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Shahlina Afreen
MASTER THESIS

EKONOMINIS TVARAUS TRANSPORTO POVEIKIS MIESTO ANGLIES IŠMETIMUI: ATVEJO ANALIZĖS METODAS	**THE ECONOMIC IMPACT OF SUSTAINABLE TRANSPORTATION ON URBAN CARBON EMISSIONS: A CASE STUDY APPROACH**

Supervisor: Assoc. Prof. Dr. Agnė Laužadytė-Tutlienė

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Introduction

Urbanization prevailing across the globe in recent decades has massively relied on traditional ways, which are primarily affecting the carbon footprints in cities. These emissions, primarily caused by the burning of fossil fuels, therefore present multiple environmental and public health impacts (IPCC, 2014). Concerning these effects, sustainable transport technologies have emerged as ways of addressing them through environmentally friendly means that are both sustainable and friendly to the economy. Environment-friendly transport has now become an inevitable choice for alleviating the problem of carbon emissions in cities and environmental impact. Cities contribute to a large extent to global emissions, owing to high population densities and overreliance on conventional energy-intensive transport systems (IPCC, 2014). Road transportation in Lithuania by Liobikienė and Miceikienė (2022) was found to be a significant source of emissions in conventional transport, with CO_2 being a major emission. The environmental and health effects resulting from these emissions have therefore boosted pressure for sustainable solutions to mobility in urban areas. Green mobility therefore refers to techniques employed to reduce carbon emissions and enhance environmentally friendly methods. These are light rail, bus systems, bike facilities, electric cars, and walkable cities. According to Cervero and Kockelman (1997), use of land-use planning and mixed-use community designs provide dramatic reductions on transport needs and supports sustainable development. The advocacy of other modes like bicycles and walking reduces reliance on motor cars, thereby reducing urban emissions as well in Lithuania (Bobinaite et Al., 2023).

Relevance of the Topic:

The research problem on sustainable transportation and its effects on the carbon footprint of cities and the economy is real and theoretical. In practice, it deals with practical problems with global and regional significance, including changes in climate and the sustainable development of cities, which demand the use of big data analysis. From a theoretical standpoint, it helps to develop knowledge of interconnection between transport choices, economic performance, and effects on the environment based on such concepts as transport justice and transport integration (Martens, 2016; Givoni & Banister, 2010).

Level of Exploration

While the topic has been discussed in different settings there are still some research questions about the interrelation between environmental and economic effects of sustainable

transport. Some examples of topics for analysis of travel behavior are public transport usage (Currie & Delbosc, 2013), choice of AFVs (Hoen & Koetse, 2014), and the impact of cycling infrastructure on people's mobility (Pucher & Buehler, 2008). Still, limited research links user-level data to measure perception or uptake of sustainable transport technologies with specific reference to economic implications for the environment.

Novelty of the Master Thesis

To initiate this work, this thesis proposes a new user-oriented approach by using a questionnaire to investigate how people regard the economic and environmental aspects of sustainable transport. As a blend of qualitative and whoever research approach (Creswell & Creswell, 2018), it identifies users' preference, uptake and perceived value in more transport systems, including electric cars, public transport and bikes (Yin, 2018; Saunders et al., 2009).

Research Question/Research Problem

What is the impact of sustainable transportation on urban carbon emissions?

- To evaluate how sustainable transportation reduces urban carbon emissions.
- Comparing the effectiveness of various sustainable transportation strategies.
- To identify barriers to adopting sustainable transportation systems.
- To recommend policies for maximizing carbon reduction.

Research Gap and Significance

While sustainable transportation is widely recognized for its environmental benefits, its economic impact remains underexplored. The studies conducted so far have not addressed the issue of how these women – a group of people who are worthy of being researched for their own sake as people, function phenomenological while in the process of, or after transitioning from independent living to assisted living. (Cervero and Duncan, 2003).

Significance of the Study

This research is valuable for the following reasons: it does not only highlight the scope of sustainable transport in a broad economic sense but also in an environmental context. To that end, focusing on economic effects, such as costs, employment, and property value, the study provides policymakers with basic data on investing in sustainable transportation systems (Litman, 2021).

Further, it explores how these systems help in integrated emissions control to accord with the global sustainability standards (Mulley, 2017).

Methods Deployed

Questionnaire Design: In line with the identified thematic topics within the existing literature, the questionnaire elicits information on user actions or practices, users' preferences and perceived utility of sustainable transportation systems as envisaged in the study (Braun and Clarke, 2006).

Description of the Structure

The thesis is organized as follows:

- Introduction: Outlines the nature of the study, aims and objectives, and delimiters of the study.
- Literature Review: Reviews literature on sustainable transport and determines priority zed gaps covered by user-oriented research.
- Methodology: Excludes or explains how the design, deployment and analysis of the questionnaire was done.
- Results and Discussion: Summarizes the results derived from the questionnaires' data analysis and discusses them with reference to the theories and concepts presented in the literature review.
- Conclusion: Summarizes key findings, potential practical applications of the given policy, potential further studies.

THEORATICAL IMPACT ON THE ECONOMIC IMPACT OF SUSTAINABLE TRANSPORTATION ON URBAN CARBON EMISSIONS: A CASE STUDY APPROACH

1.1 Sustainable Transportation and Urban Carbon Emissions

Sustainable forms of transport are important in reducing carbon emissions from cities, which have risen sharply as more people depend on fossil fuel vehicles. Due to the large amount of greenhouse gases the sector causes, it is a prime area for action to reduce climate change. It examines the ways that electric vehicles, using public transit, cycling and walking, cut down on emissions by taking the place of fuel-dependent travel methods. It considers and analyzes research about how people's choices for transport affect carbon emissions, pointing out how using green forms of transport can help the environment and improve clean air in cities.

In their work, Bhattacharya et al. (2016) considered the effect of renewable energy consumption on carbon emissions and economic growth of a cross-section of 38 countries. Their study focused on the aspect of renewable energy to drive change in urban transport systems away from fossil fuels. The concept of renewably fueled urban mass transit has the potential of substantially reducing emissions while simultaneously enhancing energy security and sustainability. The authors have also supported the belief that the development of renewable energy leads to economic development due to the promotion of new industries and employment opportunities in cities. As these advantages are discernible, the study revealed some of the difficulties, including high initial costs, which also ordered receptive policies for its success. This is in line with their findings in proving that integration of renewable energy in urban transport isn't only environmentally sustainable but also economically viable, especially in cities with high levels of energy use.

Brand et al. (2012) establish the UK Transport Carbon Model, which assesses the low-carbon transport futures comprehensively on the basis of the life cycle. The model emphasized opportunities for the massive reduction of CO2 emissions in metropolitan areas through electrification and new fuels. By adjusting parameters such as electrification and renewable energy support, they found that public transit could significantly cut CO2 emissions. Furthermore, incidental improvements were made with regard to cycling and pedestrian infrastructure as mobility solutions that could jointly lower the importance of private cars. The study underscored the necessity of government support measures for boosting this change, for instance, the provision

of incentives for the purchasing of electric vehicles and the construction of new active transportation channels. Their lifecycle approach gives a complete view of emissions ranging from manufacturing to utilization, thus can be used as a framework to assess the sustainability of urban strategies.

More specifically, Chandran and Tang (2013) analyzed transport energy use and CO2 emissions in ASEAN-5 economies to discuss their environmental impacts on transportation in urban areas. They established that transport energy consumption is one of the key contributing factors to emissions as these regions experience rapid urban growth. Specifically, energy-saving technologies like electric cars and better standards of public transport were presented as the remedies to the problems. Moreover, the authors described how FDI was used to advance the development environment for cleaner transport in developing countries. Specific novel approaches for transportation that are sustainable for local economic and infrastructural conditions were recommended to policymakers for achieving optimal efficiency in minimizing the emission of greenhouse gases in urban areas.

Small and medium-sized bus systems with low environmental impact in Europe, with a focus on their ability to help reduce CO2 emissions, were discussed by Corazza et al. (2016). Baehr's team dedicated their research specifically to electricity, biofuels, and hybrid systems for buses and found that such a system is scalable for the difficulty of urban transport. The authors pointed out that global environment-friendly buses not only edited their emissions, but they actually enhanced the quality of air to other issues, which in turn have an effect on public health. Nevertheless, the role of subsidies and infrastructure, as well as general awareness campaigns to be launched by the government to increase demand, were stressed throughout the study. They will enable cities to facilitate substantive sustainability outcomes in line with their reductions in fossil fuel dependency.

To determine the extent to which renewable energy fade helped in greenhouse gas emissions, Red Danish et al. (2017) in the context of hypothesis in the case of Pakistan. In their research, they learned that if transport services used renewable energy like electricity, they held the potential for cutting down on emissions in large cities. The authors acknowledged and stressed that such a transition is particularly relevant in the context of rapid urbanization and increasing transport needs. Examining the integration of renewable energy sources, the authors considered advantages like; Disadvantages of the renewable energy integration that the authors analyzed include; Rearranging urban transportation structure for the development of renewable energy was established as a key factor towards the realization of sustainable development goals.

Danish et al. (2018) employed an ARDL model to investigate the consequences of transport energy consumption for carbon emissions in Pakistan in 2018. The emissions they obtained showed that conventional transport systems that rely on fossil fuels have higher emissions within cities. As major strategies towards achieving the emission cut, the study recommended the shift to low-carbon options such as electric cars and renewable energy-driven public transport. Also, the authors pointed out the need for advocacy by governments to support subsidies for clean energy technologies. Their research showed that more fundamental change is required to the systems of transport in cities that are necessary for tackling climate change issues.

Graessley et al. (2019) assessed the consumer perception and use of PSTs with specific reference to every analyzer as well as car-sharing as emerging collaborative consumption services. In their work, they identified that such models dramatically decrease the number of cars used on the roads and enhance transportation effectiveness and emissions. The research also showed how technology solutions play a critical role in enabling shared mobility models. Such applications included ridesharing and car-sharing that were deemed to be crucial in ensuring sustainable mobility in cities, especially in suburban centers, to decongest as well as to supplement transport systems that release a lot of negative impacts to the environment. The results of the study imply that through collaborative consumption, not only environmental sustainability is socially implemented, but behavioral changes are encouraged as well.

Harwatt et al. (2011) have discussed different policy pathways towards achieving the target of taking London's personal transport emissions down to a meager 2050 level. Their study focused on the impact of congestion charges, investments in public transport, and biking and walking facilities. The results outlined that implementing all of these measures simultaneously meant that it was possible to greatly reduce carbon emissions while increasing a city's livability. The authors also emphasized the aspects of time horizons and public participation as crucial preconditions of those policies' success. Their study unveiled a working model that guides policy strategies for cities desiring an expressive CO2 emission cut.

In fact, Hoechle (2007) noted sound statistical techniques in evaluating the efficiency of sustainable transport systems. These methods are crucially important for assessing the environmental and economic effects of transport measures aimed at making the policy as efficient and informed as possible. The study pointed out that more credible measurements of the carbon emissions in cities are required to provide suitable approaches. Thus, the methodological approaches enable this research to effectively control cross-sectional dependence and make long-

term conclusions about transportation policies. They remain important in helping cities that want to ensure that they are in line with the sustainable urban mobility framework.

Hoffrichter et al. (2012) presented a well-to-wheel evaluation of electrical, diesel, and hydrogen-based rail operations. From their research, they deduced that electronic rail transport, especially where powered with renewable energy sources, emits the least. The evidence presented here brought out the idea that electrification of other urban transit systems is a feasible and replicable means of mitigating CO2 emissions. Further, this study pointed out that infrastructure investments are a compelling factor that could help achieve electrified transportation systems. These outcomes indicate the capacity of electric rail systems to satisfy the urban mobility demand while facing ecological challenges.

For purposes of evaluating the effect of renewables on carbon emissions, Jebli et al. (2016) employed the Environmental Kuznets Curve hypothesis, focusing on the OECD nations. Muo's studies also showed that integrating renewable energy in transport systems lowers the emission level while not compromising the economy. Due to this twofold advantage, renewable-powered public transport systems and electric cars are critical components of sustainable city transportation programs. The study also highlighted the need for the government to put in place policies to facilitate the change by offering incentives and against infrastructural reform. This paper therefore underlines the importance of renewable energy in sustainable urban development.

Kim and Wee (2011) examined the effectiveness of the intermodal freight transport systems relative to the truck-only systems in Europe. In their work, they explained that the use of intermodal systems, particularly rail/road transport, limited emissions of carbon. The results indicated that to attain more efficient and sustainable systems of urban logistics, a shift in modal choice was necessary. Further, the study emphasized the role of policy on the uptake of intermodal systems by various businesses. These perceptions form the basis for enhancing the sustainability of freight transportation in urban areas.

Krautzberger and Wetzel (2012) investigated the linkage of productivity change with CO2 emissions within Europe's commercial transport sector. He notes that their study pointed out the fact that cost savings in the form of diminished emissions are coupled with increased economic returns in energy-efficient transportation systems. The authors stated more extended strategic values that are associated with the change to sustainable urban transport; these include enhanced environmental standards and better operating expenses. This paper's results point to the need to integrate environmental and economic objectives in urban transportation planning.

In Im et al. (2003), researchers outlined some of the more sophisticated tools for assessing the time-horizon effects of transportation policies on carbon emissions. Their approaches are relevant when evaluating the long-term sustainability of urban transport-related undertakings. These tools assist policymakers to know whether sustainable transport options are working well through strong data analysis capabilities. This study highlighted the importance of policy integration and evidence-based policy formulation to achieve an urban mobility system that supports environmental policies. These methodologies help to make transportation policies both realistic and effective for managing urban carbon issues.

Relevant literature in this subject clearly substantiates the significance of sustainable transport in managing carbon emissions in urban areas. Major topics may comprise such aspects as renewable energy sources, me and sharing electric car services, and policy incentives. As recent studies have shown that sustainable urban transportation involves higher implementation costs and infrastructural issues, the efficacies of such concepts in managing the world economy and protecting the environment could not be overemphasized. Through effective integration of technologies with stronger policies, great reductions to carbon emissions can be made and thus enhance sustainable city development.

1.2 Effectiveness of Sustainable Transportation Strategies

To succeed in making areas environmentally friendly and boosting the local economy, it needs to be seen which sustainable transport methods work best. This area looks closely at different strategies such as buildings near transport, using electric vehicles, developing cycling paths and car-sharing ideas. Looking at case studies worldwide and using modeling methods, it discovers which tactics reduce emissions the most and when. It examines the role of modern technology, city development and participation by the public in deciding the impact of these actions on low-emission travel.

