V Vimal

Impact of Weather on Mode Choice

May 2024

Impact of Weather on mode choice

Master of Planning
(Transport Planning and Logistics Management)

V Vimal
[Sch. No. 2022MTPLM015]

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL
NEELBAD ROAD, BHAURI, BHOPAL (MP)-462030

May 2024

Impact of Weather on Mode Choice

Thesis submitted in partial fulfillment of the requirements for the award of the degree of

Transport planning and Logistics management

By

V Vimal

Scholar No. 2022MTPLM015

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL
NEELBAD ROAD, BHAURI BHOPAL (MP)-462030

May 2024

Declaration

I **V Vimal**, Scholar No. 2022MTPLM015 hereby declare that the thesis titled Impact of weather mode choice, submitted by me in partial fulfilment for the award of degree, at School of Planning and Architecture, Bhopal, India, is a record of bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Signature of the Student

Date: _______________

Certificate

This is to certify that the declaration of **V Vimal** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

____

Signature of the Guide

Dr. Gaurav Vaidya

ACCEPTED

____

Prof. Saurabh Popli

Head, Department of Transport Planning

May 2024, Bhopal

Acknowledgements

This thesis is dedicated to **"M Prabu Muthukumar"**, whose unwavering encouragement and selfless sacrifices have profoundly influenced my journey, shaping me into the person I am today. His steadfast presence throughout my educational endeavours has been a pillar of support, and I express my sincerest gratitude for his enduring efforts.

I extend my heartfelt appreciation to Dr. Gaurav Vaidya, my esteemed guide, whose invaluable guidance, expertise, and unwavering support have been instrumental in navigating the intricate path of my thesis journey. Dr. Mayank Dubey, my thesis coordinator, deserves special recognition for their invaluable mentorship, constructive feedback, and steadfast support throughout the rigorous research process. Additionally, I am deeply thankful to Prof. Saurabh Popli, our HOD, whose guidance and encouragement during my thesis work have significantly propelled me towards successful completion.

My gratitude also extends to my loving family and classmates, whose unwavering support, understanding, and encouragement have been a constant source of strength. Their steadfast belief in me and the sacrifices they have driven my relentless pursuit of academic excellence.

Lastly, I want to express my profound appreciation to my friends Ruban, Shravani Reddy, Justin Andrews, Omkareswar, Venkateshwaran, Vishnu Prasad, and Praveen. Their unwavering belief in me and unwavering support throughout this thesis journey have been invaluable, serving as a source of motivation and inspiration.

Abstract

This study investigates the influence of weather on people's mode choice decision in different weather conditions and different regions using primary survey. The impact of weather on people's mode choice decisions is a dynamic phenomenon that plays a crucial role in shaping transportation preferences and behaviours. This study delves into the complex relationship between weather conditions and the choices individuals make regarding their mode of transportation. As weather exerts a pervasive influence on daily life, understanding its effects on transportation decisions is essential for transportation planners, policymakers, infrastructure developers and researchers.

The research employs a comprehensive approach, examining various weather parameters such as extreme heat, heavy rainfall, wind speed, and fog and their distinct influences on mode choice. Through an extensive review of existing literature and empirical studies, the paper aims to uncover patterns and trends in how weather conditions impact people's preferences for walking, cycling, driving, or using public transportation.

The findings reveal that weather significantly shapes individuals' perceptions of comfort, safety, and convenience associated with different modes of transportation. For instance, extreme weather conditions like heavy rain or extreme temperatures may discourage walking or cycling, prompting individuals to opt for more weather-resistant modes such as cars or public transit. Conversely, pleasant weather conditions often encourage active modes of transportation, contributing to a more sustainable and health-conscious urban lifestyle.

The study also considers variations in different parameters, acknowledging that the impact of weather on mode choice can vary across different regions and demographic groups. Additionally, advancements in technology, such as real-time weather information and transportation apps, are explored as potential mitigating factors that could influence decision-making in response to changing weather conditions.

Ultimately, this research contributes valuable insights to the fields of urban planning and transportation management, offering an understanding of the intricate interplay between weather and people's mode choice decisions. By unravelling these complexities, policymakers can develop more effective strategies to promote sustainable and weather-resilient transportation systems, fostering a resilient and adaptable urban environment. The findings highlight the importance to incorporate individual and regional unique anticipation and adaptations behaviours within our policy design and infrastructure management.

Keywords: weather changes, travel mode choice, regional and seasonal variability, marginal effects.

सारांश

यह अध्ययन प्राथमिक सर्वेक्षण का उपयोग करके विभिन्न मौसम स्थितियों और विभिन्न क्षेत्रों में लोगों के मोड पसंद निर्णय पर मौसम के प्रभाव की जांच करता है। लोगों के मोड चयन निर्णयों पर मौसम का प्रभाव एक गतिशील घटना है जो परिवहन प्राथमिकताओं और व्यवहार को आकार देने में महत्वपूर्ण भूमिका निभाती है। यह अध्ययन मौसम की स्थिति और व्यक्तियों द्वारा अपने परिवहन के साधन के संबंध में चुने गए विकल्पों के बीच जटिल संबंध पर प्रकाश डालता है। चूंकि मौसम दैनिक जीवन पर व्यापक प्रभाव डालता है, इसलिए परिवहन योजनाकारों, नीति निर्माताओं, बुनियादी ढांचे डेवलपर्स और शोधकर्ताओं के लिए परिवहन निर्णयों पर इसके प्रभाव को समझना आवश्यक है।

अनुसंधान एक व्यापक दृष्टिकोण अपनाता है, जिसमें अत्यधिक गर्मी, भारी वर्षा, हवा की गति और कोहरे जैसे विभिन्न मौसम मापदंडों और मोड चयन पर उनके विशिष्ट प्रभावों की जांच की जाती है। मौजूदा साहित्य और अनुभवजन्य अध्ययनों की व्यापक समीक्षा के माध्यम से, पेपर का उद्देश्य पैटर्न और रुझानों को उजागर करना है कि मौसम की स्थिति लोगों की पैदल चलने, साइकिल चलाने, ड्राइविंग या सार्वजनिक परिवहन का उपयोग करने की प्राथमिकताओं को कैसे प्रभावित करती है।

निष्कर्षों से पता चलता है कि मौसम परिवहन के विभिन्न तरीकों से जुड़े आराम, सुरक्षा और सुविधा के बारे में व्यक्तियों की धारणाओं को महत्वपूर्ण रूप से आकार देता है। उदाहरण के लिए, भारी बारिश या अत्यधिक तापमान जैसी चरम मौसम की स्थिति पैदल चलने या साइकिल चलाने को हतोत्साहित कर सकती है, जिससे व्यक्तियों को कारों या सार्वजनिक परिवहन जैसे अधिक मौसम-प्रतिरोधी साधनों का चयन करने के लिए प्रेरित किया जा सकता है। इसके विपरीत, सुखद मौसम की स्थिति अक्सर परिवहन के सक्रिय साधनों को प्रोत्साहित करती है, जो अधिक टिकाऊ और स्वास्थ्य के प्रति जागरूक शहरी जीवन शैली में योगदान करती है।

अध्ययन विभिन्न मापदंडों में भिन्नता पर भी विचार करता है, यह स्वीकार करते हुए कि मोड की पसंद पर मौसम का प्रभाव विभिन्न क्षेत्रों और जनसांख्यिकीय समूहों में भिन्न हो सकता है। इसके अतिरिक्त, प्रौद्योगिकी में प्रगति, जैसे कि वास्तविक समय की मौसम की जानकारी और परिवहन ऐप, को संभावित शमन कारकों के रूप में खोजा जाता है जो बदलती मौसम स्थितियों के जवाब में निर्णय लेने को प्रभावित कर सकते हैं।

अंततः, यह शोध शहरी नियोजन और परिवहन प्रबंधन के क्षेत्रों में मूल्यवान अंतर्दृष्टि प्रदान करता है, जो मौसम और लोगों के मोड पसंद निर्णयों के बीच जटिल अंतरसंबंध की समझ प्रदान करता है। इन जटिलताओं को सुलझाकर, नीति निर्माता टिकाऊ और मौसम-अनुकूल परिवहन प्रणालियों को बढ़ावा देने, लचीले और अनुकूलनीय शहरी वातावरण को बढ़ावा देने के लिए अधिक प्रभावी रणनीतियाँ विकसित कर सकते हैं। निष्कर्ष हमारी नीति डिजाइन और बुनियादी ढांचे प्रबंधन के भीतर व्यक्तिगत और क्षेत्रीय अद्वितीय प्रत्याशा और अनुकूलन व्यवहार को शामिल करने के महत्व पर प्रकाश डालते हैं।

कीवर्ड: मौसम परिवर्तन, यात्रा मोड का विकल्प, क्षेत्रीय और मौसमी परिवर्तनशीलता, सीमांत प्रभाव।

Table of Contents

List of Tables

List of Figures

CHAPTER 1. Introduction

The choice of transportation mode is significantly influenced by various environmental factors, each with its own impact on decision-making. Firstly, air quality plays a crucial role, as individuals often consider the environmental implications of their mode choice, particularly in urban areas where air pollution is a pressing concern. Modes such as walking, cycling, and public transport are generally perceived as more environmentally friendly options compared to private car usage, which contributes to air pollution and greenhouse gas emissions. Secondly, climate conditions, including weather patterns such as rain, snow, and extreme temperatures, can influence mode choice by affecting the comfort and feasibility of certain transportation options. Additionally, environmental considerations extend to the broader ecological impact of transportation modes, including their contribution to noise pollution, habitat disruption, and land use. Overall, the environmental impact on mode choice reflects a complex interplay between considerations of air quality, climate conditions, and broader ecological concerns, shaping individuals' decisions towards more sustainable transportation alternatives.

Studying the environmental impacts on mode choice is crucial due to its profound influence on people's perceptions, behaviours, and adaptations towards transportation. People's awareness of environmental issues, such as air pollution and climate change, increasingly shapes their transportation decisions. As individuals become more environmentally conscious, they tend to prioritize modes of transportation perceived as less harmful to the environment, such as walking, cycling, or public transit, over private car usage. Understanding how environmental factors influence mode choice allows policymakers and urban planners to develop strategies to encourage sustainable transportation options and discourage reliance on high-emission vehicles. Moreover, studying these impacts helps in predicting and guiding people's adaptation towards more environmentally friendly modes of transport, facilitating the transition towards greener and more sustainable urban mobility systems. By elucidating the complex interplay between environmental considerations and mode choice, research in this area enables the development of targeted interventions and policies aimed at fostering environmentally sustainable transportation behaviours and lifestyles.

Transportation plays a pivotal role in shaping urban mobility patterns and influencing individuals' daily travel choices. The impact of weather conditions on mode choice has garnered increasing attention in transportation research, as weather variations can significantly alter travel behaviour and transportation preferences. Understanding how individuals select their mode of transport in response to different weather indicators is essential for enhancing transportation planning, infrastructure development, and sustainable urban mobility strategies.

This thesis focuses on investigating the relationship between weather conditions and mode choice in the cities of Madurai and Coimbatore, two urban centres with distinct weather patterns and transportation systems. By conducting a comparative analysis between these cities, this study aims to uncover the nuanced influences of weather on travel behaviour and mode selection. Through an in-depth examination of individual travel patterns, socio-demographic characteristics, and weather indicators, this research seeks to elucidate the complex interplay between environmental factors and transportation decisions.

The findings of this study are expected to provide valuable insights into how weather conditions shape mode choice preferences, travel patterns, and overall transportation dynamics in Madurai and Coimbatore. By exploring the correlations between weather indicators and individual travel behaviour, this research aims to contribute to the development of more resilient, efficient, and weather-responsive transportation systems in urban areas. Ultimately, this thesis endeavours to bridge the gap between weather science and transportation planning, offering practical implications for sustainable urban mobility management in the face of changing weather patterns.

1.1 Background of the study

The choice of transportation mode is influenced by a numerous factor, including personal preferences, accessibility, cost, and environmental conditions. Among these factors, weather conditions have emerged as a significant yet understudied determinant of mode choice and travel behaviour.

Weather variations, such as temperature fluctuations, precipitation levels, wind speed, and extreme weather events, can impact individuals' transportation decisions and preferences. Changes in weather patterns can affect the perceived comfort, safety, and convenience of different transportation modes, leading to shifts in travel behaviour and mode selection. Understanding how weather influences mode choice is crucial for optimizing transportation systems, enhancing user experience, and promoting sustainable urban mobility practices.

The cities of Madurai and Coimbatore, located in the southern region of India, present an intriguing setting for studying the interplay between weather conditions and mode choice. With distinct weather patterns and diverse transportation infrastructures, these cities offer a unique opportunity to explore how environmental factors shape travel behaviour in urban settings. By conducting a comparative analysis between Madurai and Coimbatore, this study aims to uncover the nuanced relationships between weather indicators and individual transportation decisions.

