). Beyond the icao's corsia: Towards a More Climatically Effective Strategy for Mitigation of Civil-Aviation Emissions. *Climate Law*, 104-127.

M Hrušovský, E. D. (2018). Hybrid simulation and optimization approach for green intermodal transportation problem with travel time uncertainty. *Flexible Services and Manufacturing Journal*, 486-516.

M Rahimi, A. A.-V. (2008). Integrating inland ports into the intermodal goods movement system for ports of Los Angeles and Long Beach. *MT Center*.

Ma, L., Graham, D. J., & Stettler, M. E. (2021). Has the ultra low emission zone in London improved air quality. 16(12), 124001.

Maantay, J. (2007). Asthma and air pollution in the Bronx: Methodological and data considerations in using GIS for environmental justice and health research. *Health & place*, 32-56.

Macharis, C., Meers, D., & Lier, T. (2015). Modal choice in freight transport: combining multi-criteria decision analysis and geographic information systems. *International Journal of Multicriteria Decision Making*, 355-371.

MacKay, D. J. (2008). *Sustainable Energy–without the hot air.*

Malaysia Ministry of Energy. (2017). *Green Technology Master Plan 2017-2030.*

Malaysia Ministry of Energy. (2022). *National Energy Policy 2022-2040.*

Malina, C., & Scheffler, F. (2015). The impact of Low Emission Zones on particulate matter concentration and public health. *Transportation Research Part A*, 372-385.

Markus, T., & Sánchez, P. P. (2018). *Managing and regulating underwater noise pollution.*

Masiol, M., & Harrison, R. M. (2014). Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review. *Atmospheric Environment*, 409-455.

Matsumoto, H. (2004). International urban systems and air passenger and cargo flows: some calculations. *Journal of Air Transport Management*, 239-247.

Matthes, S., Niklaß, M., Linke, F., Maertens, S., Plohr, M., Scheelhaase, J., & Wozny, F. (2022). Testing of a Monitoring, Reporting & Verification (MRV) Scheme for the integration of non-CO2 aviation effects into EU ETS. *The 5th International Conference on Transport, Atmosphere and Climate (TAC-5)*, 27.-30.

Metz, D. (2018). Tackling urban traffic congestion: The experience of London, Stockholm and Singapore. *Case Studies on Transport Policy*, 494-498.

Ministry of Climate,Energy and Utilities. (2019). *Climate and Air Plan.* Retrieved from https://ens.dk/en/our-services/plans-strategies-and-analyses/energy-and-climate-plans/climate-and-air-plan

Ministry of Energy and Natural Resources. (2017). Retrieved from https://www.enerji.gov.tr/files/uploads/duyurular/AFRegulation_eng.pdf

Ministry of Environment. (2014). *Guidance for Preparing Environmental Impact.*

Ministry of Environment. (2021). *The Development of East Coast Rail Link Project (ECRL).*

Ministry of Environment. (2022). *National Climate Change Policy of the Hashemite.*

Ministry of Environment. (2023). *Malaysia EIA report*. Retrieved from https://enviro2.doe.gov.my/ekmc/more-eia-report/

Ministry of Environment and Urbanization. (2017). *Sustainable Transportation Action Plan.* Retrieved from https://www.csb.gov.tr/db/iklimdegisikligi/files/2017/Turkey_Sustainable_Transportation_Action_Plan_2017.pdf

Ministry of Natural Resources and Environment Malaysia. (2016). *Environmental Impact Assessment Guideline in Malaysia.*

Ministry of Transport. (2016). *Jordan Long-Term National Transport Strategy and Action Plan.*

Ministry of Transport. (2020). *Green Transport Fund.* Retrieved from https://www.trm.dk/en/transport-policy/green-transport-fund/

Ministry of Transport. (2023). *Jordan - Bus Rapid Transit between Amman and Zarqa cities.*

Ministry of Transport Malaysia. (2016). *Malaysia Stocktaking Report on Sustainable Transport and Climate Change.*

Mishra, R. K., Kumar, K., Nair, K., & Shukla, A. (2021). Dynamic noise mapping of road traffic in an urban city. *Arabian Journal of Geosciences*, 1-11.

More, S. R. (2010). Aircraft noise characteristics and metrics. *Purdue University*.

Morimoto, A. (2015). Transportation and land use. *Traffic and safety sciences: Interdisciplinary Wisdom of IATSS*, 22-30.

Morrell. (2009). The potential for European aviation CO2 emissions reduction through the use of larger jet aircraft. *Journal of Air Transport Management*, 151-157.