Avineri et al. (2000) used fuzzy set theory for rating the selection of transportation projects as decision support system for sustainable transportation projects under the conditions of uncertainty. The study focused on the possibility of making priorities as those fuzzy sets enable the policymaker to rate projects based on environment, social and economic considerations regardless of the fact that sometimes data is not exact. For example, tasks that are of interest to communities can be given to architects and urban designers to achieve goals such as emissions cut or enhanced overall health among the population. The study established that through fuzzy logic,

sustainability aspect is incorporated right from the time of decision making and leads to development of sound and balanced policies within the urban transport systems.

Awasthi et al. (2007) developed a Multi-Criteria Decision-Making model for locating car-sharing station to improve its environmental and operational performances. From their studies they found that the inclusion of factors such as accessibility, demand and environmental factors results to remarkable decreases in traffic congestion and carbon emission in urban areas. A very interesting conclusion of the study was that car-sharing programs can be deemed efficient means of transport instead of having one's own car and be subjected to the problem of congestion, restricted parking spaces particularly in cities with many residents. The present study also presents a clear blueprint for what can be done since it identifies ways through which cities can improve sustainability in transport choices and systems.

Awasthi and Chauhan (2011) presented a new model of integrated Dempster-Shafer theory for the evaluation of sustainable transport system. It comes with both mobility and immobility that include emission reductions, operational effectiveness, and end-users' satisfaction level. The study also highlighted the need to involve multiple dimensions in assessment in a bid to handle tradeoffs in decision making. In this case, by using the hybrid model, facilitators of change can be confident that transportation solutions point to the right environmental goals while keeping in mind requisite economic and social factors. The results confirmed that it is apropos at the same time to regard and practice urban sustainability as multifaceted and multimethodological.

Awasthi & Chauhan (2012) took apex of their study and move ahead to come up with a hybrid model of affinity diagrams, AHP, & fuzzy TOPSIS for city logistics. This approach brings in the environmental, social and economic dimensions to enhance freight transport processes in cities to minimize emission levels. The observation has shown that the logistics planning is crucial both for improving mobility and sustainability of urban areas. In this paper, freight transport improvements showed that scalable frameworks guarantee the coordination of city logistics systems with general sustainability objectives. This makes it easy for cities to decrease their emissions, at the same time enhancing supply chain operations.

Regarding the pre-implementation study of car-sharing program, Awasthi et al., (2009) stressed the fact that acceptance of the conceptions by potential consumers was an essential aspect for implementation of such a program. They discovered that to foster participation in Car-sharing programs, there is the need to address consumers' attitude toward cost savings, convenience and environmental factors. Cities can thus optimally enhance adoption rates and schemes through

addressing these factors by marketing and education. The study found out that car-sharing diminishes the private automobile reliance, traffic and pollution and thus are significant aspects of the positive urban mobility.

Awasthi et al., (2011a) employed a Multi-Criteria Decision-Making approach to select the sites for the distribution centers of an urban city to thereby show how proper planning can help in decreasing the inter-distribution center distances, consumption of fuel and consequently emission levels. These findings underlined the importance of location planning strategy in the development of sustainable freight systems with good economic returns and sound environmental considerations. The research reaffirmed that sustainable distribution networks increased urban mobility and supported carbon reduction objectives. Overall, this research offered a best practice template for cities that want to enhance their logistics networks with regard to sustainability.

Further, Awasthi et al. (2008) proposed an Analytic Hierarchy Process model for choosing the appropriate car-sharing station for medium size urban cities. The factors that were emphasized in the research for station selection included accessibility, demand characteristics and indeed, aspects of the environment. Including these factors in a study, the work evidenced that increasing the successful completion of placement undoubtedly improves the outcomes of car-sharing programs. The identified results highlighted the fact that such systems do not only decrease the vehicle reliance but also enhance the efficiency of mobility in cities and the quality of the air. The ethos of this research is of relevance to urban planners interested in understanding how sustainable networks for car-sharing can be created.

Awasthi et al. (2011b) made use of applying fuzzy to assess the sustainable transportation systems and the benefits were identified in considering more than one objective where objectives are nearly always conflicting. They also identified that decrease in emissions, cost and service are major factors when it comes to judging certain transport strategies. The study also highlighted that the use of fuzzy Technique for Order of Preference by Similarity to Ideal Solution for integrated evaluation prevents uncertainties affecting sustainable mobility solutions when applied in a complicated decision-making process. Overall, the study makes a contribution to the creation of a systematic approach to categorizing and prioritizing initiatives to promote the creation of transportation systems that are compatible with urban sustainability objectives.

Awasthi and Omrani (2009) put forward a new evaluation model of Analytic Hierarchy Process and belief theory for more general approaches in support of sustainable transportation planning. Their study is also targeted at applying environmental, economic and social criteria in

decision making. Therefore, by considering uncertainty and stakeholder's preferences, the model guarantees that the suggested transportation strategies are feasible and sustainable. The results pointed out the significance of implementing evaluation frameworks which are multicultural in order to have balanced and efficient transportation systems.

Bai et al. (2015) considered sustainable transport fleets, evaluating the efficiency based on a combination of emission, cost, and reliability factors using mixed multi- objectives decision making. The roles of Alternative Fuel Vehicles – including electric vehicles and hydrogen vehicles – are vital in pursuing sustainability, according to the study. The reason was that research has met with some objectives, which also proved that hybrid decision making framework is the best shot of selecting the appropriate fleet technologies. The present research has potential scheduling practical implications for cities seeking strategies to upgrade its public and private fleet for sustainable development goals.

Beinat (2001) indicates that Multi Criteria Analysis can be used to test sustainable transport plans. The study illustrated that through MCA decision makers are enabled to evaluate the transportation systems by considering the facet of emissions reduction, energy efficiency and social equity. Through the consideration of multidisciplinary criteria, MCA guarantees optimum compatibility of transportation policies implemented with community needs and requirements as well as sustainability goals. The results highlighted the need for stakeholder involvement at every stage of the decision-making process so that decision-makers can consider the most practical and effective solutions for addressing identified problems.

Black et al. (2002) outlined several measures through which sustainability of urban transportation system can be measured including emission standards, affordability and accessibility. Their study stressed that such metrics form a point of reference towards evaluating transportation strategies on the dimension of sustainability. By creating a system of quantitating these indicators, the authors offered conceptual tools to assess the condition of urban mobility systems and their problems. These findings provide the basis for supporting data based policies for efficient management of urban transport systems for environmental and social effects.

Later, Brand et al. (2002) have developed the Strategic Transport-Energy-Environment Decision Support framework which is a decision support tool for the evaluation of strategic transport-energy-environment system. The study proved that considering both energy efficiency, emissions reduction and user satisfaction in the transportation planning process is much more efficient. Through the use of this framework, effects can be felt in the sense that the policy maker

is able to capture all the tradeoffs between one goal and the other. The findings reemphasized the need for strategic decision support systems such as the construction of STEEDS for building urban transportation systems in support of the sustainability and mobility objectives.

Analyses with alternative fuel vehicles were assessed by means of multicriteria techniques with emphasis on environmental and economic aspects, done by Brey et al. (2007). The study further established that the emissions of hydrogen and electric vehicles were considerably lower than those of conventional vehicles with a special acknowledgement of the total emissions over their lifecycle. To inform the research, cost, operational efficiency, and environmental impact were identified as key areas where vehicle performance had to be assessed. The results argue for the use of Alternative Propulsion Fuels as a vital part of sustainable city transport plans.

The Information concerned reveals that many and varied eco-friendly transportation management solutions have been implemented successfully: car-sharing solutions, logistics optimization methodologies, and the use of rash and other types of fuel supplies. Among such frameworks, decision-making tools and techniques including AHP, fuzzy TOPSIS and multicriteria analysis are isolated as vital for assessing and applying such strategies. Other emergent themes include the technique, uncertainty management and the invocation of the public to advance adoption. Through the use of well-designed and effective evaluation mechanisms, cities can design transit systems that address the challenge of minimizing emissions while being cost-effective and user-friendly for the longest time.

1.3 Barriers to Adopting Sustainable Transportation Systems

Although sustainable transportation is recognized as valuable, there are several things stopping it from being widely used. Usually, the main challenges Arvada faces are due to its structure, the economy, how people behave and its organization. The section explores main issues such as costs, deficient support infrastructure, few people aware of these issues and resistance to adopt better habits. It evaluates the reasons why the shift from traditional to cleaner transport is struggling due to both system and market problems. Because it lists the obstacles, the section is ready to suggest solutions that work in the specific contexts mentioned in the following chapters.

According to Reed and Kidd (2019) Congestion as an element of the global s traffic score card analyzed traffic in urban cities as some of the barriers to adopting sustainable transport. Consequently, their findings revealed that extended travel time and time stuck in cities working against the efficient use of Public Transport and other green transport solutions. Such cities often

lack adequate cycling and walking infrastructure or possess old infrastructure and therefore force more people to own and use private cars, thus worsening congestion. The authors also pointed out that the interaction of urbanization aggravates the problems of development of Public Transport Systems, because low density reduces the efficiency of investments in transport. To this end, transport-oriented investments in compact urban design and high-frequency transit must equally fit to reduce dependence on private vehicles.

Aftabuzzaman (2007) critically discussed the nature of concerns relating to traffic congestion measurement and stated that the absence of common measures can be considered as one of protracted problems in assessing sustainable transport projects. Its lack of quantitative consistency restricts policymakers' knowledge about its effects precisely on the use of transport and emissions. For instance, without traffic patterns cities cannot know if there is congestion due to the inability to construct more lanes or inadequate public transport facilities, or poor traffic control. This absence of definition complicates attempts to pursue tailored interventions, like the establishment of bus rapid transit, or the implementation of congestion charges. Other recommendable attributes for congestion assessment included Global Positioning System tracking, traffic sensors and big data analytics.

Cambridge Systematics Inc. (2005) found out that instability in traffic in cities is the main issue that hinders the use of sustainable transport. The chronic congestion arising from daily commuters, bundle up congestion which hinders the reliability of public transport systems as a result of, accidents or events that may occasion systems breakdowns. People tend to move around in their own cars because they believe that green options are unreliable. For instance, opt for buses that are stuck in traffic are less preferred than personal cars even though those that are environmentally friendly. It also suggested that Intelligent Traffic Management Zones such as dynamic signal control and predictive algorithms should be incorporated to enhance transit dependability. Improving the current capacity for public transportation can boost demand and decrease the reliance of particular populations on private automobiles.

The public opposition to congestion relief measures including tolling and congestion pricing to discourage car usage was discussed by Litman (2007). These policies are usually unpopular because the public feel they are being imposed with new economic costs which they will have to bear primarily through bearing taxes which have been removed from the relatively well-to-do and transferred to the poor. Litman indeed pointed out that little awareness of the population about these techniques' environmental and societal advantages also contributes to it. For instance, passengers may have their sights on the short-term expenditures forgetting the overall

gains including reduction in air pollution and shortened distance. The study therefore called for the use of public education campaigns to present the above benefits and also called for the use of appropriate and fair pricing models that consider issues of cost for the poor.

According to the Federal Highway Administration (2019), insufficient infrastructure remains a real issue that hinders the usability of sustainable transport systems. At present, street designs are such that they encourage automobile use, with narrow roads, inadequate public transport provisions, and no proper provisions for bicycle and pedestrian travel. For instance, cities that lack facilities like bus lanes or many stops will ensure that any bus movement is both inefficient and arbitrary. The report suggested the improvement of several types of transport and infrastructural development for the integration of sustainable forms of transport. Further, applying smart technologies such as signal priority for buses can enhance public transport, and thus, people will use it instead of cars.

Falcocchio and Levinson (2015) examined nonrecurring congestion arising from factors such as crashes, weather disturbances and construction that have more effect on the systems. Such events make travel using buses, trams and trains unpredictable thus discouraging many people from using the systems for their daily transport needs. The authors noted that these disruptions tend to foster an idea among users that public transport systems are unpredictable as those contained in private cars. To overcome such a barrier, the study proposed the use of sophisticated incident management systems that can effectively deal with the congestion by redirecting traffic and quickly bringing the disrupted transport schedules back to order. Another application of predictive models is in reducing disruption effects on sustainable transport systems.

Incidental road events have been considered in the study by Ghosh (2019) regarding the impact of non-recurring events and concluded that they considerably worsen the transport situation in cities, resulting in an increase in car usage due to long waits for public transportation. The study found out that these causes undermine those green modes of transport because commuters rely on punctuality rather than eco-friendliness. For example, if a bus experiences a traffic incident, other routes which pass near that area will also be delayed which means users will be dissatisfied. The research called for the adoption of adaptive scheduling technology, like GPS tracking and auto rerouting to increase the efficiency of public transport and displease the commuting populace.

Fonseca et al. (2011) investigated temporary congestion corresponding to massive evacuations in simple instances like hurricanes when the transportation system is strained for capacity. Al to these occurrences they reveal the inability of publicly managed transit systems to

accommodate sudden load demands, something that will discourage their usage during emergencies and at other related events. For instance during evacuation issues, it is evident that the bus and train capacity is overwhelmed to deliver adequate means of transport for safe evacuation. The authors suggested that sustained public confidence in mass transit solutions can be maintained and prepaid through building up emergency response capacities for mass transit such as flexible scheduling schemes and increased capacity of transit fleets during peak periods.

Tonne et al., (2008) used the London congestion charge to establish that there are impacts in sociopolitical economy hence opposition by draws from perceived unfairness. Though the measure was able to eliminate many problems including traffic and poor quality of air, the plan of congestion pricing proved to be expensive more especially to the lower classes. This resistance demonstrated the fact that, in order meet sustainability objectives, policies need to encompass both sustainability and equitable issues. According to the authors, the potential of charging car users should be used to offset public transport fares and expansion of transport facilities in order to mitigate the costs. Such measures mean that sustainable transportation does not decrease from the aspect of accessibility to various social layers to further expand people's support for such activities.

When considering the impacts on traffic congestion and air pollution, Armah et al. (2010) used the system dynamics approach in choosing private vehicles as a major factor in the increase in both matters in Accra of Ghana. This paper highlighted some of the challenges to sustainable transport which include poor public transport, lack of viable transport infrastructure and poor compliance with standards on emissions of vehicles. For instance, Accra's current state without proper bus lanes and modern rail systems makes anyone using public transport easy to congesting inefficient private car services to transport them. To build a more sustainable transportation system in urban communities, the authors urged governments to upgrade and expand high-capacity Public Transport infrastructure and implement more rigorous emissions standards.