Through a comprehensive examination of travel patterns, socio-demographic characteristics, and weather data, this research seeks to provide valuable insights into the complex dynamics of mode choice in response to varying weather conditions. By bridging the gap between weather science and transportation planning, this study aspires to contribute to the development of weather-responsive and sustainable urban transportation strategies, ultimately fostering more resilient and efficient mobility systems in urban environments.

1.2 Need for the study

It's clear that weather plays a significant role in shaping travel demand, flow, and individual travel behaviour. While previous studies have predominantly focused on how weather affects traffic safety and flow, a study by Keay et al. (2005) stands out, highlighting weather as the most influential factor on traffic volume flow. They observed significant reductions in car speed during misty conditions and in traffic volume during precipitation.

Additionally, a roadside questionnaire survey underscored that drivers who receive weather forecasts are inclined to alter or delay their travel plans. Despite numerous studies on weather's impact on traffic flow and safety, there remains a gap in understanding how weather influences people's mode choices. Bridging this gap would enable the design of more effective transportation policies, enhance infrastructure, and improve the accuracy of travel demand forecasting.

1.3 Aim of the study

To assess the influence of weather changes on individual’s mode choice decision by comparing with two cities of different climatic condition.

1.4 Objective of the study

- To investigate the impact of weather characteristics on individual's mode choice by doing descriptive analysis.
- To estimate multinomial logit model and to examine the marginal effects of weather characteristics on mode choices.
- To compare model results for different weather & regions to interpret individual behaviors due to difference in weather impacts.

1.4 Scope and limitation

This study encompasses a wide geographical area and examines various seasons throughout the year to analyse the marginal effects of weather attributes on different modes of travel across different regions and seasons.

However, there are certain limitations to consider. One such limitation is the potential discrepancy in the distance between the trip maker's origin and the nearest weather station, raising concerns about whether the weather data obtained from the station accurately reflects the conditions at the trip origin.

While numerous factors such as travel distance, cost, comfort, safety, and travel purpose influence mode choice, this study primarily concentrates on the impact of weather characteristics on decision-making regarding mode choice.

Furthermore, the study relies solely on primary surveys, which may introduce inaccuracies. Additionally, respondents might be influenced by the expectations of the surveyors, potentially affecting the reliability of the data collected.

1.5 Expected Outcome

The expected outcome of this study is to enhance comprehension regarding how weather attributes influence travel behaviour and mode selection across various regions and seasons. Through this understanding, the study seeks to offer recommendations and improve the accuracy of travel demand forecasting.

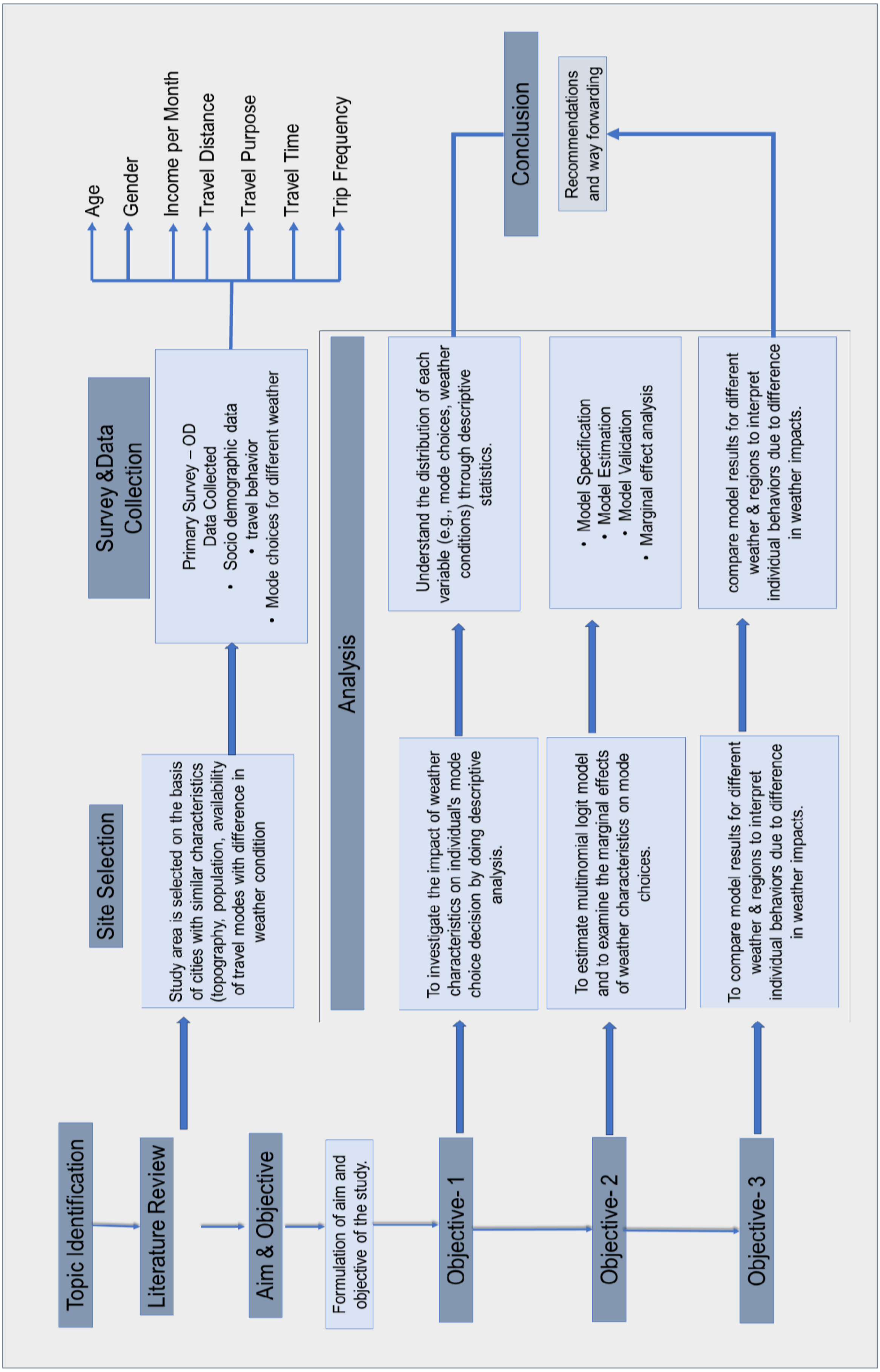
1.6 Research Methodology

The initial phase of this research entails identifying the topic, drawing insights from various research papers to establish the aim, objectives, and parameters for investigation. Following this, the selection of the study area is based on cities sharing similar characteristics such as terrain, population demographics, and availability of transportation modes, which experiencing differences in weather conditions. Once the study area is delineated, primary Origin-Destination (OD) surveys are conducted to gather pertinent data. Employing simple random sampling techniques facilitates the collection of socio-demographic information, travel behaviour patterns, and mode preferences under extreme weather conditions via scenario-based inquiries.

The research unfolds in three main objectives executed across various stages. The initial stage involves descriptive analysis to comprehend the distribution of variables like weather conditions, mode preferences, travel purposes, age, and gender. Once these relationships are established, the investigation proceeds to analyse the impact of weather on mode choices through multinomial logit modelling. The model specification phase delineates the dependent variable as mode choice, with independent variables including weather conditions, age, gender, travel purpose, and travel distance. The second step involves estimation of the model using STATA which enables interpretation of the coefficients to discern how each variable influences the likelihood of selecting a specific mode of transportation. Subsequently, model validation is conducted to assess goodness of fit, followed by calculation of marginal effects to ascertain the probability of each mode under different weather conditions.

Upon model estimation, the final step involves comparing results across various weather conditions and regions to elucidate individual behavioural responses to weather-related impacts. In conclusion, this study offers a comprehensive understanding of how weather fluctuations influence mode choices. Insights gleaned from this research can inform the development of targeted recommendations tailored to specific weather conditions and geographical locations, thus facilitating more effective transportation management strategies.

Figure 1- Research Methodology



Source: Author Generated

CHAPTER 2 – Literature review

2.1 Spatial Variations in Weather Influence on Mode Choice

The previous studies have demonstrated how weather conditions can influence mode choice differently in urban metropolises compared to rural areas, emphasizing the importance of considering spatial variations in mobility behaviour. The study's implications for transport demand models, infrastructure planning, and climate change adaptation strategies are particularly noteworthy.

Furthermore, the paper calls for further research to refine the operationalization of weather conditions in transport models and to explore the impact of heat on mode choice. The authors also suggest conducting similar studies in countries with different spatial characteristics to compare the results and enhance understanding of weather impacts on mobility behaviour.

In conclusion, "The Impact of Weather Conditions on Mode Choice in Different Spatial Areas" provides valuable insights into the complex interplay between weather conditions and mode choice, offering implications for urban planning and transportation policy-making. The study's rigorous methodology, detailed analysis, and practical recommendations make it a significant contribution to the field of transportation research.

2.2 Insights from Previous Studies on Weather and Mode Choice

Scholars have extensively studied the correlation between weather conditions and travel choices, focusing on the impacts of precipitation and temperature. Li et al. found that precipitation-related events had a negative effect on daily ridership fluctuations in Nanjing, affecting both the single metro line and the metro network. Reference discovered that humidity had minimal impact on walking but significantly decreased the share of bicycle mode, a result consistent with Böcker et al.'s findings. Chen and Wang's research revealed a negative relationship between precipitation in Beijing and the High-Speed Rail's On-Time Performance (OTP), indicating that a 1% increase in precipitation led to a 0.019% decrease in HSR's OTP.

2.3 Influence of Temperature and Precipitation on Travel Behaviour

Hagenauer and Helbich underscored the importance of temperature in predicting bicycle and public transportation usage, emphasizing its significance over precipitation and wind speed. In contrast, Li et al. observed that precipitation-related events had a more substantial influence on fluctuations in travelers compared to temperature-related events. They found that in Nanjing, daily metro traveler volume decreased slightly during temperature-related events. Conversely, an increase in temperature correlated with an increase in trips based on ridership transit data in Gipuzkoa, Spain.

Böcker et al. discovered that factors such as low temperatures, rainfall, and wind speed could discourage individuals from selecting cycling and engaging in outdoor leisure activities. Ma et al.'s study indicated that higher temperatures reduced the attractiveness of walking and public transport, with cycling being the most affected mode of transportation. Specifically, they projected that a 4°C increase in the highest temperature would increase cycling's market share by 14.7%.

Overall, these findings highlight the complex interplay between weather conditions, travel preferences, and the differential impacts of temperature and precipitation on transportation choices and behaviours.

2.4 Impact of Wind, Rain, and Snow on Travel Mode Choice

Numerous studies have delved into the impact of weather elements, particularly wind, rain, and snow, on travel mode preferences and ridership trends. Ma et al. (2014) revealed that elevated wind speeds tend to diminish the usage of walking, cycling, and public transport while promoting reliance on cars. They also found that public transport experiences decreased popularity during windy conditions. Arana et al. (2016) observed that wind exerts a more substantial influence on Saturday travel compared to Sundays.

In Norway, Böcker et al. (2017) discovered that windy conditions prompt increased trip combining, leading to more efficient trip chains and potentially reducing exposure to adverse weather. Moreover, weather phenomena such as rain and snow were found to impact travel mode selection. Li et al. (2011) highlighted that snowfall and extreme winter temperatures significantly alter ridership patterns, with heavy snow potentially increasing ridership, particularly in urban settings like New York.

Regarding rain, Singhal et al. (2016) suggested that it affects ridership throughout weekends, with midday and afternoon ridership experiencing more pronounced declines compared to morning ridership. On weekdays, afternoon ridership is more susceptible to rain than midday ridership. Arana et al. (2016) concluded that an increase of one liter of rain per square meter would lead to a decrease of 163 trips on Saturdays and 104 trips on Sundays, assuming consistent wind and temperature conditions.

In summary, weather conditions exert a significant influence on travel behaviour and ridership patterns, with wind, rain, and snow affecting mode choice and trip frequency across diverse settings.

2.5 Role of Environmental Factors in Commuting Preferences

Numerous studies have emphasized the significant influence of various weather conditions on mode choice in transportation. Parameters like sky conditions, wind speed, maximum temperature, humidity, and air quality index (AQI) were identified as key determinants of students' commuting preferences [14].

Ma et al. [14] pointed out that a transition from good to bad AQI was linked to noticeable decreases in the likelihood of walking, cycling, and using public transport by 3.4%, 5.9%, and 6.0% respectively, while the probability of choosing cars increased by 14.7%. Similarly, shifts from good to bad sky conditions were associated with declines in walking, cycling, and public transport usage by 2.3%, 21.5%, and 2.1% respectively, accompanied by an 18.1% increase in car usage.

2.6 Weather Effects on Intercity Travel Preferences: A Gap Analysis

Based on survey data from Chicago travelers conducted by Standard & Poor’s, Hyland et al. [18] found that respondents displayed a decreased preference for using cars during unfavorable weather conditions compared to favorable ones. Chen and Wang [10] emphasized that rainstorms and thunderstorms notably impacted the on-time performance (OTP) of High-Speed Rail (HSR) in southeast coastal areas, while snowstorms presented significant challenges for HSR operations in central-eastern and northern regions.