Morrell, S., Taylor, R., & Lyle, D. (1997). A review of health effects of aircraft noise. *The Australian and New Zealand Journal of Public Health* , 221-236.

Nadeem, O., & Fischer, T. B. (2011). An evaluation framework for effective public participation in EIA in Pakistan. *Environmental Impact Assessment Review*, 36-47.

Naganathan, H., & Chong, W. K. (2017). Evaluation of state sustainable transportation performances (SSTP) using sustainable indicators. *Sustainable Cities and Society*, 799-815.

Nairobi City County Government. (2015, 3). *Non-Motorized Transport Policy.* Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/25413/NairobiCity_%20Non-MotorizedTransportPolicy.pdf?sequence=1&isAllowed=y

National Highway Traffic Safety Administration. (2022). *Corporate Average Fuel Economy.* Retrieved from https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy-cafe-standards

National Platform for Future of Mobility. (2019). *Progress Report of the National Platform for Future of Mobility.*

National Platform Future of Mobility. (2021). *About the NPM.* Retrieved from NPM: https://www.plattform-zukunft-mobilitaet.de/en/about-the-npm/

Netjasov, F. (2012). Contemporary measures for noise reduction in airport surroundings. *Applied Acoustics*, 1076-1085.

O Piterina, A. M. (2019). Energy Consumption of Rail Baltica Project: Regional Aspects of Environmental Impact. *Economics and Culture*, 148-160.

OECD. (2010). *Globalisation, Transport and the Environment.* OECD.

OECD. (2011). *OECD Green Growth Studies: Towards Green Growth.* Paris: OECD Publishing. doi:https://doi.org/10.1787/9789264111318-en

OECD. (2011). *Towards green growth: Monitoring progress: OECD indicators.*

OECD. (2013). Definition of Functional Urban Areas (FUA) for the OECD metropolitan database.

OECD. (2014). *The Cost of Air Pollution: Health Impacts of Road Transport.* Paris: OECD Publishing. doi:https://doi.org/10.1787/9789264210448-en

OECD. (2014). *The Cost of Air Pollution: Health Impacts of Road Transport.* Paris: OECD Publishing.

OECD. (2022). *Spending on Transport Infrastructure.* Retrieved from https://www.itf-oecd.org/sites/default/files/docs/inland-transport-infrastructure-investment-brief-2022.pdf

Ong, H., Mahlia, T., & Masjuki, H. (2011). A review on emissions and mitigation strategies for road transport in Malaysia. *Renewable and Sustainable Energy Reviews*, 3516-3522.

overview, B. r. (2002). HS Levinson, S Zimmerman, J Clinger. *Journal of Public Transportation*, 1-30.

Ozkurt, N., Sari, D., Kutukoglu, M., & Gurarslan, A. (2014). Modeling of noise pollution and estimated human exposure around İstanbul Atatürk Airport in Turkey. *Science of the Total Environment*, 486-492.

P Buchwald, G. C. (1979). Improvement of citybus fuel economy using a hydraulic hybrid propulsion system—A theoretical and experimental study. *SAE Transactions*, 1042-1056.

P Mirchandani, F. W. (2005). RHODES to intelligent transportation systems. *IEEE Intelligent Systems*, 10-15.

Parker, D. (1999). The performance of BAA before and after privatisation: A DEA study. Journal of Transport Economics and policy.

Penner, J. E., Lister, D. H., & Griggs, D. J. (1999). *Aviation and the Global Atmosphere.* Cambridge: Cambridge University Press.

Periáñez, R. (2007). Chemical and oil spill rapid response modelling in the Strait of Gibraltar–Alborán Sea. *Ecological Modelling*, 210-222.

Pope, C. A., & Dockery, D. W. (2006). Health effects of fine particulate air pollution: lines that connect. *Journal of the Air & Waste Management Association*, 709–742. doi:https://doi.org/10.1080/10473289.2006.10464485

Popescu, F., Ionel, I., & Talianu, C. (2011). Evaluation of air quality in airport areas by numerical simulation. *Environmental Engineering and Management Journal*, 115.

Postorino, M. N., & Mantecchini, L. (2014). A transport carbon footprint methodology to assess airport carbon emissions. *Journal of Air Transport Management*, 76-86.

Postorino, M. N., & Mantecchini, L. (2016). A systematic approach to assess the effectiveness of airport noise mitigation strategies. *Journal of Air Transport Management*, 71-82.