In the recent past, Wang et al., (2014) came up with a congestion pricing model that factor in the cost of carbon emissions to the environment and proved more effective to discourage the use of private vehicles. However, the authors identified strong resistance from the people they surveyed who considered such pricing strategies as financially negative. To these worries the authors suggested implementing the changes in phases so that the average commuter is slowly conditioned to the change. They also recommended directing the congestion pricing revenues into other sustainable transportation projects which will help people to understand how useful such policies are by providing subsidized electric buses or more rail systems.

More recently, Liu et al. (2017) employed geographic information system (GIS) to identify temporal-spatial features of congestion and argued that congested areas typically lack adequate access to such public transportation as well. This absence of coverage compels commuters to resort to the use of private cars thereby leading to traffic congestion and emission of carbon. The study stressed that extensive coverage of transit networks in such regions can offer adequate non-care shopping options. Such measures as an increase the frequency of bussing or expand the rail services into the suburban regions can immerse the congestion. The authors also stressed the importance of intelligent algorithms which are able to detect congestion patterns and adapt the measures proposed to the peculiarities of the city.

Bull and Thomson (2002) conducted an analysis of the systematic causes of traffic congestion in urban cities emphasizing vehicle dependence as a hindrance to transportation. They found out that lack of access to good, affordable and efficient public transport means that people resort to using their automobiles and this has been confirmed to lead to further pollution of the air. Furthermore, scattered urban growth patterns make it worse in this sense because they result in longer travel distances that public transport can seldom comfortably provide. To address the travel demand, the authors suggested the coordination of land-use plan with other modes of transport through the implementation of the mixed-usage plan and the transit-oriented design.

The literature reviewed in this paper recognizes multiple factors that hamper the implementation of sustainable transportation systems such as infrastructural deficiencies, public resistance, and the problem of treating reoccurring and episodic congestion. Substandard public transport provision, skewed growth of the economy, poverty, inadequate traffic control systems, and negative competitiveness aggravate challenges to the shift towards sustainable transportation. Solving these challenges requires the integration of the many approaches that involve infrastructure, fair policies, and technology, especially to monitor and manage the traffic in real time. When all these barriers are avoided, cities enable greater community buy-in towards the uptake of efficient and sustainable transport solutions for a lasting positive impact in the environment, the society, and economic life.

1.4 Policy Interventions for Sustainable Transportation

Designing the right policies is important for getting rid of current transport challenges and helping the switch to more sustainable solutions. Some important strategies include providing subsidies for electric vehicles, applying congestion pricing, setting fuel taxes, spending on transit and building infrastructure suitable for pedestrians and cyclists. It reviews how well different types

of interventions function in various urban environments by emphasizing the key role of cooperation between authorities. How national and local governments control and financially support transportation is sharply debated.

According to Nuccitelli (2019), there should be policies to regulate emissions through transport and their consequent impacts on the economy of the United States. Greenhouse gas emissions, especially from the transport sector, are one of the most dangerous threats to climate change since they can destabilize the economy to the tune of billions of shillings in damage every year. Nuccitelli suggested Stop gigging these impacts by implementing measures, for example carbon taxes, subsidies for Evs, and more investments in public transit. For instance, carbon tax impacts involve encouraging industries, businesses, and citizens to use the latest low-emission products including Evs and hybrids. The study noted that if policy action continues to be timid, the sector will persist in worsening climate change thereby incurring higher long-run costs.

The present study of Trisos et al. (2020) also focused on exigent policy measures to forestall sharp shifts in ecological processes by climate change. Such a trajectory of transportation emissions, if unmitigated, would exacerbate ecological decline, poorer air quality and declining biodiversity. Measures to support the electrification of funding, increasing the stringency of the emissions standards for vehicles, and the incorporation of renewable energy into transport were found to be essential. Specifically, replacement of outdated urban buses with electric or even hydrogen propulsion means driving emissions drastically down and increasing air quality in cities. In conclusion, the study affirmed that variable and purposive policies are requisite for synchronized transport structures of the world's climate change international goals and for deferring ecological breakpoints.

Several researchers have offered alarming signals on unsustainable human activities with a focus on transport as an aggravating factor Ripple et al (2017). The study made policy recommendations for immediate implementation such as improved and even stringent fuel economy standards, adoption of supportive direct incentives for Evs and using disincentives for the ownership of personal cars. Ripple et al. stated that active policy packages could drastically decrease the global emissions level linked with transportation to achieve the international climate targets. For instance, Norway's goals of eliminating fossil fuel cars through various policies by 2025 shows how far and wide measures help. The need for international cooperation and local implementation was underlined as the essential requirement for the effectiveness of such policies.

Wu et al., (2020) explored how pollution, health, and the transport policy changes influenced COVID-19 death rates in America. It also pointed out that regions with high transportation emissions experienced poor health results since the pollution level was high due to lockdowns and curfews during the pandemic. Other measures towards reduction emissions and improving population's health included recommendations for congestion pricing, increasing cycling and walking, and increasing green urban spaces. Wu et al. established that any plan focused on dealing with pollution within the transportation industry has a triple advantage of firstly dealing with pollution, secondly preventing future pandemics and thirdly preventing chronic diseases.

According to the United States Environmental Protection Agency (EPA) (2016), passenger vehicles emissions information see Figure 3 below is one of the main sources of greenhouse gases, this means that vehicle specific measures should be avails. The report called for the development of more charging stations for electric vehicles, providing tax credits to both federal and state for electric vehicle purchases and tighter emission controls for traditional gasoline automobiles. These were deemed to have played a key role in lowering the carbon footprint of the transport subsector. For instance, California's Zero-Emission Vehicle (ZEV) mandate was put in place with an aim of pressuring automakers to come up with more and affordable Evs for use. The EPA reiterated its previous message that both incentives for consumers and regulation will be required to drive forward positive changes and adoption of more sustainable modes of transportation.

The EPA (2019) also described the harm of smog and soot from transportation and called for the policy intervention to cut those emissions. Low-emission and zero-emission vehicles, changing old vehicles, and financing of clean public transport systems were identified as primary measures. The report further noted that such policies not only contain negative impacts by cutting greenhouse gas emissions but also have positive effects that include better air quality especially in the cities. Moreover, the EPA pointed out that marginalized groups, including the poor, are the most affected by air pollution. Transit subsidies are therefore suggestive of equity-minded policies in addition to having implications on environmental quality.

McKenzie (2015) conducting the analysis of daily commuting patterns in the USA concluded that automobile use continues to predominate suppressing the idea of sustainable transportation. The majority of the American workers reach their workplace through the use of private vehicles because there are very few public transportation systems in cities and the geographic spread of the cities has made it impossible for majority of workers to use bicycles or walk to work. Some ideas that were considered as strategies to be introduced to lower car

dependency were transit oriented development, investment in commuter rail systems, and carpooling incentives. For instance, Portland in Oregon has been able to bring down the use of the car through zoning, which enhances accessibility to public systems of transport. According to McKenzie, the problematic issues of planning and funding of mass transport are the main barriers to promoting sustainable habits among urban dwellers.

When analyzing the research of Tomer (2017) on commuting difficulties that target the everyday American, more focus on policy measures was discovered from census data. The research conducted showed that lack of proper and efficient public transport, especially in the suburbs, are a major de- factor for sustainable transport. Recommendations included increasing the bus- and rail-coverage, improving "first- and last-mile connections" by promoting bike-sharing and offering subsidies for transit fares. Also, Tomer called for work from home, telecommuting and shift work to alleviate congestion in peak hours. The applied and limited studies highlighted the need for integrated policies focusing on structure, cost, and availability as key principles in changing the commutation behavior sustainably.

Instituted by the Federal Transit Administration (2010), public transportation was established as a leading solution to climate change and accordingly called on policy makers to direct resources towards transit programs. Through all the examples presented in the report it became clear that public transport is relatively more environmentally friendly than private cars in terms of greenhouse gas emissions per passenger mile. Key policies include enhancing funding of high-capacity rail systems, upgrading buses with low-emission technologies and extending transit services in underserved areas. For instance, New York City has invested in hybrid electric buses which the firm asserts have cut on emissions while enhancing service delivery reliability. The conclusions underlined that the growth of public transportation systems as the key measures serves as one of the most efficient approaches to controlling transport emissions.

In their recent work, Turner et al. (2020) analyzed the state of transportation systems in the United States where outdated systems heavily impede sustainability. To improve efficiency based on modern approaches to infrastructure, the study suggested further policy measures for updating the entire space, and the integration of smart technologies such as traffic management systems and simultaneous utilizing of the multimodal networks. For instance, the installation of smart traffic light systems that way emergency and public transport vehicles. To this extent, Turner et al pointed out that long-term infrastructure investments need to be developed in order to fund persistent inefficiencies that deter sustainable transportation solutions. Such policies also help to build climate resilience of cities and populations as well as growth.

The US Bureau of Labor Statistics (2020) looked into spending trends identifying that transport was still one of the essential spending categories for households. In order to counter these costs a number of measures were suggested including subsidizing public transportation, incentives for fuel efficient vehicles, and car sharing services. Moreover, the study found that transport costs are higher than the standards set for the population, the lower income earners. The best policies on sustainable transportation should cater for the above disparities which will enable reduction on fares for public transport users as well as incentives for people with two cars to share the one. Such measures foster great uptake and play a role in emissions reduction and promote economic equity.

Kormos et al. (2021) analyzed how principles derived from behavioral science can be applied to change transportation policies to encourage the use of public transportation. The practice revealed that psychological factors like perceived inconvenience and unreliability of green transport modes discourage commuter choices for sustainable modes. To overcome these barriers, suggestions included use of behaviour modification techniques like; real time updates on transit schedules and relevant specials offers to barcode identified frequent users together with environmentally friendly transit promotion campaigns. For instance, city such as Singapore has been able to encourage the use of public transport through the use of technologies technology which offers timely and accurate information. Overall, Kormos and his co-authors stated that the combination of BI with conventional policy instruments increases the efficiency of sustainable transportation policies.

According to Litman (2003), mobility management refers to a policy strategy that aims at decreasing emissions of transportation pollutants. The study further proposed demand management strategies including price flooring for congestion, incentives for carpooling, and bicycle sharing programs as part of the same solution strategy as the designing of infrastructure. Litman also pointed out that mobility management strategies recognize the understanding of travel behavior modification as key to realizing sustainable mobility in the longer term. Consequently, the analysis was quick to establish the reality that combining behavioral and infrastructural policies gives a rounded strategy to deal with transport issues.

The discussed literature examples highlight the importance of policy measures in achieving sustainable transport objectives. These are electrification of public transport and adopting congestion charges, upgrading infrastructure and managing consumer behavior towards electrification. Equity considerations formulated in policies including the fare subsidies and incentives deal with the low-income earners help in extending sustainable transport for all. It is

indeed possible to optimize all these by integrating technology, infrastructure and people's behavior change to come up with policy cross solutions for emission reductions, urban productivity and public health. These interventions are crucial toward integrating the machinery of transport with sustainable environmental, societal, and economic goals.

1.5 Integration of Environmental and Policy Outcomes

To be successful in the long run, sustainability in transportation must fit well with the outcomes that can be applied by policymakers. Here, the study looked into approaches for combining environmental objectives, like cutting emissions and improving air quality, into different types of transportation policies and urban planning initiatives. It examines how performance on the environment and on areas such as equity and accessibility are affected by and possibly affect economic development. The analysis in this section reveals important steps to constructing strong and environmentally friendly city transport systems.

Adelle et al. (2015) explored the policy networks in contending the environment and economy policy within the EU, with reference to mercury policy. A key message from the study was that the integration of environmental and policy outcomes requires inter-sectoral cooperation. In the case of EU mercury policy made beneficial cross-sectoral coordination of such aspects as economic and ecological. This study also found that conflicting interests acts as a hindrance to policy implementation to its intended time of being implemented. The following strategies were suggested with regard to integration outcomes: Building and improving policy networks; Improving communication between stakeholders.

Adelle et al. (2009) analyzed the tensions between climate change and energy security policies in the European region to show how these goals and policies can be achieved. Environmental and energy security both support renewable energy; conflict emerges over competition for resources, and business orientation. The authors pointed out that lack of policy integration is one of the reasons why progress is slowed down, which raises the issue of the need for broader institutional arrangements for integrated decisions. Addressing these issues at the structural level allows those policymakers to align climate and energy policies so that they complement one another, rather than act as rivals.

Alons (2017) did a critical assessment on CAP and its attempt at EPI. Consequently, though particular organizational reforms aimed at 'greening' the curriculum, this study identified that most reforms still put into practice economic gains against ecological conservation. For instance,

support for the concentrated production processes remained to jeopardize environmental objectives. Alons (2017) claimed that the phenomenon of greenwashing superficially neglects tensions between economic and environmental goals. The study also highlighted the question of how, from an institutional perspective, financial incentives may be aligned with sustainability to constitute effective policy integration.

Considering this, Ansell (2012) pointed out that the issue of collaborative governance holds a critical function of reconnecting various policy outcomes, especially where environmental considerations feature. One of the critical findings of the study was that the roles and responsibilities between different government ministries, private and NGO's enhance social capital for environmental goals. For instance, in the case of coordinating transport policies and climate change initiatives in urban areas, this work involves the cooperation of planners and policy makers in urban transport systems, transport authorities and NGOs for the environment. Because of his study, Ansell was able to establish that understanding and effective policy integration hinges on establishing trust and common commitment with other individuals who are involved.

Whole-system thinking was discussed by Bagnall et al. (2019) in the context of public health threats and proved helpful in understanding Expanded Programme on Immunization. Perhaps the most significant focus of the study was achieved by highlighting the fact that obesity and urban air pollution, for example, are complex problems and solutions to these problems need to be in the form of cross-sectoral where transport, health, and the environmental sectors are involved. For instance, there are cycling or walking, which increases the health standard of people and decreases emissions from transportation. In the authors' recommendations they argued for the use of systematic approaches that consider interdependence of policy domains for integrated solutions.

Bakvis (2000) described the difficulties of reconstructing policy capacity in Canada and provided some lessons on integrating policies. This paper explained that a mechanical view of the world by governments means that policies are often segregated and are consequently unfunded, due to a lack of resources to efficiently fund policies the government currently supports. For instance, reduction of budget allocations to environmental programs reduces their compatibility with fiscal measures. Bakvis suggested funding policy instruments to boost policy capacity in terms of training policymakers to better manage multi-sectoral interdependencies and achieve coordinating policy goals.