Moreover, Böcker et al. [17] illuminated that even dark skies, including nighttime, had adverse effects on travel patterns and the utilization of active transportation modes. Drawing from census data from the Netherlands Mobility Panel, Ton et al. [19] suggested that weather conditions had minimal influence on cycling or walking preferences. These findings collectively highlight the complex interplay between weather conditions and transportation mode choice, with factors such as air quality, sky conditions, and precipitation significantly shaping commuting behaviours.

2.7 Addressing the Gap: Weather and Intercity Mode Choice in Xi'an, China

Previous research has predominantly focused on examining how weather conditions influence transportation mode choices within urban settings, leaving a notable gap in understanding the impact on intercity travel preferences. Furthermore, studies exploring the relationship between weather and intercity mode choice are scarce, and the influence of weather conditions on intercity transportation choices can vary significantly depending on the country, region, or even specific cities. Therefore, this study aims to address this gap by analysing the effects of weather conditions on intercity mode choice, specifically focusing on modes such as airplanes, High-Speed Rail (HSR), conventional trains, and express buses in Xi'an, China. By doing so, this research endeavours to provide valuable insights that can serve as a more robust foundation for managing demand in intercity transportation modes and formulating environmentally sustainable policies, particularly in light of the challenges posed by climate change.

By examining how weather conditions impact intercity travel preferences in Xi'an, China, this study seeks to offer practical implications for policymakers and transportation authorities in effectively managing and optimizing intercity transportation systems. Understanding the nuanced relationship between weather and intercity mode choice can facilitate the development of strategies to promote greener transportation options and enhance the overall resilience of transportation networks in the face of changing climatic conditions.

2.8 Research Gap in referred literature

While the study provides valuable insights into how weather conditions influence mode choice, there is a gap in directly applying these findings to the Indian transportation context. Given the unique climate conditions, urban structures, and transportation systems in India, there is a need for research that explores how weather conditions affect mode choice behaviour in Indian cities and regions. Understanding how factors such as heat, monsoons, and air quality impact transportation preferences in India could provide valuable insights for urban planners, policymakers, and researchers in the country.

Therefore, future studies could focus on collecting data on mode choice behaviour and weather conditions in Indian cities to analyse the specific effects of weather on transportation decisions. By addressing this gap and conducting research tailored to the Indian context, scholars can contribute to a more comprehensive understanding of the relationship between weather conditions and mode choice in diverse spatial areas, including those in India.

Table 1 Summary of previous Literature

Authors and year	Travel Mode	Weather condition	Modelling Approach	Main Findings for this research
Hagenauer and Helbich [13]	Walking, bike, car, public transport	Precipitation, Temperature, Wind speed	Machine learning, MLM, Support vector machine	Temperature plays a crucial role in forecasting bicycle and public transportation usage, often outweighing factors like precipitation or wind speed when it comes to influencing people's choice of transportation mode.
Bocker et al [12]	Walking, Cycling, car, Public transport	Precipitation, temperature	Multinomial logit model	In spring, the appeal of using cars appears to decrease. However, the benefits associated with walking and cycling, particularly compared to winter, seem to be less prominent.
Ton et al [19]	Car, public transport, cycle, walk	Season and weather characteristics	Mixed multinomial logit	The weather has a limited impact on active mode choice
Arana et al. [15]	Bus	Temperature, relative air humidity, rain, wind.	Multiple linear regression	Wind and rain could decrease the number of trips, while the rise of temperature could make the number of trips increase.
Maa et al. [14]	Waking, bicycle, car public transport,	Sky conditions, temperature, air quality	Multinomial probit and MNL models	During times of poor air quality, students are more likely to opt for public transportation over driving their own cars.
Bocker et al [17]	Waking, bicycle, public transport, car	Temperature, wind speed, rainfall, snowfall	Structural Equational modelling (SEM)	Dry, warm weather in Oslo and calm, dry conditions in Stavanger boost visits to outdoor leisure spots over work trips, but this trend isn't observed in other regions outside Norway.

Source: Research papers

CHAPTER 3 – Study Area

3.1 Site Selection

In India, particularly in the southern state of Tamil Nadu, weather plays a significant role in mobility patterns, especially in cities like Coimbatore and Madurai. The tropical climate of the region, characterized by hot and humid conditions for a significant part of the year, often influences people's transportation choices. During the scorching summer months, residents may opt for indoor activities or seek cooler modes of transportation to avoid the heat. Conversely, the monsoon season brings heavy rainfall, leading to potential disruptions in mobility due to flooding and road closures. Despite these challenges, the moderate weather experienced during other times of the year encourages outdoor activities and may facilitate smoother commuting experiences. Overall, understanding the interplay between weather patterns and mobility is crucial for effectively managing transportation systems and enhancing the overall quality of life in urban centres like Coimbatore and Madurai.

3.1.1 Criteria for selection of site

The criteria for study area selection for this research involves the several factors. The study area should have diverse weather conditions to enable a comprehensive analysis of the impact of weather on mode choice. This includes areas with different temperature ranges, precipitation levels, wind speeds, and other weather indicators. The study area should include both urban and rural areas to account for the differences in transportation infrastructure, accessibility, and travel behaviour between urban and rural populations. It should also have a well-developed transportation infrastructure, including various modes of transportation such as walking, cycling, public transport, and private vehicles. This will enable a comparison of mode choice between different transportation modes and study areas. The study area should have diverse socio-demographic characteristics, including age, gender, income, and education levels, to account for the differences in travel behaviour between different demographic groups.

3.2 Study Area Profile

This chapter discusses about the selected study area and the site selection criteria. The OMCs have classified six regional territories in the state of Tamil Nadu. They are Chennai, Tiruchirappalli, Madurai, Coimbatore, Tirunelveli and Karur. Among these two of the regional territories have been identified and selected as the study area. Coimbatore and Madurai are two major cities in southern part of India, in the state of Tamil Nadu. Some of the factors involved in selection of these study area are topography, population, availability of different modes of transport and significant difference in weather condition. As Coimbatore is located near western ghats, the temperature is low when compare to Madurai. Figure 2 shows the locations of Coimbatore and Madurai in Tamil Nadu state.

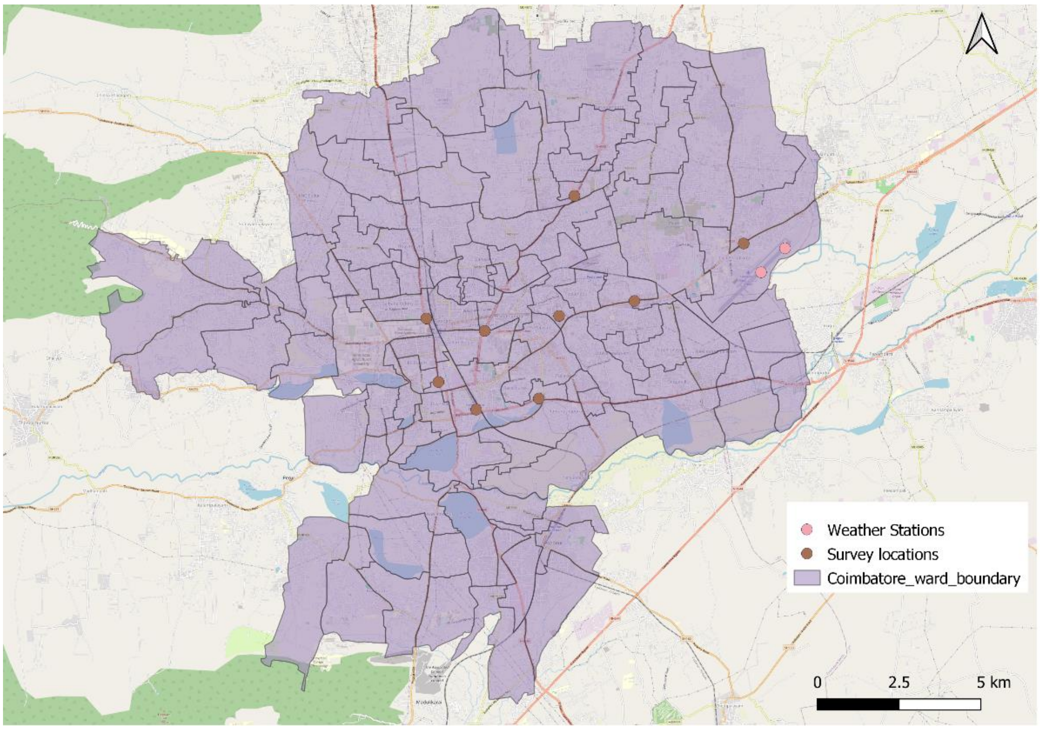
Figure 2 Locations of Coimbatore and Madurai in Tamil Nadu

Source: Author Generated

3.2.1 Coimbatore City Profile

Coimbatore is a city with a population of 21.3 lakhs and an area of 246 sq.km claims as a well-connected network of roads and highways, facilitating seamless intra-city and inter-city travel. The city is served by a mix of public transportation options, including buses operated by the Tamil Nadu State Transport Corporation (TNSTC) and private operators, as well as auto-rickshaws and taxis. Additionally, Coimbatore is emerging as a hub for sustainable transportation initiatives, with initiatives such as cycle-sharing programs gaining traction among residents. However, the city still grapples with issues such as traffic congestion, particularly during peak hours, necessitating further investments in public transit infrastructure and traffic management strategies. In terms of weather, Coimbatore experiences a tropical wet and dry climate, characterized by hot and humid conditions for much of the year. The city receives significant rainfall during the monsoon season, typically from June to September, which can lead to occasional flooding and waterlogging in low-lying areas. The monsoon rains play a vital role in replenishing water sources and sustaining agricultural activities in the surrounding regions. During the dry season, which spans from October to May, temperatures can soar, occasionally reaching uncomfortable levels. However, the city benefits from its proximity to the Western Ghats Mountain range, which helps moderate temperatures and provides a pleasant environment for much of the year. Overall, Coimbatore's transportation infrastructure and weather patterns contribute to its unique character as a dynamic and resilient urban centre in South India. Figure 3 shows municipal boundary of Coimbatore and the locations of survey conducted.

Figure 3- Map of Coimbatore showing the survey locations and locations of weather stations



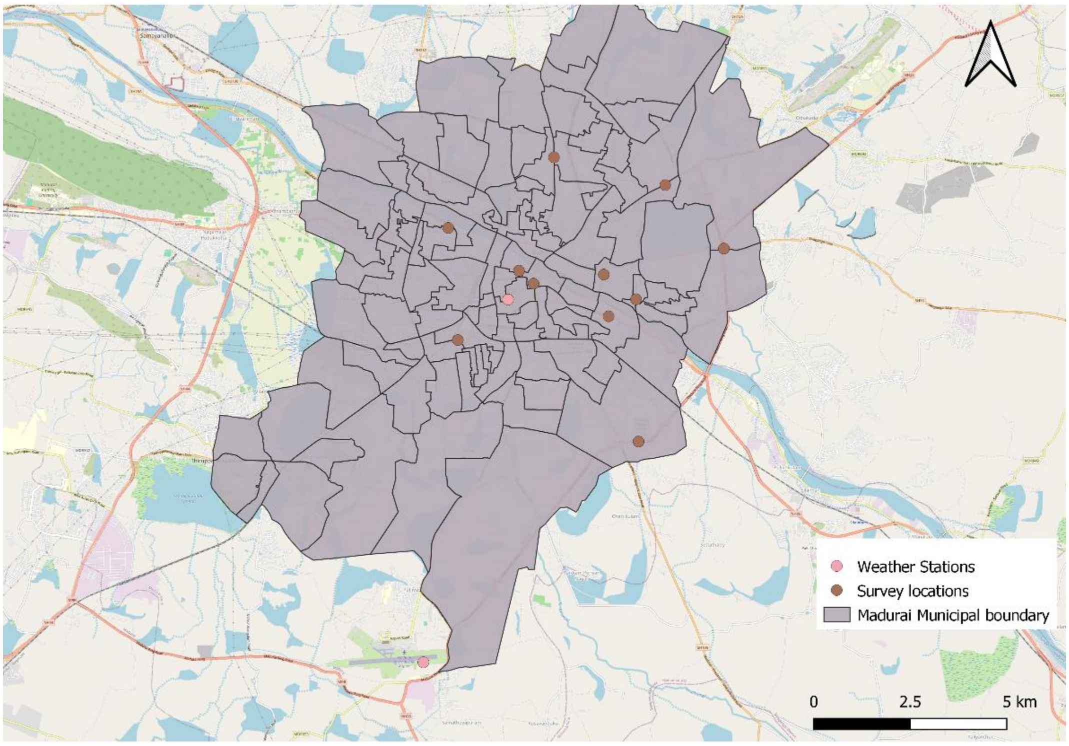
Source: Author Generated

3.2.2 Madurai City Profile

Madurai city has a population of 14.6 lakhs people and an area of 148 sq.km. It boasts a well-developed road network, connecting it to major cities and towns in the region. The city is served by a comprehensive public transportation system, primarily comprising buses operated by the Tamil Nadu State Transport Corporation (TNSTC) and private operators.