Prats, X., Puig, V., & Quevedo, J. (2011). *A multi-objective optimization strategy for designing aircraft noise abatement procedures. Case study at Girona airport.* Castelldefels.

Pritchard, J. A., & Preston, J. (2018). Understanding the contribution of tunnels to the overall energy consumption of and carbon emissions from a railway. *Transportation Research Group, University of Southampton*.

Prussi, M., Lee, U., Wang, M., Malina, R., & Valin, H. (2021). CORSIA: The first internationally adopted approach to calculate life-cycle GHG emissions for aviation fuels. *Renewable and Sustainable Energy Reviews*.

Pucher, J., & Buehler, R. (2017). Cycling towards a more sustainable transport future. *Transport Reviews*, 689-694.

Ramsar Site Information Service. (2022). *Ramsar Site Information Service*. Retrieved from Ramsar Site Information Service: https://rsis.ramsar.org/

Ranasinghe, K., Guan, K., Gardi, A., & Sabatini, R. (2019). Review of advanced low-emission technologies for sustainable aviation. *Energy*.

Randal, E., Shaw, C., McLeod, M., Woodward, A., & Mizdrak, A. (2022). The Impact of Transport on Population Health and Health Equity for Māori in Aotearoa New Zealand: A Prospective Burden of Disease Study. *International Journal of Environmental Research and Public Health*, 19. doi:http://dx.doi.org/10.3390/ijerph19042032

Rayegani, A. (2021). Synergies between the obligations and measures to reduce vessel-source underwater noise and greenhouse gas emissions. *Sustainability in the Maritime Domain: Towards Ocean Governance and Beyond*, 235-256.

Reck, H., & Schulz, B. (2011). Field Guide to the Holstein Habitat Corridors.

Ribeiro, S. K., & Kobayashi, S. (2007). Transport and It's Infrastructure. *Climate Change*.

Rodrigue, J. P. (2020). *The Geography of Transport Systems.* London: Routledge. doi:https://doi.org/10.4324/9780429346323

Rodrigue, J. P. (2020). *Transport, Energy and Environment In the Geography of Transport Systems.* Routledge, Taylor & Francis Group.

Ryerson, M. S., Hansen, M., & Bonn, J. (2011). Fuel consumption and operational performance. *Ninth USA/Europe Air Traffic Management Research and Development Seminar*, 1-10.

S Gössling, M. S. (2016). Urban space distribution and sustainable transport. *Transport Reviews*, 659-679.

S Papadimitriou, D. L. (2018). 'Motorways of the Sea'(MoS) and Related European Policies. *The Dynamics of Short Sea Shipping: New Practices and Trends*, 119-161.

Sallis, J. F., Cerin, E., Conway, T. L., Adams, M. A., Frank, L. D., Pratt, M., . . . Van Dyck, D. (2016). Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. *Lancet*, 2207–2217. doi:https://doi.org/10.1016/S0140-6736(15)01284-2

Samberg, S., Bassok, A., & Holman, S. (2011). Method for Evaluation of Sustainable Transportation: Toward a Comprehensive Approach. *Volume 2242, Issue 1*.

Saxena, A., & Habib, B. (2022). Safe Passage or Hunting Ground? A Test of the Prey-Trap Hypothesis at Wildlife Crossing Structures on NH 44, Pench Tiger Reserve, Maharashtra, India. *Diversity*. doi:https://doi.org/10.3390/d14050312

Schlenker, W., & Walker, W. R. (2016). Airports, air pollution, and contemporaneous health. *The Review of Economic Studies*, 768-809.

Schuitema, G., Steg, L., & Kruining, M. v. (2011). When Are Transport Pricing Policies Fair and Acceptable? *Soc Just Res*, 66–84.

Sen, B. N. (2017). Will Corporate Average Fuel Economy (CAFE) Standard help? Modeling CAFE's impact on market share of electric vehicles. *Energy Policy, 109*, 279-287.

Sen, B., Noori, M., & Tatari, O. (2017). Will Corporate Average Fuel Economy (CAFE) Standard help? Modeling CAFE's impact on market share of electric vehicles. *Energy Policy*, 279-287.

Shahid, S., Minhans, A., & Puan, O. C. (2014). Assesment of greenhouse gas emission reduction measures in transportation sector of Malaysia. 70(4), 1-8.

Sittig, S. E., Nesbitt, J. C., Krageschmidt, D. A., Sobczak, S. C., & Johnson, R. V. (2011). Noise levels in a neonatal transport incubator in medically configured aircraft. *International Journal of Pediatric Otorhinolaryngology*, 74-76.