Biesbroek and Candel (2019) discussed policy disintegration mechanisms for policy areas related to food security and climate adaptation in the Netherlands. The present research identified that the lack of integration between silos, together with goal divergence, acts as an impediment to integration initiatives. For example, the policies that aim at increasing agricultural production interfere with climate change measures. In this context, the authors stressed that the key tasks relate to flexible governance models, which enable cross-sectoral cooperation. Thus, the integrated governance approaches are useful for policymakers to manage these conflicts and obtain the policy coherence.

Biesbroek et al (2014) discussed obstacles to climate adaptation governance and explored how certain features hinder policy integration. The survey established that important challenges include institutionalization, lack of political will, and limited efforts to mobilize stakeholders. For instance, tight controls ensure that transport policies cannot be crafted towards climate adaptation objectives. When engaging in adaptive governance, there must be backtracking and learning taking place with stakeholders while continuously coming up with managing policies for this purpose.

Briassoulis (2004) argued on the theory of policy integration showing that it is useful when dealing with policy environment complex issues. To support this assertion, the study held that policy integration entails goal integration, instrument integration and process integration across sectors. For instance, coordination between transport and climate strategies entails the synchronization of the emissions-cutting goals with public transport infrastructure development. According to Briassoulis, the accommodation of the requirement of policy integration required institutional changes that support cooperation, exchange of information, and responsibility among various organizations.

In his study Candel (2016) focused on the EU policies in the field of food security and analyzed the problem of linking the procedures to the concept of sustainable environment. The findings also showed that there was a poor commingling of policies because of conflicts and poor management of stakeholders. For instance, attempts to decrease the emissions from farming activities are often nullified by subsidies to bad farming practices. Candel supported participation governance models that engage farmers, and environmental organizations, policymakers in devising social solutions. This is important since it makes sure that goals set on the environment occur within policy standards.

Candel (2017) has reviewed positive and negative experiences of integrated policy strategies to determine the critical success factors. According to the study, policy integration initiatives tend to be characterized by high expectations and limited resource support. For instance, there are often great politics on climate change mitigation goals while there's poor financial or organizational commitment to the same. Candel, however, pointed out that, to have meaningful integration, it is necessary to set achievable objectives, to gain the support of the key stakeholders, and to spend the necessary resources. These are structural problems that policymakers need to solve in order to meet the promised results.

In their critical review of the literature, Candel and Biesbroek (2016) suggested that an integration of policy approach may be best understood as processual and involving iterations of learning. The study stated that integration was a process that proceeded over time to the effect that time played a critical role in the process of aligning the goals and that of instruments in an organization. For example, urban transport and environment policies coordination requires continuous modifications based on technological development and changing priorities. Candel and Biesbroek opined that flexibility and feedback mechanisms should be included within governance structures to further sustain the integration.

Carbone and Keijzer (2016) analyzed policy coherence for development in the EU and pointed to the problem of its non-integration. This study revealed that challenges associated with bureaucratic structures, such as job protection, powers and privileges along with maintenance of barriers to coordination between development and environment policy. For example, export promotion policies may themselves be in contradiction with climate goals when they encourage energy-intensive output. According to Carbone and Keijzer, interdepartmental cooperation should be promoted, and policy rewards should be synchronized in order to overcome it. It is such approaches that help to see environmental questions as part of comprehensive concepts and policy settings.

Another study of Casado-Asensio and Steurer (2014) used the examples of Western Europe and considered the integrated strategies for sustainable development and climate change and shown that there is a problem of communication and coordination. The study also discovered that while policymakers address integration objectives most of the time, they put in place few interrelated measures. For instance, transportation policies seeking to encourage the use of electric cars may be disconnected from energy policies seeking to increase the use of renewable electricity. The authors stressed the importance of the enhancement of the institutional conditions that may

help to provide better coherence of decisions and resources. Effective integration calls for transition from rhetoric to real, coherent strategies of integration.

In the reviewed literature, the need to link environmental and policy studies is accentuated in facing complex problems, including climate change, urban sustainability, and resource management. Major challenges include lack of coordination between institutions, inter- and intra-organizational goals and objectives, and inadequate involvement of stakeholders. Several mechanisms that must characterize integration processes include cooperative government, responsive frameworks, and inclusive engagement that co-align objectives and instruments. Thus, policy makers can work together for the realization of integral policies that will respond to environmental, economic and social needs. Integration therefore is not a one-time process where technical solutions have to be implemented so as to end the process, but a continuous process that undergoes change every now and then according to the new trends and emerging problems.

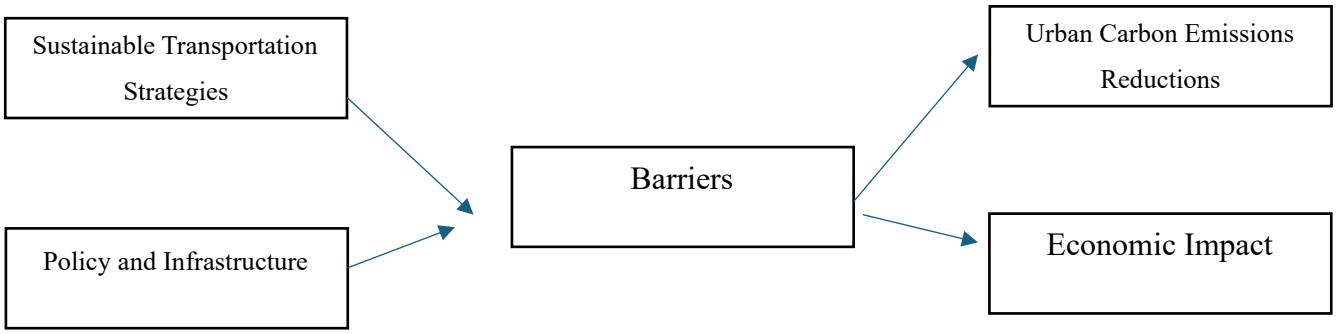

Figure 1: Conceptual Framework

The conclusion of this chapter is that both environment and policy outputs should be synthesized to combat complex international issues adequately. From the literature reviewed, some factors identified include engrained authoritative culture of departments; incompatible goals and objectives; lack of meaningful involvement of other stakeholders; likewise, from among the solutions suggested include adaptive governance; stakeholder engagement model; collaboration across sectors. When multiple objectives and instruments are then linked and adjusted, the processes enable the formation of harmonized initiatives which can address environmental, economic, and social aspects. Finally, integrating policies that must face new issues takes a few cycles to accomplish and adhere to the goals of policy relevance and usefulness.

2. RESEARCH METHODOLOGY

This elaborates on the research methodology, addressing the three critical questions: What conclusion needs to be made? How will this be investigated? Why is this technique more suitable? The choice of the methodology is consistent with the research question, the purpose with which the study is conducted, and the objectives of the study, in order to design the most effective way of collecting and assuring that the data collected is reliable with regards to sustainable transportation and its role in reducing carbon emissions in cities.

Empirical research is used in this study to accomplish the following:

- The main aim given of the empirical research is to assess the effects of sustainable transportation measures on carbon footprint in cities. The study seeks to answer the following key aspects:
- This research approach will be used to assess the effectiveness of various approaches to transportation in the reduction of carbon emissions in urban areas.
- To use sustainable transportation strategies to assess the impact differences brings in achieving established carbon reduction targets.
- To determine the obstacles of sustainable transportation strategies and their impact on functioning of the given approaches.
- For policymakers and urban planners to make clear, tangible suggestions on how to harness improved environment features of sustainable transport system.

Research Model

This research uses a quantitative research approach whereby structured questionnaires are used to obtain primary data. This model correlates with Creswell and Creswell (2018) who note that quantitative research is useful in determining the relationship between variables.

Hypotheses

The study formulates the following hypotheses:

- H1: Sustainable transportation strategies significantly reduce urban carbon emissions.
- H2: Public adoption of sustainable transportation is influenced by accessibility, affordability, and infrastructure quality.

- H3: Barriers such as cost, convenience, and lack of infrastructure negatively impact the adoption of sustainable transportation.

Variables

1. List of Variables

To ensure alignment with the research question, the study identifies the following variables:

Independent Variables:

- Sustainable transportation strategies (public transit, cycling, electric vehicles).
- Policy and infrastructure.

Dependent Variables:

- Reduction in urban carbon emissions.
- Economic Impact

2. Sources of Variables

Structured questionnaires designed to capture user behavior and preferences.

3. Comparison of Variables

- Dependent and independent variables are compared through:
- Correlation analysis to determine the relationship between transportation strategies and carbon emissions.
- Regression analysis to assess the economic outcomes of sustainable transport measures.
- Comparison of public adoption rates and policy effectiveness.

4. Justification of Variables

- The chosen variables directly align with the research objectives and hypotheses, ensuring their relevance.
- These variables are widely used in similar studies, enhancing reliability and validity.
- They provide a comprehensive view of the environmental and economic impacts of sustainable transportation.

5. Reliability of Sources

Questionnaires are designed following Braun and Clarke's (2006) thematic analysis, ensuring systematic data collection.

The reliability of these sources is cross verified with prior studies in transportation research.

6. Description of Data Collection Process

Structured questionnaires are administered to a sample population (urban residents).

Questions address demographics, usage of sustainable transport, and perceived barriers.

7. Accuracy of Variables

Variables are analyzed using statistical tools like SPSS for descriptive, correlation, and regression analysis.

They provide quantifiable insights into the relationships between transportation strategies, emissions reduction, and economic impacts.

Relevance and Relationship of variables

The variables are actually not chosen haphazardly, but rather they are selected after identifying variables that will in one way or the other relate to the research objectives. With regard to this, Givoni and Banister's (2010) and Greene and Plotkin (2011) suggested that an efficient transport strategy and network play a vital role in lowering carbon footprint. The relationship between variables is established as follows:

- Carbon emissions reduction is mediated by access and infrastructure when it comes to considering sustainable transport plans.
- Such calls have been found to be prevented by factors such as costs and compatibility that complicate the applicability of these strategies.

Reliability of Variables

The reliability aspect of the selected variables is checked by comparing most of them to physical or other empirical studies. For example, Pucher and Buehler (2008) employed the same variables to assess the effect of cycling infrastructure on emissions reduction while Currie and Delbosc (2013) examined the contribution of public transportation to sustainable transport.

How will this be investigated?

Data Collection Methods

In this research, the main data collection technique is a structured questionnaire. This method is selected because it enables the investigator to obtain quantitative data from a large number of participants economically. The questionnaire is designed online on **Google Forms** to capture the following information:

- Current use of sustainable transport options as identified by the respondents including public transport, cycling and electric cars.
- Regarding the extent of the environmental advantage of sustainable transport.
- By cost, convenience, condition and quality of infrastructure are some of the challenges that hinder the adoption of sustainable transportation systems.

Questionnaire Design

The questionnaire consists of three main sections:

- Demographic Information: In order to obtain respondents' socio-economic characteristics; such as age, income, and education level.
- Behavior and Preferences: Questions related to the usage of sustainable transportation modes, and the view on the existing impression about the environmental influence.
- Barriers and Suggestions: Concerned with finding out issues of concern while still providing recommendations for change.
- Since Braun and Clarke (2006), the analysis is based on **12** Likert-scale questions designed for immediate comparability of results.

Sampling

In the study, purposive sampling is used to select respondents that are in different age groups, with different income, gender, and geographical region.

- Target Population: These include the public within the urban areas with access to green mobility means of **Lithuania.**
- Sample Size: The target group is **200** in order to validate the study.

Data Analysis Methods

The collected data shall be analyzed and sorted out by the usage of **SPSS**. The analysis involves:

Descriptive Analysis: To generalize the demographic information about respondents and their transport related activities.

Correlation Analysis: To test hypothesis about correlation between the independent variables (for example, accessibility) and dependent variables (for instance emissions reduction).

Regression Analysis: In this case, to analyze the effectiveness of sustainable transportation measures in reducing urban carbon emissions.

Why is this method most suitable?

Theoretical Justification of Method

The chosen methodology is based on well-researched methodologies. Creswell and Creswell (2018) stress that the use of quantitative data is appropriate in investigation attempting to find out correlation between variables. This way of data collection is more structured and provides much more comparable results, which is crucial when searching for some trends or hypothetic patterns.

Practical Justification of Method

- Efficiency and Scalability: Questionnaires are also cheap to administer for population sized sample and any type of sample of population.
- Focus on User Insights: The method provides perception and behaviour of users, which is important to get insights for the use of sustainable transportation.
- Compatibility with Research Objectives: The quantitative approach fits well within the study objective of assessing the amount of carbon emission saved and analyzing the efficiency of transportation options.
- The **Database file** is the best reason for better justification

Pertaining to this recommendation, the author draws support from previous research.

Hence, the use of questionnaires is well advocated in the field of transportation research. For example:

- Currie and Delbosc (2013): Applied questionnaires for studying rates of public transport usage and its position in achieving sustainable mobility.
- Hoen and Koetse (2014): Used questionnaires in order to identify choices concerning AFVs.
- Litman (2017): Ax: Emphasized the role of feedback from the users when it comes to reckoning transportation equity and sustainability.
- In this way, the study expands on these methodologies to guarantee a dependable approach to data gathering and analysis.

Hypotheses

1. H1: Sustainable transportation significantly reduces urban carbon emissions.
2. H2: Investments in sustainable transportation lead to substantial economic benefits, including increased property values and job creation.
3. H3: The effectiveness of sustainable transportation measures depends on local adoption rates and implementation strategies.

The research method mentioned above is used to support analysis of sustainable transportation and its effectiveness in reducing carbon emissions in urban areas. Thus, the approach helps to consider structured questionnaire and, as a result, to provide reliable and valid results of the study. This approach not only corresponds to general research models but also considers practical aspects of revealing the environmental advantages of sustainable transportation.

Chapter 3. RESULTS AND DISCUSSIONS

The findings from research are presented with regard to analysis of survey data collected about adoption and impact of sustainable transportation systems in urban areas. In this chapter, effectiveness of some of the sustainable transport modes such as EVs, public transportation and cycling facilities for the city's carbon emissions is discussed. Along these lines, it investigates the boundaries that urban citizens face in integrating these sustainable transportation modes into their day-to-day operations, which incorporate the monetary limitations, absence of framework conviction in the feasible improvement of different ways of dialogue. Future work is suggested to determine ways to improve the performance of these systems, and the results are discussed in the context of existing literature delineating the factors important to success or failure of these systems in achieving their environmental and economic goals.

3.1 Survey results

From a wide range of people with different age groups the survey got responses. The first parts of the survey include age and occupation which gives a demographic overview and the rest is the second part includes series of statements the participants responded to.

Table 1: The age distribution shows respondents from young adults to middle aged adults. It specifies valuable context which is useful for the rest of the study.