Madurai experiences a hot and dry climate for the majority of the year, typical of the region. Summers are particularly scorching, with temperatures often soaring above 40 degrees Celsius (104 degrees Fahrenheit). The city receives minimal rainfall during the southwest monsoon season, which occurs from June to September. However, occasional heavy showers may occur, providing relief from the sweltering heat. The winter months, from November to February, offer more pleasant weather, with cooler temperatures and clear skies. Madurai's climate, characterized by its hot and dry conditions punctuated by brief monsoon showers, significantly influences daily life and activities in the city. Figure 4 shows municipal boundary of Madurai and the locations of survey conducted.

Figure 4- Map of Madurai showing survey locations and locations of weather stations



Source: Author Generated

CHAPTER 4 – Data Collection

4.1 Data Collection Process

4.1.1 Data Collection Strategy

The data collection process is a crucial aspect of any research study, and in the context of the study on the impact of weather on mode choice in Coimbatore and Madurai, it is essential to ensure that the data collected is accurate, reliable, and representative.

To collect data for this study, a primary survey was conducted in Coimbatore and Madurai. The survey was designed to gather information on weather conditions, mode of transport, age, gender, trip purpose, travel distance, temperature, economic status, and travel cost. The survey was conducted with a diverse sample of respondents to ensure a representative sample of the population.

The data collection process was facilitated through a google form method. The survey was designed to be self-administered, ensuring that respondents could complete the survey at their own pace and convenience. The survey questions were designed to be clear, concise, and unambiguous to minimize any confusion or ambiguity among respondents.

To ensure the accuracy and reliability of the data collected, the survey was pre-tested with a small sample of respondents to identify any issues or challenges with the survey design or implementation. Based on the feedback received, the survey was revised and refined to improve its quality and effectiveness. The data collection process for this study was designed to be comprehensive, representative, and reliable. By employing an online google form methods, a diverse sample of respondents, and a well-designed survey, the data collected is expected to be accurate and valuable for the analysis and conclusions drawn from the study.

4.1.2 Design of Questionnaire

The questionnaire was structured into three sections. Initially, it focused on the individual characteristics of the travellers, such as age, gender, monthly income, and car ownership. The second part encompassed the travel details of the respondents, including the trip's start time, origin, destination, and purpose. Lastly, it included inquiries about travel mode-related factors, such as access mode, travel cost, and travel time.

Due to limitations in conducting surveys throughout the entire year, four scenario-based questionnaires were developed to gather weather-related travel behavior data. These scenario-based questions enabled the collection of information on travel modes chosen by individuals under various extreme weather conditions.

4.1.3 Field Investigation Process

This study was conducted through field investigations. The survey locations are selected that is easily accessible for conducting surveys and ensures a diverse and representative sample of respondents. The selected locations are transportation hubs like bus stands, bus stops, parking spaces, hospitals, public spaces and petrol stations. Respondents were selected randomly regardless of their age, gender and other factors.

4.2 Data Collection and Description

During the field investigation, a comprehensive dataset comprising 205 samples from Coimbatore and 187 samples from Madurai was acquired. These samples encompassed a range of socio-demographic characteristics, including age, gender, and monthly income, as well as travel characteristics such as preferred travel mode, travel distance, travel purpose, and travel time.

Table 2- Description of categorical variables (socio demographic variables)

			Coimbatore		Madurai	
Variables	Category	Code	N	Percentage	N	Percentage
Age	<15	1	8	3.9%	17	9.1%
	15-30	2	62	30.4%	60	32.1%
	30-50	3	104	51.0%	81	43.3%
	50-70	4	29	14.2%	25	13.4%
	>70	5	1	0.5%	4	2.1%
Gender	Male	0	120	58.8%	118	63.1%
	Female	1	84	41.2%	69	36.9%
Income per Month	<10000	1	29	14.2%	32	17.1%
	10000-50000	2	157	77.0%	128	68.4%
	50000-100000	3	18	8.8%	27	14.4%

Source: Primary Survey

The collected data provides an understanding of the diverse socio-economic backgrounds and travel behaviours prevalent in both cities. Through detailed analysis, insights into the factors influencing transportation choices and travel patterns within each urban setting can be collected. This dataset serves as a valuable resource for conducting in-depth research on various aspects of urban mobility, facilitating evidence-based decision-making in urban planning and transportation policy formulation. By leveraging this dataset, policymakers and urban planners can devise strategies aimed at enhancing transportation infrastructure, promoting sustainable travel modes, and improving overall mobility outcomes in Coimbatore and Madurai.

Table 3- Description of categorical variables (Travel behaviour variables)

			Coimbatore		Madurai	
Variables	Category	Code	N	Percentage	N	Percentage
Mode	Car	1	37	18.1%	23	12.3%
	Cycle	2	9	4.4%	11	5.9%
	Public Transport	3	42	20.6%	50	26.7%
	Two-wheeler	4	97	47.5%	87	46.5%
	Walk	5	19	9.3%	16	8.6%
Travel Distance	<1Km	1	10	4.9%	6	3.2%
	1-5Km	2	54	26.5%	52	27.8%
	5-10Km	3	75	36.8%	84	44.9%
	10-20Km	4	53	26.0%	35	18.7%
	20-30Km	5	2	1.0%	3	1.6%
	30-50Km	6	7	3.4%	5	2.7%
	>50Km	7	3	1.5%	2	1.1%
Travel Time	<5Mins	1	3	1.5%	3	1.6%
	5-10Mins	2	21	10.3%	20	10.7%
	10-20Mins	3	62	30.4%	83	44.4%
	20-30Mins	4	77	37.7%	35	18.7%
	30-1hr	5	27	13.2%	42	22.5%
	>1hr	6	14	6.9%	4	2.1%
Travel Purpose	Business	1	61	29.9%	44	23.5%
	Commute Trips	2	53	26.0%	65	34.8%
	Leisure Trips	3	77	37.7%	66	35.3%
	Social Visit	4	13	6.4%	12	6.4%

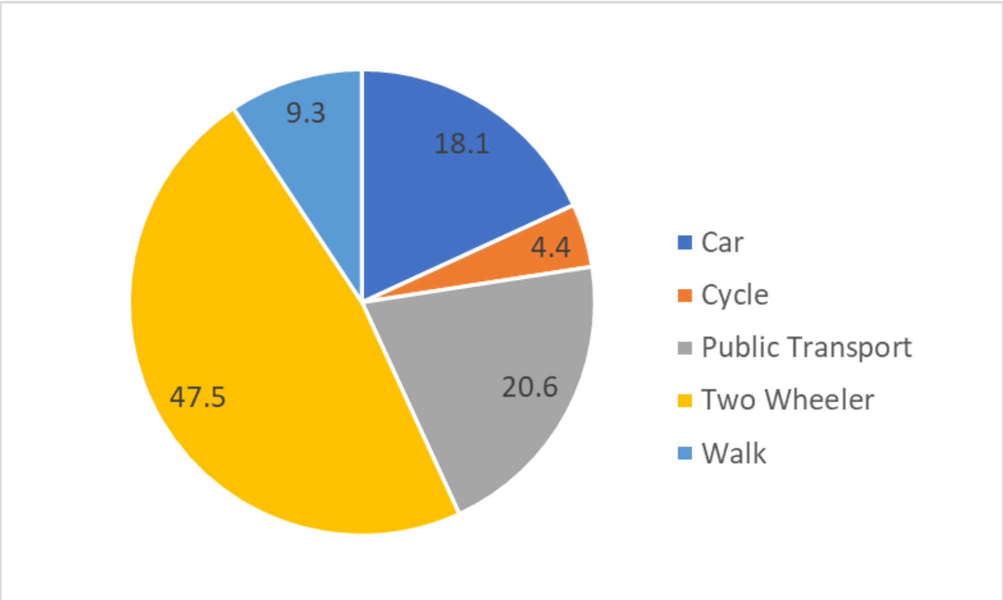
Source: Primary Survey

The descriptions of categorical variables regarding socio demographic variables are presented in Table 2 and travel behaviour variables are presented in Table 3.

4.3 Ridership Data

Ridership data obtained through a primary survey reveals the distribution of various transportation modes, including walking, cycling, private cars, two-wheelers, and public transport, in both Coimbatore and Madurai. In Coimbatore, 18.1% of respondents reported using private cars, while 4.4% preferred cycling, and 20.6% relied on public transport. Furthermore, 47.5% of respondents favoured two-wheelers, and 9.3% chose walking for their transportation needs. Conversely, in Madurai, 12% of respondents indicated private car usage, 6% opted for cycling, and 27% utilized public transport.

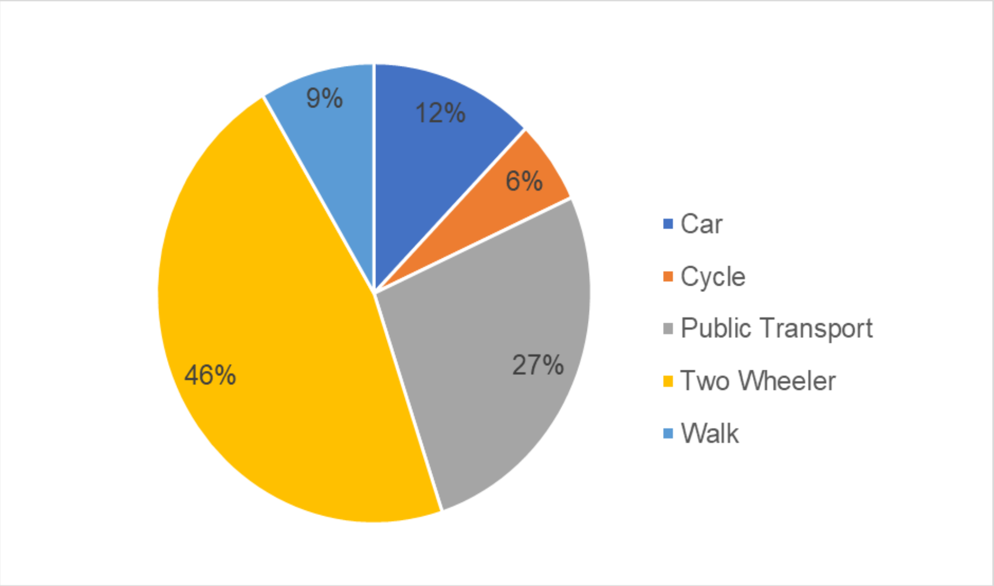
Figure 5- Mode share in Coimbatore



Source: Author Generated

Additionally, 46% of respondents favoured two-wheelers, while 9% preferred walking for commuting. The analysis underscores a notable similarity between the two cities, with approximately 47% of the mode share being occupied by two-wheelers. However, significant variations emerge between the samples collected from Coimbatore and Madurai, particularly in the distribution of private cars and public transport usage. Notably, a higher percentage of respondents in Coimbatore reported owning private cars compared to those in Madurai, while a greater proportion of respondents in Madurai relied on public transport for their transportation needs. These findings illuminate distinct transportation preferences and patterns within each city, which could be attributed to factors such as urban infrastructure, economic conditions, and cultural norms. Understanding these variations is crucial for informed urban planning and the development of effective transportation policies tailored to the specific needs of each city. Figure 5 represents the mode share in Coimbatore and Figure 6 represents the mode share in Madurai.

Figure 6- Mode share in Madurai



Source: Author Generated

4.4 Distribution of motorized and non-motorized modes in the dataset

Analysis of the collected sample reveals that a significant proportion of respondents in both Madurai and Coimbatore own private cars. Specifically, 26.2% of respondents in Madurai and 33.6% of respondents in Coimbatore reported owning a private car. This data highlights a notable difference in car ownership rates between the two cities, with a higher percentage of respondents in Coimbatore owning private cars compared to those in Madurai. The higher percentage of car ownership in Coimbatore might be indicative of a greater reliance on private vehicles for transportation compared to Madurai. Individuals prefer to use public transport more for commute trips and business trips than leisure trips and social visit. People tend to opt for public transportation predominantly during their commute to work or for business-related trips, as opposed to leisure activities or social visits.

A comparison was made between the average trip distances for various modes of transportation in both Coimbatore and Madurai. This analysis involved calculating the total distance covered by each mode and dividing it by the total number of trips made using that mode. The findings reveal interesting insights into the travel behaviour of residents in these cities.