Soleymani, S. (2022). CO2 emissions and the transport sector in Malaysia. 9.

Soria-Lara, J. A., Batista, L., Pira, M. L., Arranz-López, A., Arce-Ruiz, R. M., Inturri, G., & Pinho, P. (2020). Revealing EIA process-related barriers in transport projects: The cases of Italy, Portugal, and Spain. *Environmental Impact Assessment Review*.

Statista. (2023). *Carbon dioxide emissions of transport sector worldwide*. Retrieved from Statista: https://www.statista.com/statistics/1291615/carbon-dioxide-emissions-transport-sector-worldwide/

Statista. (2023). *Statista*. Retrieved from https://www.statista.com/statistics/1291615/carbon-dioxide-emissions-transport-sector-worldwide/

Steinemann, A. (2001). Improving alternatives for environmental impact assessment. *Environmental Impact Assessment Review*, 3-21.

Strouhal, M. (2020). CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation. *Magazine of Aviation Development*.

T. E. (2000). *Directive 2000/53/EC on end-of life vehicles* . European Comission.

Tang, H., & Zhang, Y. (2018). Reducing Airport Pollution and Consequent Health Impacts to Local Community. *U.S. Department of Transportation*.

Teles, M. d., & Sousa, J. F. (2014). Environmental Management and Business Strategy: Structuring the Decision-Making Support in a Public Transport Company. *Transportation Research Procedia*, 155-164.

Tenaga, S. (2020). *Malaysia Energy Statistics Handbook.*

Texas Department of Transportation-Shared Mobility Programs. (2016). *SHARED MOBILITY PROGRAMS - GUIDEBOOK FOR AGENCIES* . Retrieved from https://communications.tti.tamu.edu//files/2016/10/Shared-Mobility-Guidebook-0-6818-P1.pdf

The Institute of Noise Control Engineering of the USA. (2023, May). *What is Noise?* Retrieved from INCEUSA: https://www.inceusa.org/about-ince-usa/what-is-noise/

The Institute of Noise Control Engineering of the USA. (n.d.). *What is Noise?* Retrieved from INCEUSA: https://www.inceusa.org/about-ince-usa/what-is-noise/

The Ministry of Environment. (2020). *guidelines for transportation and road projects.* Retrieved from https://enviro2.doe.gov.my/ekmc/digital-content/eia-guidelines-for-transportation-and-road-projects/

The World Bank. (2022). *Jordan Public Transport Diagnostic and Recommendations.*

The World Bank Group. (2022). *Jordan Country Climate and Development Report.* Retrieved 10 08, 2023, from https://openknowledge.worldbank.org/server/api/core/bitstreams/7c81f-f9b-6f43-5648-be15-b2e2b25d1d33/content

Tomkins, J., Topham, N., Twomey, J., & Ward, R. (1998). Noise versus access: The impact of an airport in an urban property market. *Urban studies*, 243-258.

Toth, C., Suh, W., Elango, V., Sadana, R., Guin, A., Hunter, M., & Guensler, R. (2013). Tablet-based traffic counting application designed to minimize human error. *ransportation research record*, 39-46.

Transport & Environment. (2016). *The Belgian Example: A Successfull Distance-Based Tool for Trucks.* Retrieved from Transport & Environment: https://www.transportenvironment.org/wp-content/uploads/2021/07/2016_03_briefing_Belgium_Road_Charge_FINAL_0.pdf

Transport for London. (2023). Retrieved from https://tfl.gov.uk/ruc-cdn/static/cms/images/ulez-boundary-map.gif

Transport for London. (2023). *Ultra Low Emission Zone*. Retrieved from https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ways-to-meet-the-standard

Trumbull, N., & Bae, C. (2000). *Transportation and Water Pollution*.

U.S. Department of Transportation. (2023). *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* Retrieved from https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

U.S. Federal Highway Administration. (2008). *A Review of HOV Lane Performance and Policy Options in the United States.*

U.S. Fuel Economy. (2023). *Greenhouse Gas Emissions from Electric and Plug-In Hybrid Vehicles*. Retrieved from https://fueleconomy.gov/feg/Find.do?action=bt2

UK Department for Transport. (2020). *Decarbonising Transport Setting the Challenge.*

UK Department for Transport. (2022). *Decarbonising Transport- A Better Greener Britain.*

UK Department for Transport. (2023). *TAG Unit A1.1 Cost-Benefit Analiysis.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1164818/tag-unit-a1.1-cost-benefit-analysis-may-2023-v1.0.pdf

Underhill, J., & Angold, P. (1999). Effects of roads on wildlife in an intensively modified landscape. *Environmental Reviews*, 21-39.