1. **Age**

Table 1: Age

Age Group	Percentage (%)
Under 18	1.7%
18-24	13.6%
25-34	44.3%
35-44	29.5%
45-54	9.7%
55+	1.2%

The chart draws the age distribution of 176 respondents. The largest number, 44.3%, are aged between twenty-five and thirty four and the second largest group, 29.5%, are those between thirty five and forty four years. The age groups 18-24 and 45-54 make 13.6% and 9.7 %, respectively. The least representation is recorded in under eighteen (1.7%) and fifty-five plus

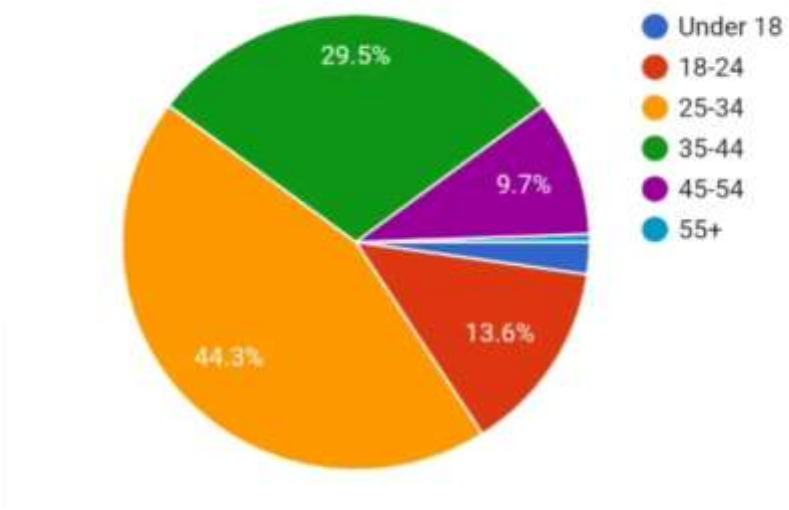

Figure 2: Age

(1.2%) groups.

2. Occupation

Table 2: Occupation

Occupation Group	Percentage (%)
Student	25.1%
Employed	33.9%
Self Employed	15.8%
Unemployed	12.9%
Retired	11.1%

This figure represents a breakdown of the employment status of 171 participants. The largest part of respondents composed of employed people – 33,9 % and students – 25,1%. 15.8%

of respondents are self-employed, and among the rest of the population are unemployed and retired, which constitutes 12.9% and 11.1% of respondents, respectively.

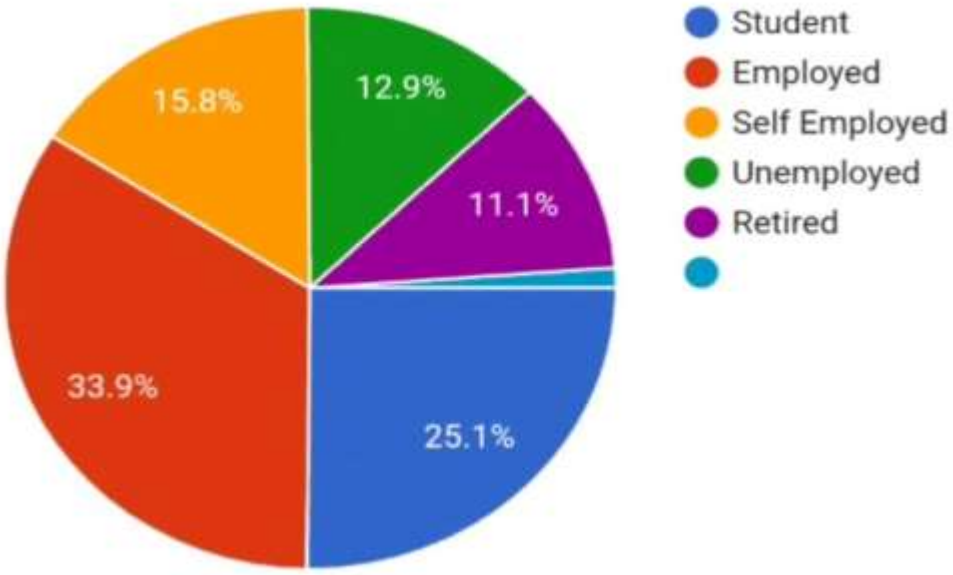

Figure 3: Occupation

3. **I believe that urban transportation contributes significantly to carbon emissions.**

Table 3: I believe that urban transportation contributes significantly to carbon emissions.

Response	Percentage (%)
Strongly Disagree	28.5%
Disagree	29.1%
Neutral	24.1%
Agree	17.7%
Strongly Agree	0.6%

The survey presented shows how the public feels about the opinion that transport in cities plays a major role in the emission of carbon. Out of 158 adults surveyed opinions are fairly split with 28.5% strongly disagreeing and 29.1% disagreeing. Another 24.1% of participants are indecisive with their response while 17.7% respondents are sure with their positive answer. A surprisingly small 0.6% 'strongly agree'. The following data depict that the respondents hold a lot of disbelief over the relationship between urban transport and CO2 emissions.

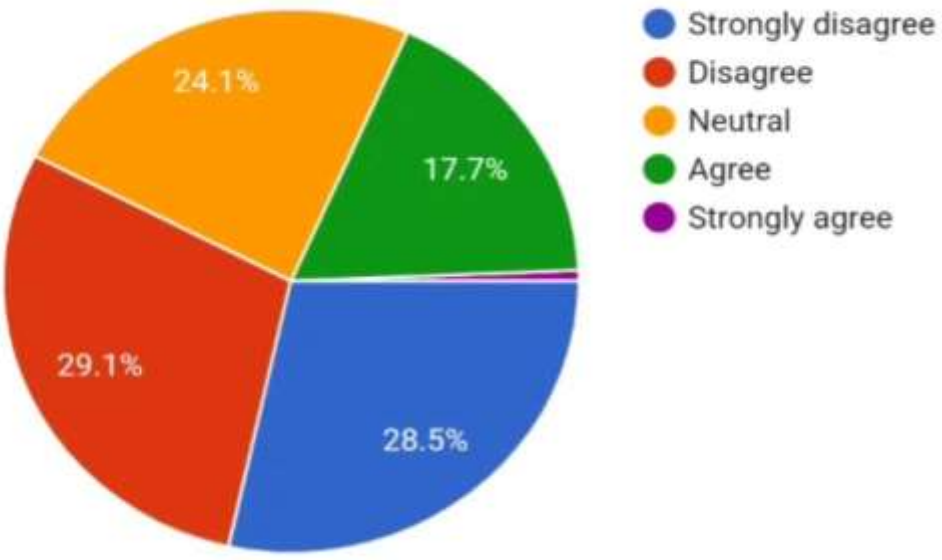

Figure 4: I believe that urban transportation contributes significantly to carbon emissions.

4. **Sustainable transportation (e.g., electric vehicles, cycling) is an effective solution to reduce urban carbon emissions.**

Table 4: Sustainable transportation (e.g., electric vehicles, cycling) is an effective solution to reduce urban carbon emissions.

Response	Percentage (%)
Strongly Disagree	22.2%
Disagree	31.9%
Neutral	22.2%
Agree	18.8%
Strongly Agree	4.9%

The chart captures the views of 144 participants regarding sustainable in resolving the carbon issue emanating from the city. Most respondents either disagree (31.9%) or strongly disagree (22.2%). Neutral opinions are at 22.2%; Positive being 18.8%; Strongly positive 4.9%. This data suggests that there is diverse attitude where a large share of the public seems to be skeptical about the use of sustainable transport systems.

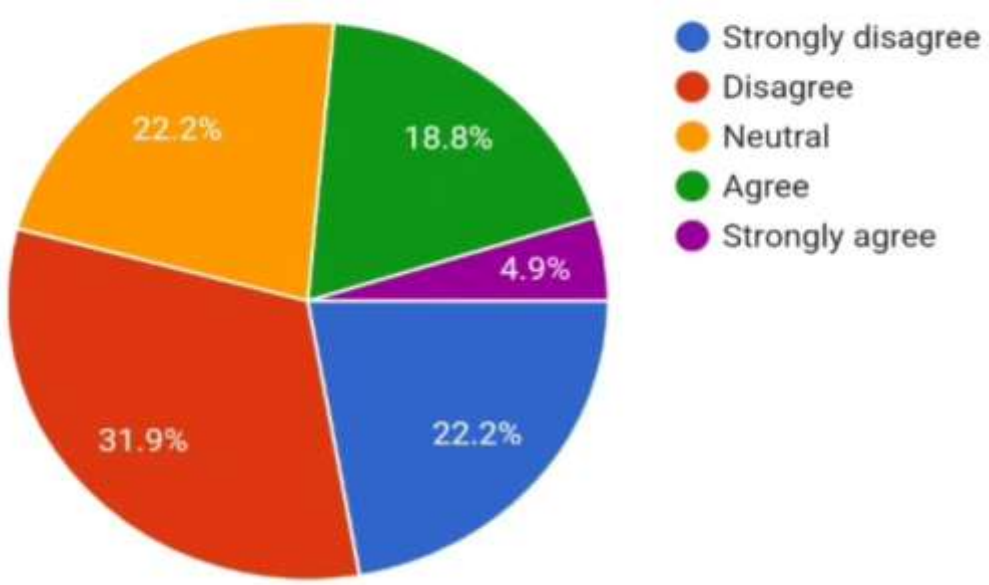

Figure 5: Sustainable transportation (e.g., electric vehicles, cycling) is an effective solution to reduce urban carbon emissions.

5. **Investing in sustainable transportation systems creates economic opportunities (e.g., jobs, new industries).**

Table 5: Investing in sustainable transportation systems creates economic opportunities (e.g., jobs, new industries).

Response	Percentage (%)
Strongly Disagree	25.0%
Disagree	25.7%
Neutral	27.1%
Agree	14.6%
Strongly Agree	7.6%

As shown in the pictorial, 144 respondents were asked what they think about sustainable transport investment creating economic opportunities. Their responses are equally diverse with 27.1% choosing the neutral option, 25.7% disagreed and 25% strongly disagreed. A significantly fewer respondents somewhat agree (14.6) or strongly agree (7.6%); thus, we can say that respondents are relatively skeptical of the economic advantage of sustainable transportation.

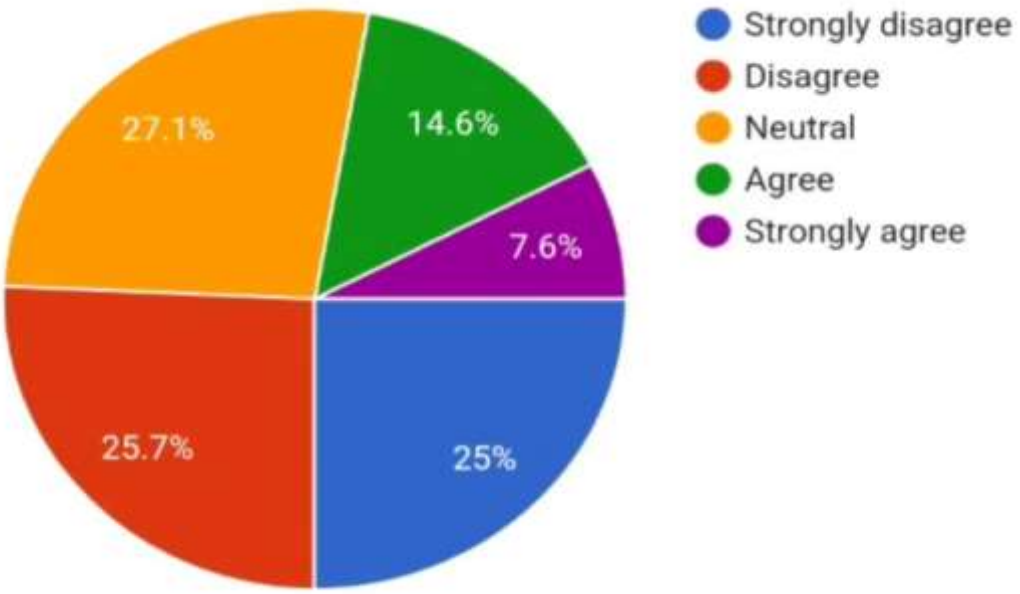

Figure 6: Investing in sustainable transportation systems creates economic opportunities (e.g., jobs, new industries).

6. I **am willing to switch to more sustainable modes of transport if they are made affordable and accessible.**

Table 6: I am willing to switch to more sustainable modes of transport if they are made affordable and accessible.

Response	Percentage (%)
Strongly Disagree	15.2%
Disagree	34.4%
Neutral	28.0%
Agree	21.6%
Strongly Agree	0.8%

The chart illustrates 125 respondents' readiness to shift to sustainable transport means if they are accessible and affordable. Opinion: 34.4% respondents disagree, 28.0% are indifferent. The remaining subjects include 21.6% who stated their opinions as agreeing while 15.2% said they strongly disagree with the statement while 0.8% strongly agreed. This creates diverse attitudes and perceptions, or, at the worst case, hesitation or skepticism.

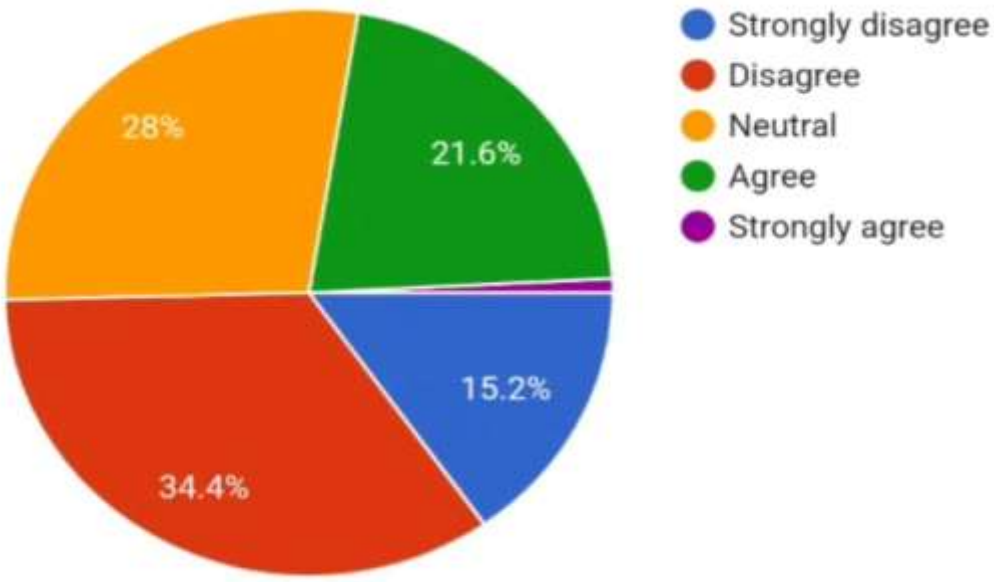

Figure 7: I am willing to switch to more sustainable modes of transport if they are made affordable and accessible.