Table 4 Distribution of motorized modes in the datasets used

Mode		**Car**		**Public Transport**		**Two Wheelers**	
Data base	**Category**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**
Number of Trips		37	23	42	50	97	87
Average Trip Distance (KM) (S.E in parenthesis)		17.7 (0.231)	12.2 (0.224)	13.7% (0.160)	14.0(0.131)	12.1 (0.082)	9.4(0.088)
Percentage of having a car		100%	100%	2.40%	8%	28.90%	31%
Percentage of Male		62.20%	56.50%	43.90%	62.00%	61.90%	70.10%
Percentage of trip purpose	Commute Trips	0%	0%	43.90%	54.00%	28.90%	32.20%
	Business Trips	32.40%	56.50%	48.80%	22.00%	27.80%	21.80%
	Leisure Trips	48.60%	43.50%	7.30%	20.00%	38.10%	37.90%
	Social Visit	18.90%	0.00%	0%	4.00%	5.20%	8.00%

Source: Primary Survey

In Coimbatore, it was observed that individuals tend to cover longer distances when using private cars, with an average trip distance of 17.7 kilometres. This suggests a preference for private vehicle usage for journeys requiring extensive travel. On the contrary, in Madurai, public transport emerges as the mode associated with the highest average trip distance, standing at 14 kilometres. This underscores the significance of public transportation infrastructure in facilitating longer-distance travel within the city.

Delving deeper into the data, it becomes apparent that the shortest average trip distance in Madurai is attributed to walk trips, with a mere 1.3 kilometres. This highlights the importance of pedestrian-friendly infrastructure and the prevalence of short-distance travel on foot within the urban landscape of Madurai. Conversely, in Coimbatore, cycle trips exhibit the shortest average distance travelled, recorded at

1.8 kilometres. This indicates a relatively shorter range of cycling activities within the city compared to other modes of transportation.

Table 5 Distribution of non-motorized modes in the datasets used

Mode		**Cycle**		**Walk**	
Data base	**Category**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**
Number of Trips		10	11	19	16
Average Trip Distance (KM) (S.E in parenthesis)		1.8 (0.133)	2.3 (0.141)	3.32 (0.159)	1.3(0.359)
Percentage of having a car		0%	0%	11.10%	0%
Percentage of Male		100%	63.60%	50%	37.50%
Percentage of trip purpose	Commute Trips	62.50%	54.50%	11.10%	25.00%
	Business Trips	0%	0%	11.10%	6.30%
	Leisure Trips	37.50%	45.50%	72.20%	50.00%
	Social Visit	0%	0.00%	5.60%	18.80%

Source: Author Generated

Overall, the comparative analysis sheds light on the diverse transportation patterns and preferences in Coimbatore and Madurai, offering valuable insights for urban planners and policymakers aiming to enhance mobility and sustainability in these cities.

CHAPTER 5 - ANALYSIS

5.1 Approach of Analysis

The analysis of the impact of weather on mode choice will be conducted in three stages to comprehensively understand the relationship between various variables such as mode choice, weather conditions, travel purpose, travel distance, gender, and other socio-demographic factors. The first stage involves descriptive analysis to comprehend the distribution and relationship of each variable. This includes mode choice, weather condition, travel purpose, travel distance, gender, and other relevant factors. Descriptive statistics will be employed to summarize the characteristics of the dataset, providing insights into the initial relationships between variables. The second stage utilizes multinomial logit models to analyze the impact of weather conditions on mode choice. Multinomial logit models are a type of regression analysis suitable for modeling categorical dependent variables with more than two categories, such as travel mode choice. STATA software will be employed for this analysis. The dependent variable consists of travel mode choices including walking, cycling, car, and public transport, while weather variables (e.g., temperature, precipitation, wind speed) along with socio-demographic characteristics (e.g., age, gender, income) and travel-related factors (e.g., travel distance, trip purpose, travel cost) are considered as factors and covariates. The model estimates the probability of selecting each travel mode given a set of explanatory variables, indicating the significance of weather variables on mode choice decisions. The third stage involves examining marginal effects to understand the change in the probability of selecting one mode relative to a reference mode, given a one-unit change in an independent variable while holding other variables constant. Marginal effects provide interpretable insights into the nonlinear impact of weather variables on mode choice decisions, facilitating a deeper understanding of individual behavior. Marginal effects will be identified for each explanatory variable on each transport mode using the multinomial logit model. This enables the identification of specific weather impacts on mode choice and enhances interpretability.

Additionally, the model results of two different cities will be compared to comprehend and interpret individual behavior variations due to differences in weather impacts.

Comparative analysis allows for the exploration of how diverse weather conditions influence mode choice decisions in different urban settings.

Through this comprehensive analysis methodology, the study aims to shed light on the intricate relationship between weather conditions and mode choice, providing valuable insights for urban transportation planning and policy-making.

5.1.1 Descriptive Analysis

Descriptive analysis serves as an initial step in understanding the dynamics of the impact of weather on mode choice, constituting a crucial aspect of thesis research. By conducting descriptive analysis, you can comprehensively characterize the relationships between various variables such as mode choice, weather conditions, travel purpose, travel distance, gender, and other socio-demographic factors. This initial exploration allows for the identification of patterns, trends, and disparities within the dataset, providing essential context for subsequent analyses. Moreover, descriptive analysis enables the examination of the distribution of key variables across different demographic groups and geographical locations, shedding light on variations in transportation behaviors and preferences. Through this methodical approach, you can gain valuable insights into the interactions between weather conditions and mode choice, laying the groundwork for more advanced statistical analyses such as multinomial logit modeling and marginal effects examination.

5.1.2 Multinomial Logit Model (MLM)

the multinomial logit model serves as a powerful tool to analyze how various weather conditions influence individuals' decisions regarding transportation modes. This model is particularly suitable for your study because it allows for the analysis of nominal outcome variables with multiple unordered categories, such as the different transportation modes (e.g., car, bus, bike, walk).

By estimating a multinomial logit model, you can quantify the relationships between weather variables (independent variables) and the probabilities of selecting each mode of transportation (outcome categories). The model provides parameter estimates that indicate how changes in weather conditions affect the odds of choosing one mode over another, while controlling for other relevant factors. Additionally, the calculation of marginal effects enables you to interpret the magnitude and direction of these impacts, offering insights into how specific weather parameters influence the likelihood of selecting different transportation modes.

The multinomial logit approach in your thesis allows for a comprehensive understanding of the complex interplay between weather and mode choice, providing valuable insights for transportation planning, policy development, and individual decision-making processes. By leveraging this model, you can contribute to the growing body of knowledge on the factors shaping transportation choices and inform strategies to promote sustainable and resilient transportation systems.

5.1.3 Marginal effects

Investigating the impact of weather on mode choice, the utilization of marginal effects offers a valuable analytical approach to quantify the influence of weather conditions on the probabilities of selecting different transportation modes. By deriving marginal effects from the multinomial logit model, you can assess how changes in weather variables affect the likelihood of choosing specific modes of transportation over others. These effects provide a nuanced understanding of the relationship between weather parameters and mode choice probabilities, allowing for the identification of significant factors driving transportation decisions in varying weather conditions. Through the interpretation of marginal effects, your thesis can offer insights into the relative importance of different weather variables in shaping mode choice behaviours, contributing to a deeper understanding of the complex interactions between weather conditions and transportation preferences.

5.2 Analysis based on Descriptive Analysis

5.2.1 ADT across different weather conditions

Table 6 illustrates the mean number of daily trips per person across various weather conditions. The data collection process involved determining the trip frequency for each individual across different modes of transportation under varying weather conditions. It was observed that during rainy days, there was an increase in both car trips and public transport usage, while the number of daily walks and two-wheeler trips decreased correspondingly. In contrast, the average daily trip count remained consistent across all other weather conditions, except for rainy days where notable fluctuations were observed.

Table 6 Average daily trips made per individual per day across different weather condition

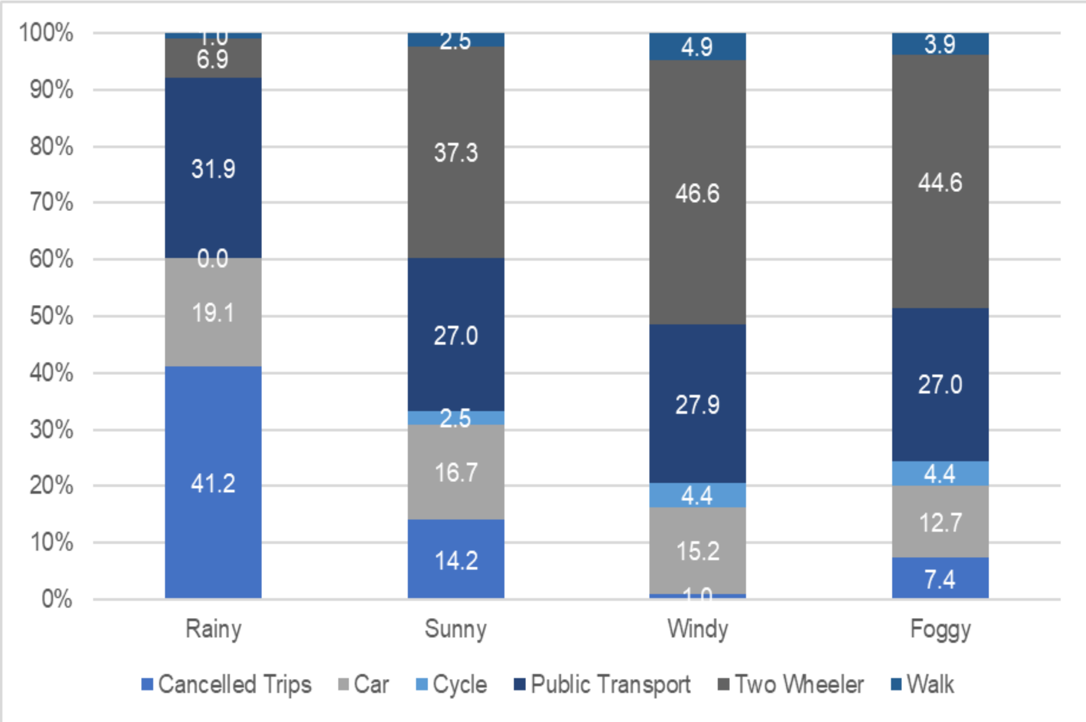
Mode	Car		Cycle		Public Transport		Two Wheelers		Walk	
weather	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**
Sunny	0.33 (19.4%)	0.41 (24.3%)	0.91 (2.8%)	1.42 (5.92%)	0.68 (31.4%)	0.909 (32.2%)	0.55 (43.4%)	0.66 (34.86%)	1 (2.8%)	1.5 (2.63%)
Rainy	0.52 (32.5%)	0.45 (33%)	-	-	0.71 (54.1)	1.13 (53%)	0.97 (11.6%)	0.52 (14%)	0.78 (1.6%)	-
Windy	0.17 (15.5%)	0.35 (13.9%)	0.93 (3.5%)	1.31 (5.2%)	0.69 (28.5%)	0.85 (27.9%)	0.5 (47.5%)	0.61 (50%)	0.74 (5%)	0.89 (2.3%
Foggy	0.19 (13.7%)	0.36 (11.7%)	0.79 (4.7%)	1.34 (5.8%)	0.65 (29%)	0.84 (26.5%)	0.56 (48.1%)	0.57 (50.5%)	0.78 (4.2%)	0.93 (4.7%)

Source: Author Generated

5.2.2 Mode share as per weather condition

The data reveals a notable trend in trip cancellations, particularly among two-wheeler users, indicating a heightened sensitivity to weather conditions, especially adverse ones like heavy winds and rainfall. Among these cancellations, the impact on bicycle trips stands out, highlighting the vulnerability of this mode of transportation to weather fluctuations, particularly strong winds. An interesting observation emerges regarding the demographic breakdown of cancellations, with a significant portion attributed to individuals partaking in leisure activities and social visits. This suggests that for non-essential trips, individuals may be more inclined to forego their plans in unfavourable weather conditions, prioritizing safety and comfort. Furthermore, the data underscores the importance of last-mile connectivity in transportation planning, particularly during inclement weather. Daily commuters, especially those residing far from bus stops, face challenges in accessing public transportation during heavy rainfall, leading to a notable increase in trip cancellations. The lack of convenient last-mile options prompts individuals to reconsider their travel plans, highlighting the need for infrastructure improvements to enhance accessibility and connectivity, especially in adverse weather conditions.