United Nations Economic Commission for Europe. (2018). *Case Study Fact Sheet: German Federal Transport Infrastructure Plan.*

United Nations Environment Programme. (2022). *Mapping environmental risks in the transport sector: Current practices and future challenges.*

Van Parijs, S., Clark, C., & Sousa-Lima, R. (2009). Management and research applications of real-time and archival passive acoustic sensors over varying temporal and spatial scales. *Marine Ecology Progress Series*, 21-36.

Vardoulakis, S., Gonzalez-Flesca, N., Fisher, B. E., & Pericleous, K. (2005). Spatial variability of air pollution in the vicinity of a permanent monitoring station in central Paris. *Atmospheric Environment*, 2725-2736.

Waheed, F., Ferguson, G. M., Ollson, C. A., MacLellan, J. I., McCallum, L. C., & Cole, D. C. (2018). Health Impact Assessment of transportation projects, plans and policies: A scoping review. *Environmental Impact Assessment Review*, 17-25.

Walker, T. R., Adebambo, O., Feijoo, M. C., Elhaimer, E., Hossain, T., Edwards, S. J., . . . Zomorodi, S. (2019). Environmental Effects of Marine Transportation. *Volume III: Ecological Issues and Environmental Impacts*, 505-530.

Wang. (2010). Shaping urban transport policies in China: Will copying foreign policies work? *Transport Policy*, 147-152.

Wang, L., Xue, X., Zhao, Z., & Wang, Z. (2018). The Impacts of Transportation Infrastructure on Sustainable Development: Emerging Trends and Challenges. *International journal of environmental research and public health*.

Wang, Y., & Miao, Q. (2021). The impact of the corporate average fuel economy standards on technological changes in automobile fuel efficiency. *Resource and Energy Economics*.

Wellings, R. (2014). The privatisation of the UK railway industry: An experiment in railway structure. Economic affairs.

WHO. (2011). Burden of disease from environmental noise: quantification of healthy life years lost in Europe. *World Health Organization*. Retrieved from https://apps.who.int/iris/handle/10665/326424

WHO. (2016). Ambient air pollution: a global assessment of exposure and burden of disease. *WHO*. Retrieved from https://apps.who.int/iris/handle/10665/250141

WHO. (2018). *Global status report on road safety 2018.* France: World Health Organization.

WHO. (2022, December 19). *Ambient (outdoor) air pollution*. Retrieved from WHO: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

WHO. (2022, December 19). *Ambient (outdoor) air pollution*. Retrieved from World Health Organization: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health#:~:text=Ambient%20(outdoor)%20air%20pollution%20in,and%20respiratory%20disease%2C%20and%20cancers.

Wilcox, J., Nasiri, F., Bell, S., & Rahaman, M. (2016). Urban water reuse: A triple bottom line assessment framework and review. *Sustainable cities and society*, 448-456.

Wiley. (2018). *Handbook of Environmental Engineering.*

World Bank. (2023). Retrieved from documents1.worldbank.org

World Business Council for Sustainable Development. (2008). *Managing End-of-Life Tires.* World Business Council for Sustainable Development.

Yang, B., Gu, J., Zhang, T., & Zhang, K. M. (2019). Near-source air quality impact of a distributed natural gas combined heat and power facility. *Environmental pollution*, 650-657.

Zachary, D. S., Gervais, J., & Leopold, U. (2010). Multi-impact optimization to reduce aviation noise and emissions. *Transportation Research Part D: Transport and Environment*, 82-93.

Zaporozhets, O., Attenborough, K., & Tokarev, V. (2011). *Aircraft Noise: Assessment, prediction and control.* New York: CRC Press.

Zdravev, A. (2017). Port sustainability practices: a case study of port of rotterdam and port of los angeles. *Port and Transport Economics Erasmus University Rotterdam, Department of Urban*.

Zhai, M., & Wolff, H. (2021). Air pollution and urban road transport: evidence from the world's largest low-emission zone in London. 1-28.

Zhu, D., & Ru, J. (2008). Strategic environmental assessment in China: Motivations, politics, and effectiveness. *Journal of Environmental Management*, 615-626.

Zuniga-Garcia, N., Machemehl, R. B., & Ross, H. W. (2018). Multimodal Level of Service Methodologies: Evaluation of the Multimodal Performance of Arterial Corridors. *Transportation Research Record*, 142-154.