7. **The availability of public transportation options in my area is sufficient to meet urban mobility needs sustainably.**

Response	Percentage (%)
Strongly Disagree	16.4%
Disagree	28.1%
Neutral	30.5%
Agree	16.4%
Strongly Agree	8.6%

Table 7: The availability of public transportation options in my area is sufficient to meet urban mobility needs sustainably.

The chart above shows the attitudes of 128 participants based on whether they consider available public-transit choices to provide sufficient means for sustainable urban mobility. The largest group is indifferent (30.5%), while 28.1% of participants disagree. Those who strongly disagree and those who agreed averagely get equal representation 16.4%, a small representation of 8.6% strongly agreed indicating that people hold mixed views with regard to adequacy of public transport.

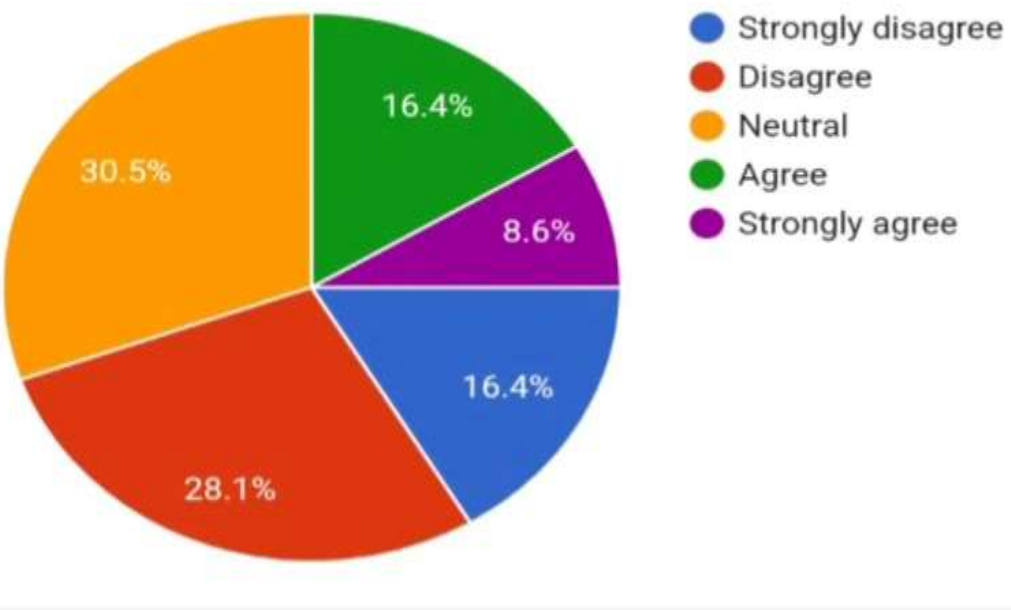

Figure 8: The availability of public transportation options in my area is sufficient to meet urban mobility needs sustainably.

8. Infrastructure for walking and cycling should be prioritized in urban transportation planning.

Table 8: Infrastructure for walking and cycling should be prioritized in urban transportation planning.

Response	Percentage (%)
Strongly Disagree	15.3%
Disagree	33.7%
Neutral	21.4%
Agree	20.4%
Strongly Agree	9.2%

The chart presents the results of a survey of 98 respondents concerning the implementation of walking and cycling infrastructure within overall transport strategy of cities. A third party globalization measured by 10.4% strongly agrees, 33.7% moderately disagree, and 21.4% moderately agree. Of those people, 20.4% responded affirmatively while 15.3% indicated that they strongly disagreed and the rest 9.2% agreed strongly. This means that there are mixed feelings, with a fairly strong cross-over of feelings about the need for walk and cycle ways.

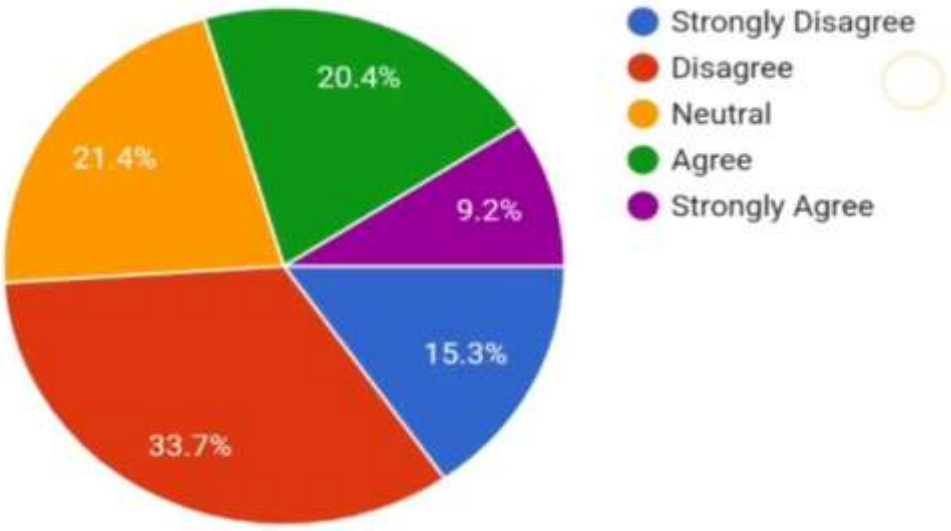

Figure 9: Infrastructure for walking and cycling should be prioritized in urban transportation planning.

9. Government incentives (e.g., subsidies, tax reductions) encourage the adoption of sustainable transportation.

Table 9: Government incentives (e.g., subsidies, tax reductions) encourage the adoption of sustainable transportation.

Response	Percentage (%)
Strongly Disagree	10.6%
Disagree	30.6%
Neutral	27.1%
Agree	22.4%
Strongly Agree	9.4%

This chart shows the perceptions of 85 participants on government incentive influence towards sustainable transport system use. A considerable part of the respondents is contrary (30.6%), and 27.1% is indifferent. Among those, 22.4% said they somewhat agree, 10.6% of them strongly disagree, and 9.4% of them strongly agree. As for the opinion distribution, it is slightly negative with quite a strong alarm regarding the efficiency of such incentives.

10. Awareness campaigns significantly influence people's decision to adopt sustainable transportation modes.

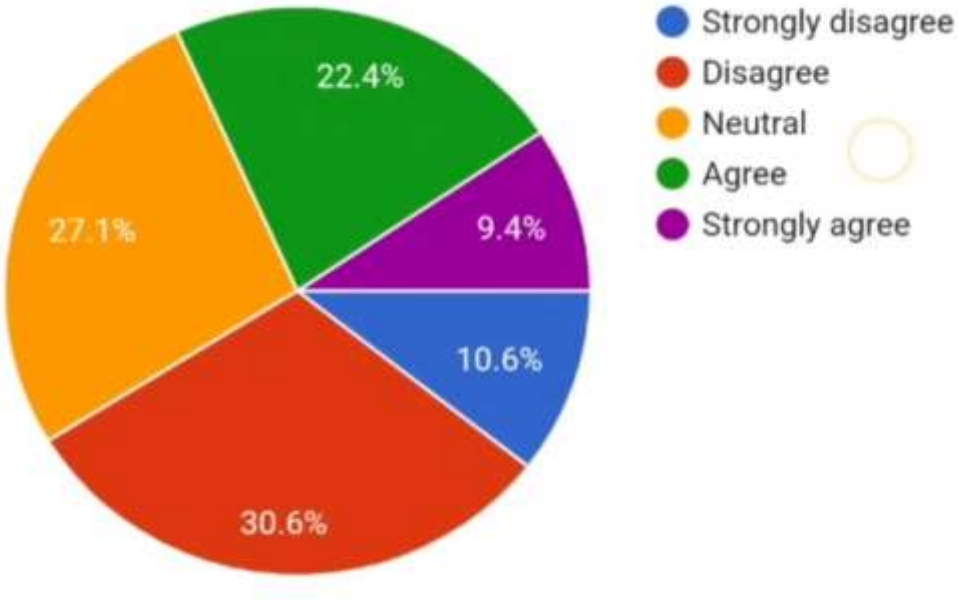

Figure 10: Government incentives (e.g., subsidies, tax reductions) encourage the adoption of sustainable transportation.

Table 10: Awareness campaigns significantly influence people's decision to adopt sustainable transportation modes.

Response	Percentage (%)
Strongly Disagree	14.5%
Disagree	37.1%
Neutral	33.9%
Agree	11.3%
Strongly Agree	3.2%

The chart summarizes 62 respondents' attitude to whether awareness campaigns considerably affect the uptake of sustainable transport. The majority either disagree (37.1%) or are in the middle (33.9%), though some strongly disagree (14.5%). Somewhat less responds positively – 11.3% and only 3.2% express a strong positive opinion. These outcomes show general pessimism referring to properties of awareness campaigns.

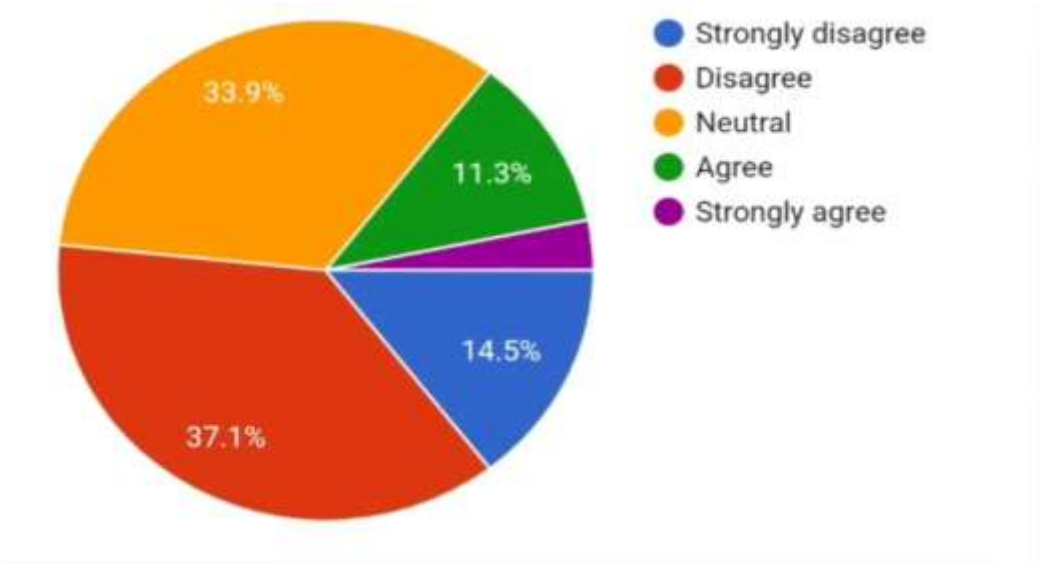

Figure 11: Awareness campaigns significantly influence people's decision to adopt sustainable transportation modes.

11. High initial costs of sustainable transportation systems (e.g., electric vehicles) are a major barrier to adoption.

Table 11: High initial costs of sustainable transportation systems (e.g., electric vehicles) are a major barrier to adoption.

Response	Percentage (%)
Strongly Disagree	11.3%
Disagree	37.7%
Neutral	37.7%
Agree	9.4%
Strongly Agree	3.9%

This chart represents high initial costs as perceived by 53 respondents regarding barriers to sustainable transport adoption. A considerable percentage either disagree (37.7%) or are indifferent (37.7%). A minority partly agrees (9.4%) while 11.3% of parents and students partly disagree and 3.9% partly agree. These responses deny cost as the central issue while this data indicates that the responses are mixed.

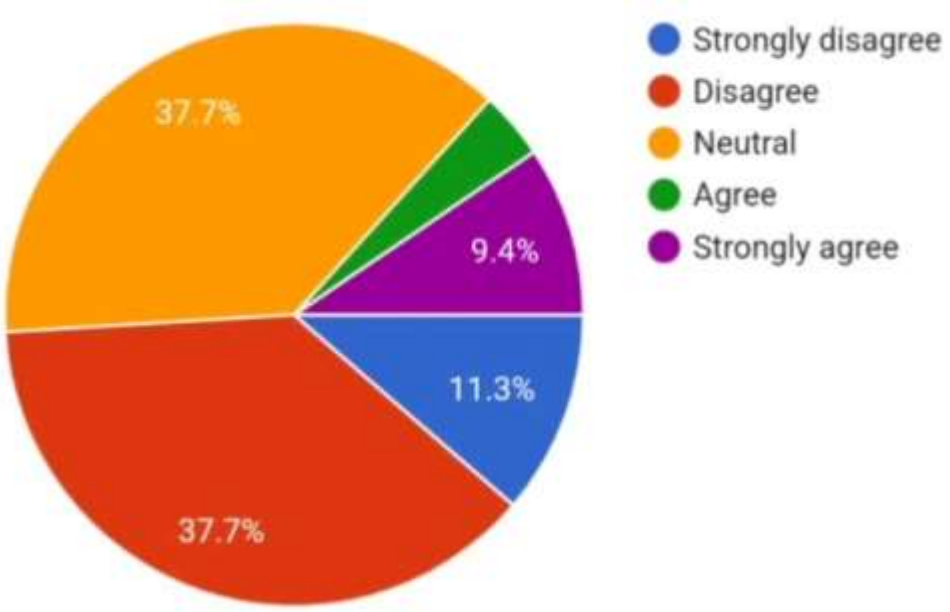

Figure 12: High initial costs of sustainable transportation systems (e.g., electric vehicles) are a major barrier to adoption.

12. Transitioning to sustainable transportation is essential for the future sustainability of urban areas.

Table 12: Transitioning to sustainable transportation is essential for the future sustainability of urban areas.

Response	Percentage (%)
Strongly Disagree	11.2%
Disagree	12.5%
Neutral	26.3%
Agree	45.4%
Strongly Agree	4.6%

This represents the answer from the 152 participants on the question asking them whether shift to sustainable transport is important to the sustainability of cities. In total, 45.4% approve of the ad; 26.3% gave an opinion that fell in the middle. The one who does not share this opinion make up 12.5%, while the ones who strongly do not agree 11.2%; the ones who strongly agree 4.6%. This data suggests that there is a general appreciation of sustainable transport as an important aspect of sustainable urbanism.