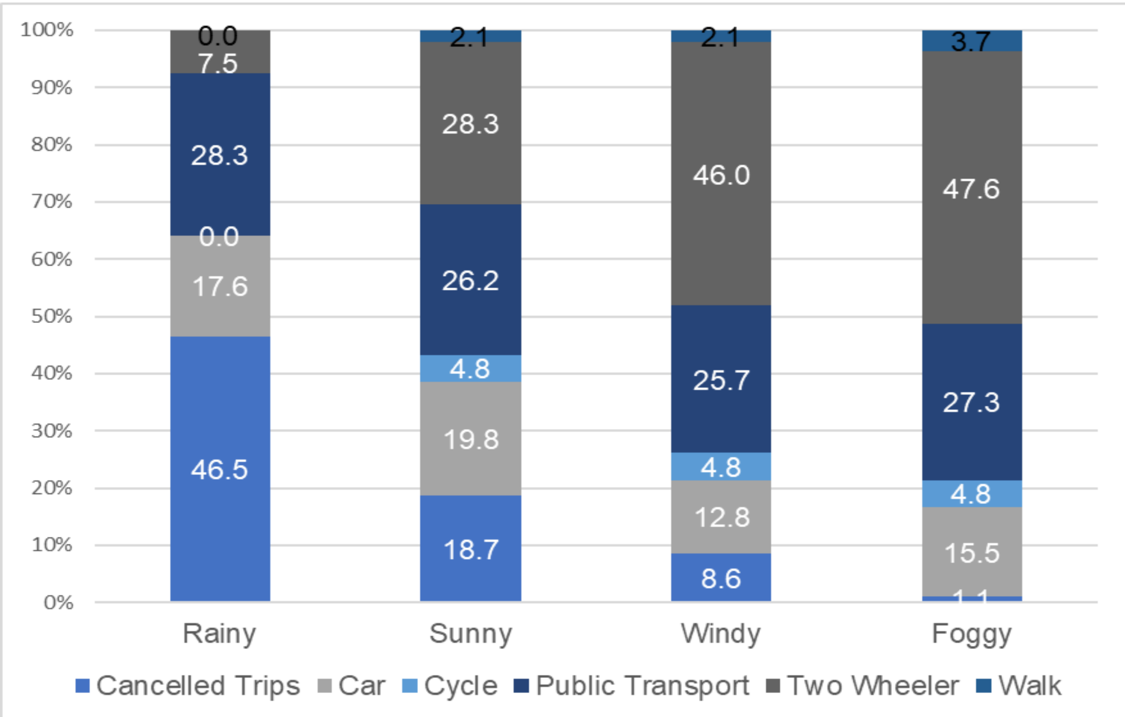
Figure 7 Modal split per categorized weather conditions in Coimbatore



Source: Author Generated

The presence of precipitation significantly diminishes the usage of two-wheelers and bicycles, with around 40% reduction observed in their normal modal share. This highlights the substantial negative impact that rainfall has on the usage of these modes of transportation.

Figure 8 Modal split per categorized weather conditions in Madurai

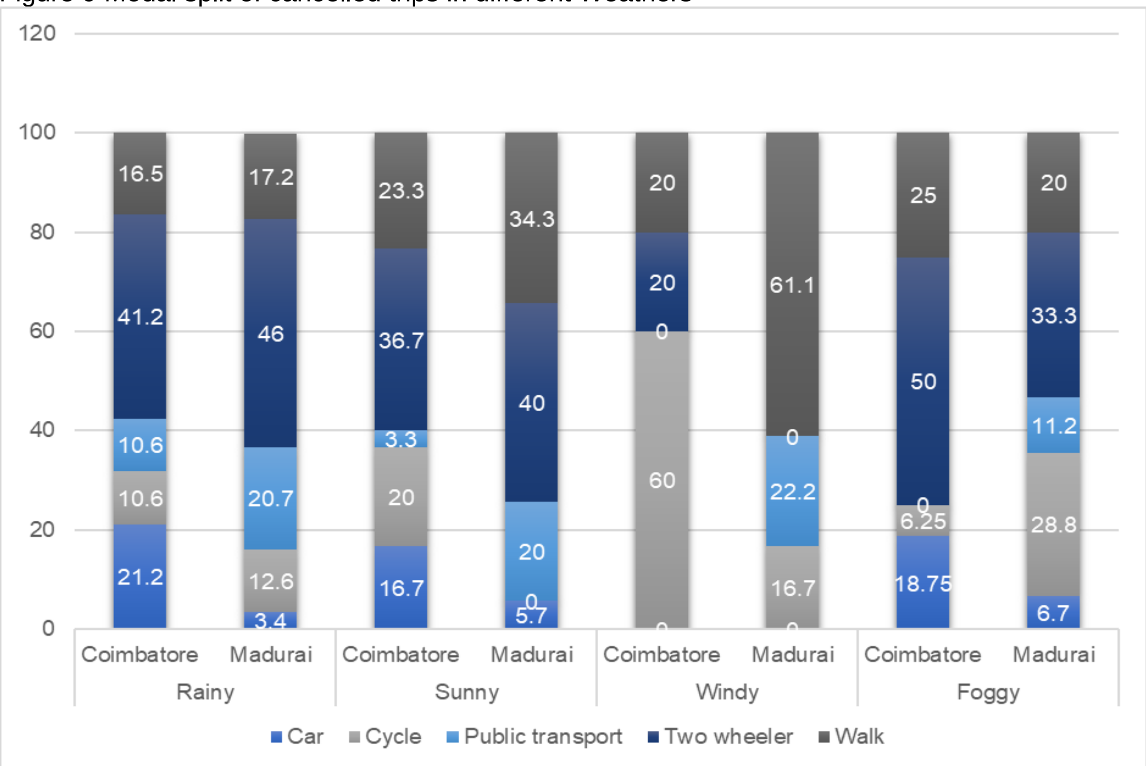


Source: Author Generated

5.2.3 Mode share of cancelled weather trips

The data paints a clear picture of the impact of weather conditions on transportation choices, particularly highlighting the vulnerability of two-wheelers and bicycles to adverse weather. These cancellations signify not only a practical response to safety concerns but also shed light on the behavioural patterns of commuters, especially in relation to leisure activities, social visits, and daily commuting routines. Two-wheelers, encompassing motorcycles and scooters, emerge as the most affected mode of transportation, indicating a heightened sensitivity to weather variations. This could be attributed to factors such as increased exposure to elements and reduced stability compared to other vehicles. Heavy winds, in particular, pose a significant challenge for bicycle trips, affecting both safety and comfort. The cancellation trend among two-wheeler users underscores the need for weather-sensitive transportation planning and infrastructure development, including dedicated lanes and shelters. The demographic breakdown of trip cancellations offers valuable insights into commuter behaviour. The significant portion of cancellations among individuals engaging in leisure activities and social visits suggests that non-essential trips are more susceptible to weather-related disruptions. This highlights the importance of considering not only practical transportation needs but also social and recreational aspects when designing resilient transportation systems.

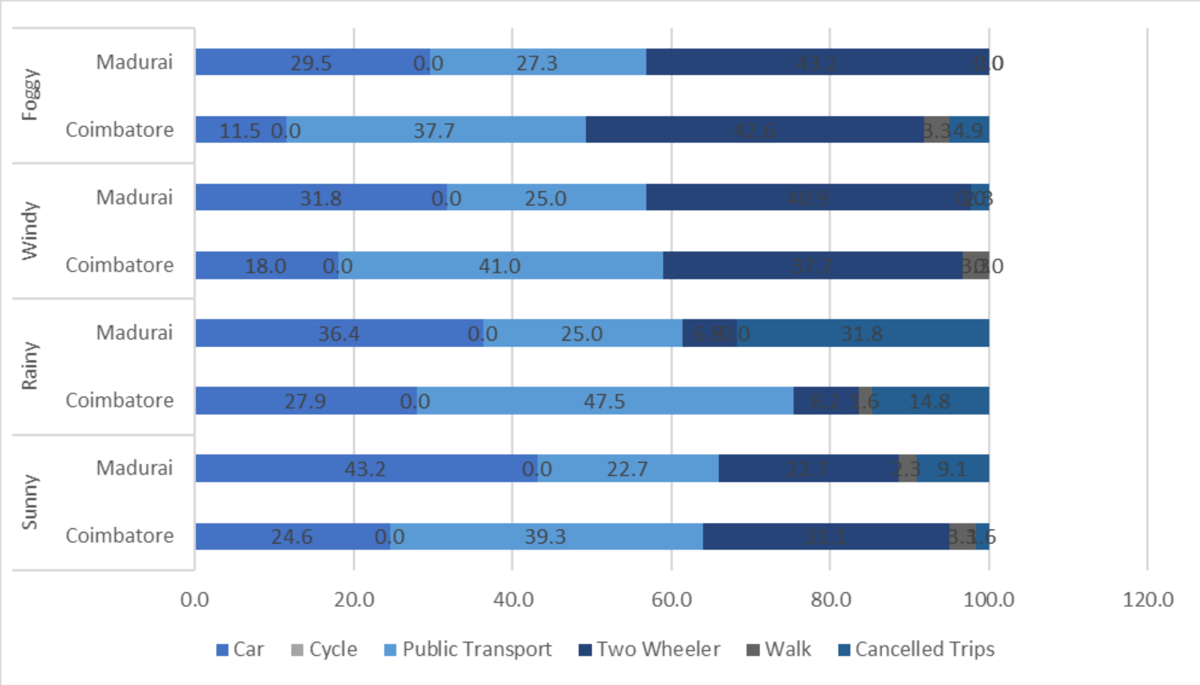
Figure 9 Modal split of cancelled trips in different Weathers



Source: Author Generated

5.2.4 Purpose wise mode share under different weather conditions

Figure 10 Business Trips mode share under different weather conditions

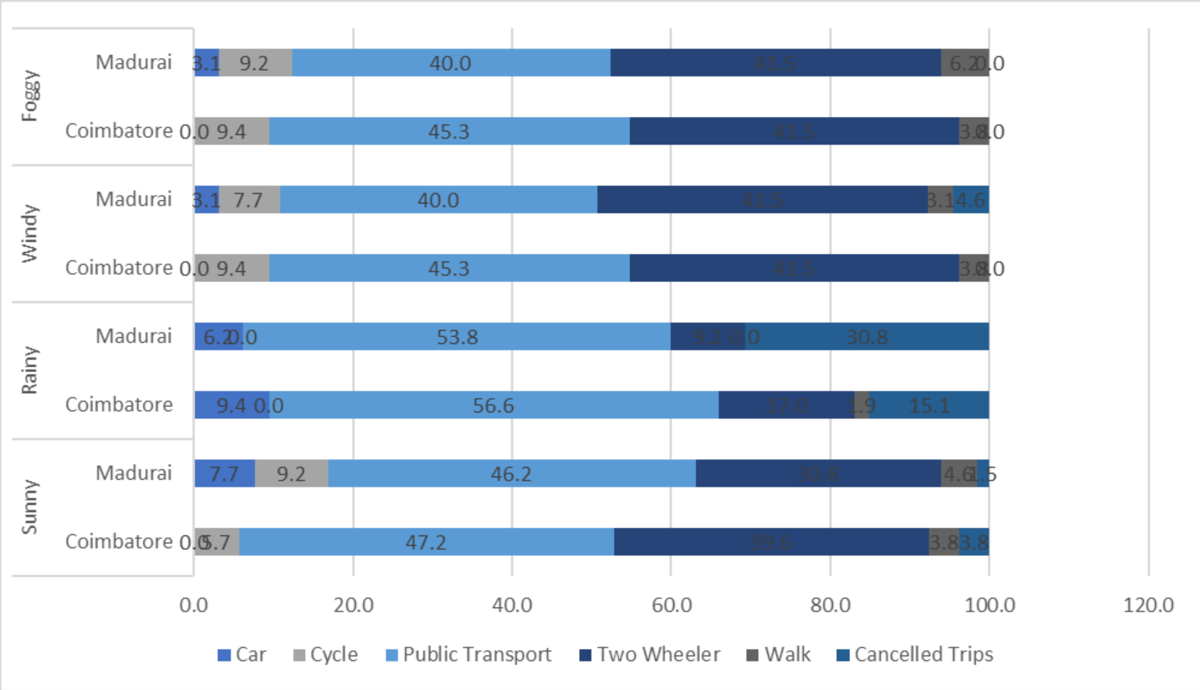


Source: Author Generated

During rainy days in Coimbatore city, individuals undertaking business trips exhibit a preference for switching to alternative modes of transportation rather than outright cancelling or postponing their plans. Conversely, in Madurai, business travellers tend to opt for trip cancellations during rainy weather. Additionally, during periods of extreme temperature, approximately 14% of car trips in Madurai experience an increase, which comes at the expense of reduced two-wheeler usage. This shift underscores the adaptability of travel patterns in response to weather conditions, with individuals making strategic choices to accommodate varying environmental factors.