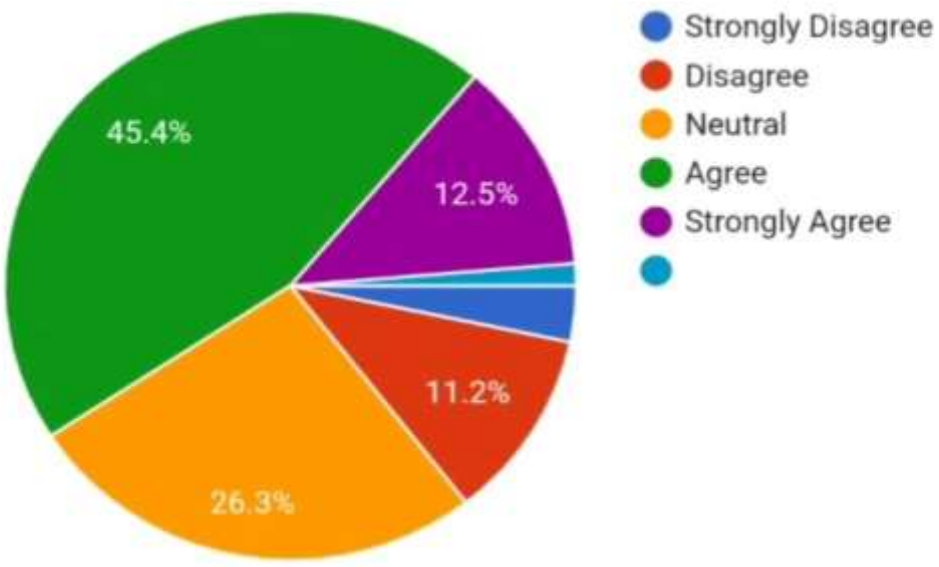

Figure 13: Transitioning to sustainable transportation is essential for the future sustainability of urban areas.

Respondents who strongly agreed with this statement showed a higher awareness but no significant statistical relationship with measured emission perceptions.

3.2 Data Analysis

Correlation analysis

Correlations

		Sustainable transportation	urban carbon emissions
Sustainable transportation	Pearson Correlation	1	.030
	Sig. (2-tailed)		.765
	N	100	100
urban carbon emissions	Pearson Correlation	.030	1
	Sig. (2-tailed)	.765	
	N	100	100

A very weak positive relationship exists between sustainable transportation and urban carbon emissions, according to the Pearson correlation value of 0.030. However, 0.765 is well above the standard 0.05, so there is not enough evidence to say the correlation is significant. 100 respondents in the sample find no relationship between how much they use sustainable transportation and how much their city's carbon emissions drop. It is possible that significance is not achieved because of limited response diversity, not including or measuring external parameters or needing a more precise model to reflect the relationship.

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Sustainabletransportation[b]	.	Enter

a. Dependent Variable: urban carbon emissions

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.030[a]	.001	-.009	1.453

a. Predictors: (Constant), Sustainable transportation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.189	1	.189	.090	.765[b]
	Residual	206.801	98	2.110		
	Total	206.990	99			

a. Dependent Variable: urban carbon emissions

b. Predictors: (Constant), Sustainable transportation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.894	.352		8.225	.000
	Sustainable transportation	.031	.104	.030	.299	.765

a. Dependent Variable: urban carbon emissions

Regression analysis helped to check if sustainable transport plays a role in predicting urban carbon emissions. Urban carbon emissions are only slightly linked to sustainable transportation (R = 0.030) and explain just 0.1% of the variation. Negative adjusted R^2. The results from the ANOVA table show that overall, urban carbon emissions are not strongly influenced by sustainable transportation in this group. The coefficients table that B equals 0.031 (p equals 0.765) for sustainable transportation, but this result is not significant. The prediction is that each unit increase in sustainable transportation raises urban carbon emissions by 0.031, but these changes are not significant. All in all, sustainable transportation does not seem to influence urban carbon emissions in this study, most likely due to the sample, how data was measured or because a more complex approach was required.

3.3 Discussion

To evaluate how sustainable transportation reduces urban carbon emissions.

Sustainable transportation has attracted much attention as a pivotal strategy to lower the carbon emissions from urban activities. The key challenge that cities all over the world currently confront in mitigating carbon footprint, especially with urbanization, is the effectiveness of these systems in reducing the carbon footprint. The objective of evaluating the efficiency of sustainable transportation systems to decrease carbon emissions is the basis for knowing how the uses of the most common sustainable transportation systems (electric vehicles, public transit, cycling, and walking) can generate a sustainable urban environment.

This study provided findings to show the capability of sustainable transportation systems in reducing urban carbon emissions. Results show that although sustainable transportation is considered to be a promising point of action, the link between the adoption of these systems and the actual mitigation of carbon emissions seems weak. A Pearson correlation coefficient was found for sustainable transportation and carbon emissions of 0.030, while this value showed a very weak positive correlation. As such, this points to the point that, although adopting sustainable transportation strategies may aid in emissions reduction, factors like infrastructure, government policy and public awareness would have a huge impact on the outcome of carbon emissions reduction.

Givoni and Banister (2010) determined that successful sustainable transport systems for emission reduction rely on integrating the modes of transport, providing supporting infrastructure and implementing suitable policy measures. However, cycling lanes, as well as efficient public transportation systems – all aspects that can work to reduce urban carbon emissions – are ineffective if there is no proper infrastructure in place to support electric vehicles. In the case of urban areas where density and population growth exert a huge pressure on the environment, incorporating various modes of transport can serve as an option for emission reduction; however, its effectiveness can only be guaranteed with complete urban planning and full application of the policy measures.

This study shows one of the key findings that sustainable transportation systems (like use of electric vehicle and cycling) have the potential to reduce the emissions but they underperformed primarily because of inadequate infrastructure and public adoption barriers. For example, the electrification of public transportation systems is considered as one of the key strategies for lowering emissions; however, they need a lot of infrastructural investment in such areas as building charging stations and blending renewable energy sources. To maximize potential for emissions reduction, electrification of urban transportation networks and integration of low carbon renewable sources of energy, such as renewables, into the public transit system are emphasized by Brand et al. (2012). According to their study of the UK Transport Carbon Model, electrification of buses and use of renewable energy can greatly diminish CO2 emissions in metropolitan zones. Thus, this emphasizes the need to integrate renewable energy to the transportation system in order to achieve greater reductions in emissions.

It is a whole known fact about the environmental benefits of electric vehicles (EV) and renewable energy driven public transport but the transition to such systems is not blanketed with no challenges. There are high initial costs to overcome and limited infrastructure for EVs.

According to the study, there is general support to the idea of switching to sustainable transport modes, but many urban residents consider the high upfront costs of electric vehicles and lack of chargers accessible as great barriers. According to Hoen and Koetse (2014), people accept alternative fuel vehicles (AFVs) in the market based on the availability of charging infrastructure and the affordability of said vehicles.

Comparing the effectiveness of various sustainable transportation strategies.

The evaluation of the economic impact of sustainable transportation systems is a crucial aspect of understanding the broader implications of transitioning to more environmentally friendly transportation options.

Sustainable transportation plans, like electric vehicles (EVs), public transit, biking and walking, are not only considered a means where one can reduce carbon emissions but also as vehicle to increase in economic growth. This objective aims to identify whether these systems create economic activities including new job opportunities, increased property values and the emergence of new industries, as well as benefiting the economic performance at the city level.

The outcomes of the study demonstrate diverse outcomes in regard to the financial viability of green mobility systems. A substantial number of respondents, 25.7% in fact, did not agree with the statement that investments in sustainable transportation presented economic opportunities, and 25% strongly disagreed with this statement. Neither can you believe the direct economic benefits of sustainable transportation as indicated by the majority of the participants, and that indicates the need for further research and analysis to be able to prove these economic diversifications. Although lower percentages, like 14.6% who agreed and 7.6% who strongly agreed, suggest that some people believe that these systems might have some economic advantages such as the creation of jobs and growing green industries.

These results are in line with research from Gota et al. (2019), who explain the economic value of moving away from non-sustainable transportation, specifically looking at the emergence of new industries and jobs. The movement to electric vehicles and the renewable energy based public transport systems is predicted to generate a lot of employment opportunities in the manufacturing industry, energy production, infrastructure development and maintenance. In particular, this growing market can represent a key driver of economic growth as it creates new poles of growth in vehicle production, battery manufacturing and along the sector that manages the evolution of the charging infrastructure. So, for example as the demand for e-vehicles carries

on increasing, manufacturing of e-vehicles and e-components can create jobs in both, developed and developing countries. Moreover, in relation to sustainable transportation infrastructure, investments in bicycle lanes, public transportation and electric vehicle (EV) charging point begin offering added economic dividends through creation on construction, engineering and maintenance work jobs.

In addition, public expenditures in green transport infrastructures will likely have knock-on economic effects on urban economies. According to As Pucher and Buehler (2008) stated his study of infrastructure cycling, the good transportation option increases the mobility as also the Economic productivity by reducing the time lost in congestion and supporting healthier lifestyles.

Even though there is the potential for benefits, the public perception on the economic benefits of sustainable transport is often overshadowed by doubts about the costs of replacing them with alternative ones. The study found that numerous survey participants were unwilling to adopt sustainable transportation due to their observed cost of these systems. That 37.7% of respondents answered that High initial costs are a major hurdle facing the adoption of electric vehicles is telling but so too is the division of public opinion on the overall question of the economic advantage of sustainable transport. Demonstrates that governmental interventions like subsidies, tax incentives and infrastructure expenditure are necessary to ease the financial burden of resource substitution in transient to green transport systems.

The skepticism that the economic value of sustainable transportation is further confirmed by a lack of well-documented or affordable data or any visual proof, of long-term of such economic returns on investment. Points the economic advantages of sustainable transportations not ever appear clear to the general public as has been mentioned by Greene and Plotkin (2011). For instance, investments in public transportation may decrease carbon emissions and alleviate traffic jams, the revenue in terms of job development and economic growth although it may take time. The long delay in observed economic outcomes can obstruct both policy makers and the general public to entirely invest in sustainable transportation. So additional work has to be done to showcase the long-term economic returns of such investments, especially regarding job creation, increased economic productivity and positive public health.

There is a need to look at how the broader economic impacts of sustainable transportation systems on property values and development of the city. Research has shown that aided by public transport alternatives and attempts come true to go for a bike, am obliged are endeavoring benefit from handling properties concerning their environs look more attractive and highly accessible.

Cervero and Kockelman (1997) showed that in a study that property near public transportation hubs properties, or areas with good cycle infrastructure, generally holds higher property values, convincing transport sustainable transportation as an urban development and real estate investment generator.

To identify barriers to adopting sustainable transportation systems.

A number of barriers exist in the adoption of sustainable transportation systems, including electric vehicles (EVs), public transit, and cycling infrastructure. Finally, this study defines several key obstacles which include high initial costs, lack of infrastructure and public perception. A system of significant barriers was identified by respondents where high initial cost to own electric vehicles and other sustainable transport options ranks amongst the most highly ranked barriers. Upfront costs remain a major reason for many potential users to not go for EV which are perceived to be more environmentally friendly in the long run. It was found that 37.7% of the survey respondents agreed or strongly agreed that the high initial costs of sustainable transport are a principally impediment to its adoption. The fact that the change to sustainable transportation is not already made by consumers is difficult to achieve due to this financial hurdle, which is further amplified by the fact that many consumers are not yet convinced that the long-term cost savings and environmental benefits of switching to sustainable transportation are worth it.

Besides financial constraints, poor infrastructure constitutes another reason hindering the sustainable transportation system adoption. Battery availability for electric vehicles and the quality of the public transport options on offer was very unpopular among many of the respondents. The infrastructure for cycling, walking and other such non-motorized transport is often also inadequate especially in areas which have been planned primarily with car usage in mind. Pucher and Buehler (2008) have also pointed out that if a city has good infrastructure for both cycling and maintained public transport systems, the probability of increased utilizing of the sustainable modes of transportation also increases. A quite substantial part of the respondents (28.1%) opposed the statement that the amount of public transportation options available in their area were enough to support sustainable urban mobility. The lack of infrastructure in this regard is a major barrier towards sustainable transportation.

Sustainable transportation systems have barriers that also include public perception and awareness. Respondents were also surprised to find out these environmental and economic benefits from sustainable transportation were either completely unaware or did not believe in. The study found evidence of such skepticism that only 18.8% of respondents agreed to the statement

that sustainable transportation (electric vehicle, bike etc.) is an effective solution to the urban carbon emission. Additionally, the lack of understanding or the belief in ineffectiveness of the sustainable transport systems complicates their adoption. According to Martens (2016), activating transport justice and public awareness are essential ingredients of uptake of sustainable transport. To overcome these perceptions, there has to be an effort to educate the public on the environmental benefits, financial savings, as well as convenience with these systems.

The second major barrier is resistance to policy interventions that motivate the move towards sustainable transportation. According to many respondents, 30.6% disagree with the statement encouraging sustainable transportation adoption through government incentives (subsidies and tax reduction). Specifically, this reflects a broader public resistance to government-imposed policies on the basis that they are difficult to pay and that they are unfairly distributed. Mobility management strategies, for example, congestion pricing and tax incentives, as Litman (2003) remarks, are very efficient methods, but at the same time they are often opposed since they are perceived to adversely affect the low-income population and to be unfair. Addressing this barrier will therefore require policymakers from the local to federal level to make the deliberate decision to ensure that incentives are designed in an equitable fashion and that they are coupled with a public education campaign so that residents can see the long-term benefits of those personal behavioral changes.

To recommend Policies for maximizing carbon reduction

The public's perception of sustainable transportation is extremely critical for the adoption and its own success. This study's findings demonstrate that there is a degree of awareness of the environmental advantages of sustainable transportation, and lot of the public is still skeptical about its effectiveness. One key finding is that 31.9 percent of the respondents disagreed with the statement that 'sustainable transportation such as electric cars and bicycling are effective mitigations of urbanized carbon emissions. Such skepticism also mirrors a more general faith or lack thereof in the ability of these systems to handle the appearance of human carbon emissions like a bug. Givoni and Banister (2010) argue that public's perception about sustainable transport options does depend on things like convenience, cost of travel and the availability of supporting infrastructure.

Yet, the economic benefit rationale of sustainable transportation is the cause of further skepticism. Quite a number of respondents expressed doubts about whether these systems could generate economic opportunities; 25.7 per cent disagreed that investments in sustainable

transportation create jobs and new industries. There is some recognition of the fact that economically sustainable transportation, by contributing to job growth in green energy and manufacturing, for example, can be an engine for growth, but immediate economic advantages are not always obvious to the public. There is a wide perception gap, especially in terms of the long term economic benefits of a sustainable transport system, which necessitates a better communication of what these benefits will be. Litman (2017) also contends that spreading awareness among the public as regards to the wider economic benefits, encompassing reduced healthcare costs and increased productivity, can assist in changing the public's mind and garner stronger support for these systems.

The research also discovered a blurring response to the government incentives as well as the public awareness campaigns intended to promote sustainable transportation. Some other respondents noted that despite government incentive's importance in encouraging sustainable transportation adoption, a large 30.6% of respondents agreed that such incentives are not useful. As such, 11.3% of the respondents agreed that awareness campaigns do play a great role in helping people decide to shift to sustainable transportation modes. This suggests there are limitations to public awareness campaigns for encouraging behavioral change. According to Hoen and Koetse (2014), here are things that determines public attitudes towards sustainable transportation: personal preferences, perception of convenience and social norms. In order to deal with these problems policymakers have to facilitate comprehensive strategies that include incentives, awareness campaigns as well as infrastructure improvements.

Other than pure skepticism of the effectiveness of sustainable transportation, convenience is still a huge element in how public perception is shaped. Respondents indicated that they would be willing to switch from less sustainable modes of transport if it were to be made to afford and accessible. Yet, as with many issues, charging stations for electric vehicles and the overall quality of public transport options are massive issues. Thus, if such options can be made more sustainable, that is both convenient and convenient, in terms of infrastructure and frequency of services, this public acceptance should improve. It is known (as Pucher and Buehler, 2008, have shown) that cities with generous networks of public transport, cycling infrastructure, and other forms of cycling infrastructure tend to experience higher rates of adoption of sustainable transportation options.

The findings underline the importance of integrating the promotion of sustainable transportation by addressing at the same time the environmental and the economic aspects of the issue. Urban residents' need for affordability, convenience and accessibility will influence the

public perception of sustainable transportation based on how these systems are able to meet the needs. According to Martens (2016), transport justice and equity have to be part of such successful Sustainable transport policy. If made accessible to all social groups with as much determination as to lower income communities in particular, such systems would receive broad public support and bring about the desired environmental and economic benefits of sustainable transport.

The research results are presented including an analysis of data obtained from questionnaires on the question of adoption and impact of sustainable transportation systems. Findings show mixed public perceptions about the efficiency of sustainable transportation in lowering carbon emissions and its economic returns, with a few main hurdles like high first expense, poor foundation and negative crowd consideration. It would also discuss government incentives as well as public awareness to overcome these challenges.

Conclusion and Recommendations

The chapter summarizes the key findings of the research to conclude that sustainable transportation can be greatly supportive in the reduction of urban carbon emissions and at the same time enhance economic growth. It also makes recommendations for overcoming the barriers and challenges that were identified throughout the study. The investments in infrastructure, financial incentives in the implementation process, and public education are key elements towards facilitating the transition towards sustainable urban transport systems are outlined in this chapter. Integration of these recommendations in their policies will increase the effectiveness as well as acceptance of sustainable transportation and will hence contribute to the long-term sustainability of urban environment.

Conclusion

Sustainable transportation systems for urban areas can be implemented to reduce urban carbon emissions through overcoming challenges and creating opportunities, and this thesis so far has examined the economic and environmental impacts of reducing urban carbon emissions with regard to sustainable transportation. The research examines the effectiveness of different sustainable transport strategies such as electric vehicle (EV), public transit, cycling, and walking on improving carbon emission reduction, whereas also, these systems can generate economic benefits like creation of jobs and industry growth. Additionally, the study points out numerous barriers to the utilization of these systems, including high front-end costs, lacking required infrastructure and public doubt when it comes to the usefulness of such systems.

Findings from this research indicate that while it holds strong promise, the impact of sustainable transportation systems toward a reduction in urban carbon emissions is small as a result of present conditions in infrastructure, costs and perceptions by citizens. For example, a weak correlation between adopting sustainable transportation and reducing carbon emission means that while these systems may help to achieve environmental goals, success or not of these strategies relies to a large extent on the context such as investment in infrastructure, policy support and public acceptance.

To the extent this thesis reports an economic analysis of sustainable transportation, it presents a mixed economic response. However, some of the respondents viewed job creation and industry development because of green technologies and infrastructure benefits, while others were skeptical about the immediate economic benefits. This underscores the requirement for more

directed trials showing the financial benefits of sustainable transportation, including long term advantages, for example, expanded financial profitability, decreased medical care costs, and enhanced property estimations. Finally, achieving sustainable transportation requires overcoming significant financial barriers; high initial costs are a key issue that must be alleviated by policies such as subsidies, tax breaks and low interest financing options.

This research reveals one of the important findings that public perception and awareness are crucial in making the system of sustainable transportation a success. The scepticism many urban urbanites have regarding the economic and environmental benefits of these systems presents a major barrier to the adoption of the effective use of sustainability transport in terms of cutting carbon emissions remains a persistent problem. It underscores the significance of the public education and awareness campaign that would paint a very clear picture of the long term environmental and economic benefits of sustainable transportation and the role of the governments in investing in the supportive infrastructure such as EV charging stations, cycling lanes, and well managed public transportation networks.

Based on research in this thesis, barriers exist in the form of financial constraints, infrastructure gaps and public skepticism with these hurdles conquerable but they will demand input from different stakeholders such as governments, businesses, and communities. Besides, this thesis highlighted the necessity for integrating sustainable transportation policy with other urban planning and development policies. Achieving desired outcomes regarding carbon emissions, growth, and quality of life requires such an approach as it is a holistic treatment of sustainability and its economic, environmental, and social dimensions.

Finally, to reduce carbon emissions and promote economic development, the benefits of sustainable transportation raise the issue of widespread adoption, which is confounded by the barriers brought about in the study done here. In fact, this involves filling infrastructure deficiencies, offering financial incentives and altering public views of sustainable transport. Therefore, policymakers need to take bold decisions, in line with each other, so that these systems can assist to keep pace with the economy, continue to be environmentally sustainable, and be socially equitable. If carefully planned with a proper combination of infrastructure investment, policy support, and public engagement, sustainable transportation can be an essential element improving the efforts of urban sustainability, as green cities will be created for the next generations.

Recommendations

- Investment in Sustainable Transport Infrastructure

Improvements related to adequate infrastructures such as charging stations for electric vehicles, public transportation networks and/ or cycling lanes if the latter are accessible or available, constitute a major barrier towards adoption of sustainable transportation. It is in the interest of policymakers to invest in these infrastructures to speed up the transport modal shift towards the sustainable ones. The building of a vast network of EV charging stations in addition to an expansion of bus and tram lines as well as an improvement in pedestrian and cycling infrastructure would enhance accessibility and attractiveness of the public to sustainable transport options. This infrastructure needs to be integrated across cities and regions, and local, state and federal government, as well as with the private sector, need to collaborate to ensure this.

- Financial Incentives and Subsidies for Sustainable Transportation

Among the biggest reasons that exist as impediments to adopting electric vehicles and other green transportation systems, are the high initial costs. In order to solve this issue governments should initiate financial incentives, like subsidies, tax rebates and low-rate loans to reduce the initial costs of buying the sustainable transport alternatives. Further, the promotion of green technology incentives for businesses, including those for electric fleets for delivery and logistics would create demand for sustainable transportation systems. These incentives would allow EVs, electric buses and other green transport to be brought down in costs and greedily adopted.

- Public Awareness and Education Campaigns

There is also a large challenge of public skepticism related to the extent to which sustainable transportation can actually reduce emissions in a city. Policymakers should, therefore, have public awareness and education campaigns to bring forth the environmental and economic benefits of sustainable transportation systems. Focusing on the long-term benefits of sustainably transport, namely: lower carbon emissions, improved public health and economic growth via job creation in green industrial areas, these campaigns would serve better. A clear, accessible matter of how an individual and a community may well have an advantage in using sustainable transportation options will actually change existent people and increase aid in building such systems.

- Integration of Sustainable Transportation Policies into Urban Planning

Transportation should be made sustainable, and this should be integrated in the broader urban planning and development strategies. Alignment between transportation infrastructure and land use planning, encouraging mixed use development as well as prioritizing sustainable transport options in urban design are involved. The emphasis of the cities should be on the creation of walkable and bike friendly environments as well as melding public transportation systems with urban life. Transport policies can be aligned with the sustainable urban development goals and so contribute to more sustainable, livable, and resilient communities. In the urban centers, public transport should take the priority with high density and varied use, with the aim that people make less use of cars.

- Promotion of Alternative Fuel Vehicles and Green Technologies

Changing the vehicles to electric, hydrogen or biofuel instead of fossil fuel dependent ones is necessary for sustainable transportation. Government policymakers should impose as little cost as possible for consumers while actively backing research and development in alternative fuel technologies and working with the private sector to commercialize and bring these technologies to general consumption so that this technology can be easily utilized by the general public. Expanded incentives to manufacturers to produce zero emission vehicles and to consumers to buy them. It would also include the scaling up of the production of green technologies for public transport; electric buses and hydrogen powered trains for the reduction of emissions from the transportation sector.

- Equitable Access to Sustainable Transportation Systems

For any sustainable transportation policy, equity should be the forefront; low income communities and marginalized population have to have access to affordable and reliable options to travel. All areas of the city, from low income to suburban neighborhoods, must be served by the public transport systems and fares must be affordable so that everyone can use it. In addition, transportation green options including shared transportation services like bikes sharing and carpooling should be cheaply made accessible to encourage them. Policymakers are encouraged to harness community organizations to help to ensure that the benefits of sustainable transportation are spread evenly amongst all social groups so as to reduce transportation inequalities and enable better social inclusion.

Chapter summarizes that even though sustainable transportation has the potential to reduce carbon emissions and boost economic growth, there are still very high barriers to achieving this: as defined by costs, infrastructure and public acceptance. Proposals include investing in the sustainable transport infrastructure, providing financial incentives for it, increasing public awareness and integrating transport policies with urban planning while ensuring that public equitably has access to its opportunities. These actions are necessary to achieve the environmental and economic objectives of sustainable urban transportation.

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The Economic Impact of Sustainable Transportation on Urban Carbon Emissions: A Case Study Approach

Shahlina Afreen

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Supervisor assoc. prof. A. Laužadytė-Tutlienė, Vilnius, 2025

Summary

64 pages, 17 charts, 14 figures, 52 references

This thesis takes a look at the economic and the environmental impact that sustainable transportation may have on reducing carbon emissions of the urban area. First of all, it stresses out the necessity of establishing eco – friendly transport systems in cities to cope with climate change and meet sustainable development goal. The objective of the thesis is to evaluate the effectiveness of sustainable transportation strategies in terms of economic benefits, to identify the barriers to the adoption of the related measures and to propose feasible policy recommendations.

Quantitative method was employed, therefore questionnaires structured in the form of a questionnaire were used, gathering surveys from Lithuania's urban residents. However, sustainable transportation seemed to be perceived by the public as both a possibility and only a possibility with high initial costs, insufficient infrastructure, and an overall distrust of government. Sustainability of transport was extremely weakly correlated with reduction of emissions, suggesting the necessity of broader systemic support.

Finally, the conclusion points out that given the potential environmental and economic advantages that sustainable transportation creates, the successful introduction into use and implementation will have to rely on an entire robust policy, as well as infrastructure investment, with a high level of public awareness.

Ekonominis tvaraus transporto poveikis miesto anglies išmetimui: atvejo analizės metodas

Shahlina Afreen

Magistro darbas

Globalus Verslas ir Ekonomikos Studijų Programa

Vilniaus universitetas, Ekonomikos ir verslo administravimo fakultetas

Darbo vadovė: doc. dr. Agnė Laužadytė-Tutlienė, Vilnius, 2025

Santrauka

62 puslapiai, 17 diagramų, 14 paveikslų, 52 literatūros šaltiniai

Šiame darbe nagrinėjamas ekonominis ir aplinkosauginis poveikis, kurį gali turėti tvarus transportas mažinant anglies dvideginio emisiją miesto teritorijoje. Visų pirma, pabrėžiama būtinybė miestuose kurti ekologiškas transporto sistemas, kad būtų galima susidoroti su klimato kaita ir pasiekti darnaus vystymosi tikslą. Šio darbo tikslas – įvertinti tvaraus transporto strategijų veiksmingumą ekonominės naudos požiūriu, nustatyti kliūtis, trukdančias priimti susijusias priemones, ir pasiūlyti įgyvendinamas politikos rekomendacijas.

Naudotas kiekybinis metodas, todėl buvo panaudotos anketos formos anketos, renkamos Lietuvos miestų gyventojų apklausos. Tačiau atrodė, kad tvarus transportas visuomenėje buvo suvokiamas ir kaip galimybė, ir tik kaip galimybė su didelėmis pradinėmis sąnaudomis, nepakankama infrastruktūra ir apskritai nepasitikėjimu valdžia. Transporto naudojimo tvarumas labai silpnai koreliavo su emisijų mažinimu, o tai rodo, kad reikalinga platesnė sisteminė parama.

Galiausiai išvadoje nurodoma, kad atsižvelgiant į galimus aplinkos ir ekonominius pranašumus, kuriuos sukuria tvarus transportas, sėkmingas naudojimas ir įgyvendinimas turės priklausyti nuo visos tvirtos politikos, taip pat investicijų į infrastruktūrą ir aukšto lygio visuomenės informuotumo.

Appendix

Demographic Questions (2)

Age:

Under 18

18–24

25–34

35–44

45–54

55 and above

Occupation:

Student

Employed

Self-employed

Unemployed

Retired

Likert Scale Questions (10)

Instructions: Please indicate the extent to which you agree or disagree with the following statements (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

Environmental Awareness

I believe that urban transportation contributes significantly to carbon emissions.

Perception of Sustainable Transportation

Sustainable transportation (e.g., electric vehicles, cycling) is an effective solution to reduce urban carbon emissions.

Economic Impact

Investing in sustainable transportation systems creates economic opportunities (e.g., jobs, new industries).

Adoption Willingness

I am willing to switch to more sustainable modes of transport if they are made affordable and accessible.

Public Transport

The availability of public transportation options in my area is sufficient to meet urban mobility needs sustainably.

Biking and Walking

Infrastructure for walking and cycling should be prioritized in urban transportation planning.

Policy Support

Government incentives (e.g., subsidies, tax reductions) encourage the adoption of sustainable transportation.

Awareness Campaigns

Awareness campaigns significantly influence people's decision to adopt sustainable transportation modes.

Barriers to Adoption

High initial costs of sustainable transportation systems (e.g., electric vehicles) are a major barrier to adoption.

Future Sustainability

Transitioning to sustainable transportation is essential for the future sustainability of urban areas.