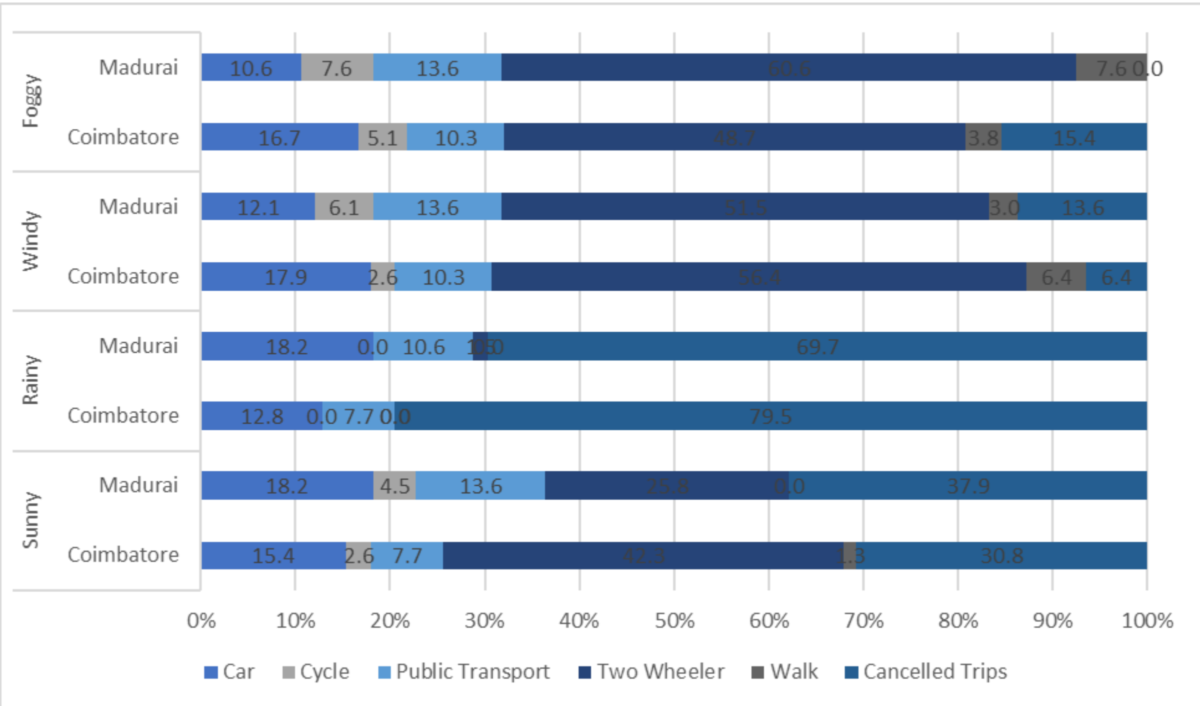
The data clearly indicates a strong preference for public transportation for daily commute trips. Specifically, in Coimbatore, there is a notable increase in the usage of public transport during rainy days, rising to 22% compared to typical usage. Conversely, the utilization of car trips experiences a sharp decline for daily travel purposes compared to other trip purposes. This trend highlights the significance of public transportation as a favoured mode of commuting, particularly during inclement weather conditions such as rainfall.

Figure 11 Commute Trips mode share under different weather conditions



Source: Author generated

Figure 12 Leisure Trips mode share under different weather conditions

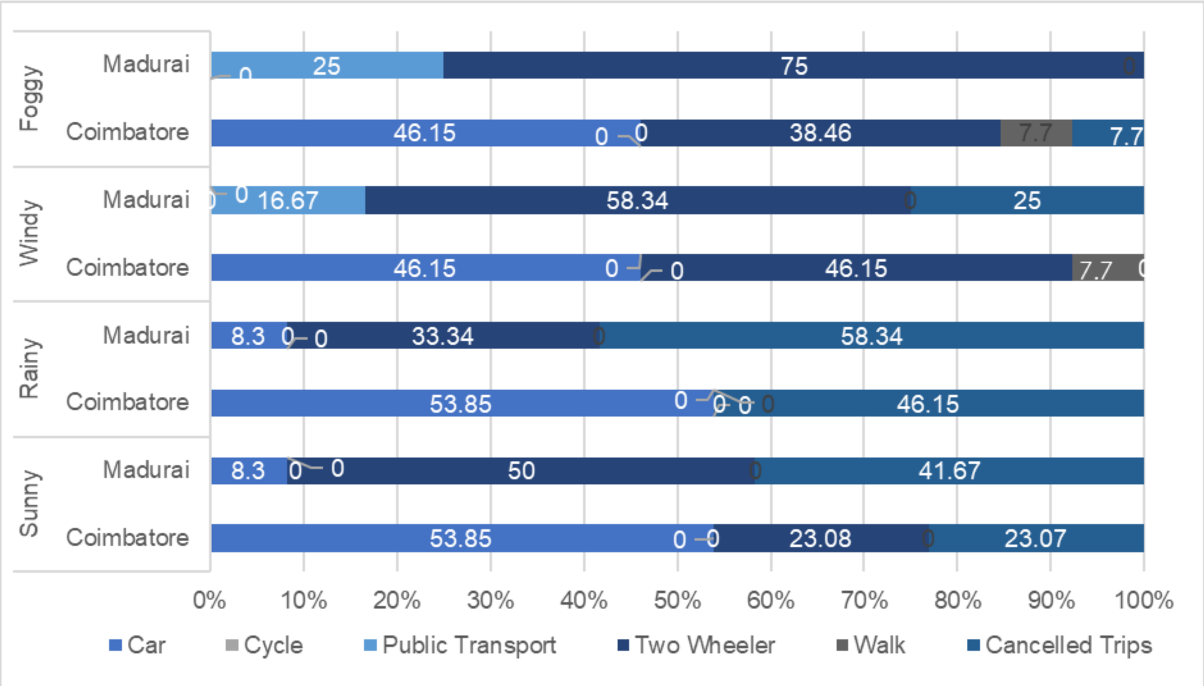


Source: Author Generated

The majority of cancelled or postponed trips are predominantly associated with leisure activities. Specifically, during rainy days, two-wheeler and walking trips are entirely abandoned within the context of leisure travel. Conversely, the utilization of public transportation experiences a slight uptick across all extreme weather conditions in Coimbatore, suggesting a tendency towards its increased use during such periods. In contrast, contrasting trends are observed in Madurai, where the propensity to use public transport diminishes during extreme weather events. These patterns underscore the differential responses to weather conditions between the two cities, with Coimbatore exhibiting a greater reliance on public transportation during adverse weather scenarios compared to Madurai.

During both sunny and rainy days in Madurai, there is a minor transition observed from public transportation to private cars. Conversely, in Coimbatore, there is a tendency for two-wheeler trips to be cancelled or postponed during such weather conditions. Additionally, in Madurai, walks and bicycle trips are prone to cancellation or postponement during periods of heavy winds. These variations highlight the nuanced responses to weather conditions across different modes of transportation in the two cities, with Madurai showing a preference towards private car usage during certain weather conditions, while Coimbatore experiences disruptions primarily in two-wheeler travel.

Figure 13 Social Visit mode share under different weather conditions



Source: Author Generated

In summary, the distribution of trips across different purposes in both Coimbatore and Madurai within the dataset was not uniform across various weather conditions. This uneven distribution may have impacted the outcomes of the multinomial logit models and should therefore be taken into consideration when interpreting the results. It's important to acknowledge that the variability in trip purposes across different weather conditions could introduce biases or distortions in the analysis, potentially influencing the conclusions drawn from the models. As such, researchers and analysts should exercise caution and awareness of these disparities when interpreting and generalizing the findings.

5.3 Model application Based on MLM

5.3.1 Model Specification

Model specification involves defining the functional form of the multinomial logit model, specifying the dependent and independent variables, and identifying the relationships between them. In this thesis, the dependent variable is the choice of transportation mode (e.g., walking, cycling, car, public transport), while independent variables include weather conditions (e.g., temperature, precipitation, wind speed), socio-demographic factors (e.g., age, gender, income), and travel-related characteristics (e.g., travel distance, trip purpose).

Table 7 Dependent and Independent variables in mode choice models

	Name	Type/ Scale
Dependent Variable	Mode	Nominal
Independent Variable	Gender	Nominal
	Age	Ordinal
	Economic Status	Ordinal
	Weather Condition	Nominal
	Travel Purpose	Nominal
	Travel Distance	Ordinal
	Travel Time	Ordinal

Source: Author Generated

5.3.2 Model Estimation

Model estimation entails using statistical software such as STATA to estimate the parameters of the multinomial logit model based on the collected data. This process involves calculating maximum likelihood estimates of the model coefficients, which represent the impact of each independent variable on the probability of selecting a specific transportation mode.

The results of estimated multinomial logit model is shown in **(Annexure B-Multinomial Logit Model Results)** for reference.

5.3.3 Model validation

Model validation involves assessing the goodness-of-fit and predictive accuracy of the multinomial logit model. This includes conducting statistical tests to evaluate the overall fit of the model, examining the significance of individual coefficients, and assessing the model's ability to accurately predict mode choice behaviour. By rigorously specifying, estimating, and validating the multinomial logit model, this thesis ensures robust and reliable analysis of the relationship between weather conditions and mode choice.

The given table 7 below shows the goodness of fit test results of multinomial logit models for Coimbatore and Madurai city.

Table 8 MNL model test results

Region	Purpose		Number of Obs	LR chi^2	Pseudo R^2	Log likelihood
Coimbatore	Business Trips	Model 1	244	282	0.4414	-178.4102
	Commute Trips	Model 2	212	162.4	0.3103	-180.47978
	Leisure Trips	Model 3	312	168.76	0.1882	-363.98373
	Social Visit	Model 4	52	27.21	0.2291	-45.788788
	Full Dataset	Model 5	205	87.97	0.1583	-233.93042
Madurai	Business Trips	Model 6	172	148.25	0.314	-161.94916
	Commute Trips	Model 7	260	263.82	0.3659	-228.57444
	Leisure Trips	Model 8	264	355.77	0.4455	-221.38299
	Social Visit	Model 9	48	85.47	0.8371	-8.3177662
	Full Dataset	Model 10	187	92.78	0.1847	-204.83749

Source: Author Generated

5.4 Analysis based on Marginal Effects

The model Table 9 reveals noteworthy distinctions in mode choice probabilities influenced by changes in travel purpose and travel distance. Notably, as travel distance increases, there is a gradual rise in the probability of selecting car and public transport, while the likelihood of choosing to walk decreases.

Table 9 marginal Effects of models with full datasets

Region	Variable	Category	Car	Cycle	Public Transport	Two-Wheeler	Walk
Coimbatore	Trip Purpose	Business Trips	-0.3429	0.0000	0.3279	0.0569	-0.0418
		Commute Trips	-0.5396	0.1018	0.3312	0.1444	-0.0378
		Leisure Trips	-0.3092	0.0602	0.0525	0.0874	0.1090
	Gender	female	-0.0170	-0.0834	0.1034	-0.0567	0.0538
	Age	15-30	0.1599	-0.1120	-0.3752	0.4281	-0.1007
		30-50	0.2123	-0.1318	-0.4294	0.4499	-0.1010
		50-70	0.0621	0.0300	-0.3607	0.4127	-0.1441
		>70	-0.0095	-0.1318	0.6051	-0.0608	0.8071
	Travel Distance	1-5km	0.1160	0.1228	0.0928	0.5941	-0.9257
		5-10km	0.2434	0.0161	0.1779	0.5057	-0.9431
		10-20km	0.1887	0.0000	0.3205	0.4860	-0.9951
		20-30km	0.0000	0.0000	0.0000	0.9951	-0.9951
		30-50km	0.2925	0.0000	0.6977	0.0000	-0.9902
		>50km	0.7286	0.0000	0.0000	0.0000	-0.7286
Madurai	Trip Purpose	Business Trips	0.2612	0.0000	0.1221	-0.0901	-0.2933
		Commute Trips	0.0000	0.1137	0.2365	-0.1062	-0.2439
		Leisure Trips	0.1523	0.0650	-0.0246	0.0055	-0.1982
	Gender	female	0.0093	-0.0186	0.0671	-0.1894	0.1316
	Age	15-30	0.1334	0.0303	-0.2042	-0.1324	0.1729
		30-50	0.1526	0.0718	-0.2363	-0.0259	0.0378
		50-70	0.0393	0.1720	-0.1417	-0.1649	0.0953
		>70	0.0000	0.0000	0.1382	-0.5500	0.4118
	Travel Distance	1-5km	0.0192	0.1538	0.1154	0.5385	-0.8269
		5-10km	0.1548	0.0357	0.2857	0.5238	-1.0000
		10-20km	0.1429	0.0000	0.4857	0.3714	-1.0000
		20-30km	1.0000	0.0000	0.0000	0.0000	-1.0000
		30-50km	0.0000	0.0000	0.60	0.4000	-1.0000
		>50km	0.4997	0.0000	0.0000	0.0000	-0.4997

Source: Author Generated

This suggests a shift towards motorized modes for longer trips, reflecting considerations of convenience and efficiency. Moreover, the comparison between the two cities highlights both similarities and variations in mode choice probabilities. While certain patterns may be consistent across Coimbatore and Madurai, such as the preference for public transport during rainy days, differences in mode choice behaviour may also be observed due to unique contextual factors. These variations could stem from differences in infrastructure, cultural preferences, or socio-economic factors influencing travel patterns.

According to the model findings, during rainy days, individuals are most inclined to cancel their leisure trips, with a probability of cancellation standing at 0.641 in Coimbatore and 0.7 in Madurai. Conversely, social visits and business trips exhibit the lowest probability of cancellation, with figures of -0.098 and -0.318, respectively, indicating a lesser likelihood of trip disruptions in these categories.

Public transportation emerges as the preferred mode of travel during rainy days, consistently exhibiting a higher probability of selection compared to other weather conditions. Conversely, two-wheeler usage experiences a negative impact during rainy weather, highlighting a decrease in its popularity and usage. For extreme temperature and precipitation conditions, both public transportation and private cars emerge as the most favoured modes of transportation for business and commute trips, displaying a positive effect in both cities. However, leisure and social visit trips witness a negative effect on these modes during such weather conditions. Furthermore, the utilization of two-wheelers and bicycles demonstrates a consistent negative impact across all extreme weather conditions, irrespective of the purpose of travel. This suggests a general reluctance or hindrance in using these modes during adverse weather scenarios. Overall, these insights underscore the differential responses of mode choices to varying weather conditions, emphasizing the need for tailored transportation strategies that account for weather-related impacts on travel behaviour.

Table 10 Marginal effects of purpose-oriented model (Weather and Gender)

Purpose	Region	Mode of Transport	Weather			Gender
			Sunny	Rainy	Windy	Female
Business	**Coimbatore**	**Cancelled Trips**	-0.033	0.098	-0.049	0.011
		Car	0.131	0.164	0.066	-0.059
		Public Transport	0.016	0.098	0.033	0.231
		Two-Wheeler	-0.115	-0.344	-0.049	-0.236
	Madurai	**Cancelled Trips**	0.091	0.318	0.023	0.092
		Car	0.136	0.068	0.023	0.108
		Public Transport	-0.045	-0.023	-0.023	0.029
		Two-Wheeler	-0.205	-0.364	-0.023	-0.219
Commute Trips	**Coimbatore**	**Cancelled Trips**	0.038	0.151	0.000	-0.029
		Car	0.000	0.094	0.000	-0.005
		Cycle	-0.038	-0.094	0.000	-0.112
		Public Transport	0.019	0.113	0.000	0.083
		Two-Wheeler	-0.019	-0.245	0.000	0.066
	Madurai	**Cancelled Trips**	0.015	0.308	0.046	0.041
		Car	0.046	0.031	0.000	0.103
		Cycle	0.000	-0.092	-0.015	-0.076
		Public Transport	0.062	0.138	0.000	0.211
		Two-Wheeler	-0.108	-0.323	0.000	-0.342
Leisure Trips	**Coimbatore**	**Cancelled Trips**	0.154	0.641	-0.090	-0.059
		Car	-0.013	-0.039	0.013	0.011
		Cycle	-0.026	-0.051	-0.026	-0.041
		Public Transport	-0.026	-0.026	0.000	-0.033
		Two-Wheeler	-0.064	-0.487	0.077	0.086
	Madurai	**Cancelled Trips**	0.379	0.697	0.136	0.146
		Car	0.076	0.076	0.015	-0.026
		Cycle	-0.030	-0.076	-0.015	0.040
		Public Transport	0.000	-0.030	0.000	-0.031
		Two-Wheeler	-0.348	-0.591	-0.091	-0.118
Social Visit	**Coimbatore**	**Cancelled Trips**	0.154	0.385	-0.077	0.107
		Car	0.077	0.077	0.000	-0.232
		Two-Wheeler	-0.154	-0.385	0.077	0.042
	Madurai	**Cancelled Trips**	0.417	0.583	0.250	0.146
		Car	0.083	0.083	0.000	0.000
		Public Transport	-0.250	-0.250	-0.083	0.208
		Two-Wheeler	-0.250	-0.417	-0.167	-0.354

Source: Author Generated

Table 11 Marginal effects of purpose-oriented model (Travel distance and Age)

Purpose	Region	Mode of Transport	Travel Distance						Age			
			1-5km	5-10km	10-20km	20-30km	30-50km	>50km	15-30	30-50	50-70	>70
Business	**Coimbatore**	**Cancelled Trips**	0.060	0.034	0.062	0.000	0.145			0.039	0.122	
		Car	0.245	0.462	0.000	0.583	0.000			-0.19	0.189	
		Public Transport	0.095	0.024	0.601	-0.123	0.732			-0.03	-0.18	
		Two-Wheeler	0.477	0.347	0.214	0.417	0.000			0.144	-0.15	
	Madurai	**Cancelled Trips**		- 0.090	-0.177	-0.220	-0.220	-0.220	0.141	0.054	0.313	
		Car		0.305	0.503	1.000	0.000	0.000	0.453	0.359	0.000	
		Public Transport		0.216	0.312	0.000	1.000	1.000	-0.79	-0.82	-0.31	
		Two-Wheeler		- 0.442	-0.639	-0.780	-0.780	-0.780	0.203	0.402	0.000	
Commute Trips	**Coimbatore**	**Cancelled Trips**	- 0.027	- 0.023	0.048				0.035	0.008	0.205	
		Car	0.000	0.018	0.032				0.000	0.065	0.000	
		Cycle	0.184	0.031	0.000				0.000	0.000	0.198	
		Public Transport	0.079	0.580	0.446				- 0.547	- 0.521	- 0.623	
		Two-Wheeler	0.408	0.332	0.412				0.444	0.448	0.104	
	Madurai	**Cancelled Trips**		-0.1	-0.181		-0.181		0.166	0.056	0.130	0.177
		Car		0.056	-0.033		-0.033		0.030	-0.02	0.032	0.048
		Cycle		-0.09	-0.159		-0.159		0.081	0.086	0.079	0.208
		Public Transport		0.167	0.771		0.624		-0.35	-0.18	-0.49	-0.23
		Two-Wheeler		0.026	-0.341		-0.196		0.124	0.161	0.376	-0.19
Leisure Trips	**Coimbatore**	**Cancelled Trips**	0.076	0.120	-0.131		-0.042	0.042	-0.52	-0.43	-0.32	-0.03
		Car	0.069	0.118	0.304		0.750	0.667	0.147	0.183	0.000	0.000
		Cycle	0.049	0.000	0.018		0.000	0.000	-0.03	-0.16	-0.16	-0.16
		Public Transport	-0.38	-0.37	-0.458		-0.458	-0.458	0.052	-0.06	0.036	-0.08
		Two-Wheeler	0.417	0.382	0.518		0.000	0.000	0.334	0.395	0.431	0.275
	Madurai	**Cancelled Trips**		-0.41	-0.529	-0.715		-0.807	-0.25	-0.23	-0.14	0.257
		Car		0.060	0.200	0.291		0.000	0.172	0.219	0.037	0.000
		Cycle		0.096	0.000	0.000		0.000	0.000	0.021	0.184	0.000
		Public Transport		0.066	0.146	0.079		0.970	0.156	0.185	0.037	0.000
		Two-Wheeler		0.345	0.368	0.516		0.000	-0.07	-0.19	-0.20	-0.5
Social Visit	**Coimbatore**	**Cancelled Trips**	-0.25	-0.29	-0.44				0.115	0.282	0.317	
		Car	0.750	0.583	0.375				0.612	0.370	-0.06	
		Two-Wheeler	0.000	0.208	0.562				-0.77	-0.68	-0.25	
	Madurai	**Cancelled Trips**	-0.64	-0.25	-0.708					-0.56	-0.35	
		Car	0.125	0.000	0.000					0.347	0.024	
		Public Transport	-0.03	0.389	-0.111					0.042	0.034	
		Two-Wheeler	0.549	-0.13	0.819					0.173	0.296	

Source: Author Generated

Across all weathers and travel distances, there is a higher probability of cancelled trips for females compared to males. This holds true for both Coimbatore and Madurai. Sunny weather in both Coimbatore and Madurai increases the probability of car use for commute trips across most travel distances, especially for longer trips (greater than 10km). This effect is more pronounced in Madurai compared to Coimbatore. Rain and strong wind tend to decrease the probability of car use for commute trips, with this effect being more prominent in Coimbatore. Interestingly, for short trips (less than 5km) in both cities, there seems to be a slight increase in car use during rainy weather. Public transport ridership for commute trips generally shows an increasing trend with increasing travel distance in both cities and across all weathers. However, the effect is more pronounced in Madurai compared to Coimbatore. There seems to be a slight decrease in public transport use during rainy weather conditions for both cities. Two-wheeler usage for commute trips is generally high for short travel distances (less than 10km) and tends to decrease for longer trips in both cities and across all weathers. Sunny weather seems to encourage two-wheeler use for commute trips compared to rainy or windy weather conditions. The probability of cancelled trips for business trips is generally lower compared to commute trips. Similar to commute trips, there is a higher probability of cancelled trips for females compared to males. Car usage for business trips follows a similar pattern as observed for commute trips. Sunny weather increases the likelihood of car use, while rain and wind decrease it. The probability of cancelled trips for leisure trips is significantly higher compared to commute and business trips, especially for longer travel distances (greater than 10km). This is true for both genders and across all weathers in both Coimbatore and Madurai. Car usage for leisure trips shows a similar pattern as observed for commute trips. Sunny weather increases the likelihood of car use, while rain and wind decrease it. The effect is more pronounced for longer leisure trips. Public transport ridership for leisure trips is generally lower compared to commute trips. There is a slight increase in public transport use with increasing travel distance, especially in Madurai. Two-wheeler usage for leisure trips is similar to that observed for commute trips. It is generally high for short trips and tends to decrease for longer trips. Sunny weather encourages two-wheeler use for leisure trips compared to rainy or windy weather conditions. The probability of cancelled trips for social visit trips is similar to that observed for leisure trips, and is significantly higher compared to commute and business trips. This is true for both genders and across all weathers in both Coimbatore and Madurai. There is a slight increase in cancelled trips for females compared to males. Car usage for social visit trips follows a similar pattern as observed for commute and leisure trips. Sunny weather increases the likelihood of car use, while rain and wind decrease it. The effect is more pronounced for longer trips. Public transport ridership for social visit trips is similar to that observed for leisure trips. There is a slight increase in public transport use with increasing travel distance, especially in Madurai. Two-wheeler usage for social visit trips is similar to that observed for commute and leisure trips. It is generally high for short trips and tends to decrease for longer trips. Sunny weather encourages two-wheeler use for social visit trips compared to rainy or windy weather conditions.

Age seems to have an influence on travel mode choices as well. Younger people (15-50 years) are more likely to use two-wheelers compared to older people (>50 years) who tend to prefer cars or public transport.

The table also shows the marginal effects of other factors like purpose (business, commute, leisure, social visit), mode (car, public transport, two-wheeler, cycle), weather (sunny, rainy, windy), gender (male, female), and age group (15-30, 30-50, 50-70, >70) on the probability of trip cancellation.

5.5 Findings

5.5.1 Issues Identified

In both Madurai and Coimbatore, extreme weather conditions such as heavy rainfall and high temperatures pose significant safety risks for daily commuters, particularly those using non-motorized modes of transportation. Inclement weather events, including heavy rainstorms, frequently disrupt public transport services, resulting in delays, cancellations, and reduced service frequencies. This disruption can inconvenience commuters who depend on public transit for their daily travel needs, leading to longer travel times and disruptions to work and other activities.

During periods of heavy rainfall and extreme heat, some commuters in both cities opt for private cars over other modes of transportation. This shift in mode choice contributes to increased congestion on roads, diminishing the overall efficiency of the transportation network. Moreover, poor weather conditions exacerbate accessibility challenges for vulnerable populations such as the elderly and those residing far from bus stops.

These weather-related challenges highlight the importance of implementing weather-responsive transportation strategies tailored to the unique characteristics of Madurai and Coimbatore. Solutions may include enhancing the resilience of public transport infrastructure to withstand adverse weather conditions, implementing flexible scheduling to accommodate fluctuating demand during inclement weather, and improving last-mile connectivity options to address accessibility challenges. By addressing these issues, transportation authorities can mitigate the impact of extreme weather events on commuters and foster a more resilient and efficient transportation network in both cities.

5.5.2 Summary of Analysis

The data highlights several key insights into travel behaviours in Coimbatore and Madurai across various weather conditions and trip purposes. Firstly, females exhibit a higher probability of cancelled trips compared to males, regardless of the purpose of the trip or the weather conditions. Sunny weather increases car usage for commute, business, leisure, and social visit trips, especially for longer distances, with Madurai showing a more pronounced effect. Rain and strong wind decrease car usage, particularly in Coimbatore, although there's a slight increase in car use for short trips during rainy weather. Public transport usage generally increases with travel distance, especially in Madurai, but decreases slightly during rainy weather. Two-wheeler usage is prominent for shorter trips and decreases for longer trips, with sunny weather encouraging its use across all trip purposes. Additionally, age plays a role in mode choice, with younger individuals more likely to use two-wheelers compared to older individuals, who prefer cars or public transport. These findings provide valuable insights for urban planners and policymakers in understanding and improving transportation infrastructure and services in these cities.

CHAPTER 6- RECOMMENDATIONS AND CONCLUSIONS

6.1 Recommendations

In Coimbatore and Madurai, where weather variations can significantly impact transportation, implementing weather-informed strategies is crucial for ensuring efficient mobility year-round. Here's a detailed plan tailored to these cities:

6.1.2 Weather Informed Transportation Strategies:

weather-informed transportation strategies for Coimbatore and Madurai entails a nuanced approach that acknowledges the region's unique weather patterns and their influence on mode choice.

One key tactic is to introduce adaptable scheduling systems for public transport services that can dynamically respond to inclement weather conditions. For instance, during periods of heavy rain or extreme heat, transit schedules could be adjusted to ensure more frequent service or extended operating hours, accommodating the needs of commuters while mitigating the impact of weather-related disruptions on travel.

Furthermore, enhancing the resilience of transportation infrastructure is essential to minimize disruptions caused by adverse weather. In Coimbatore and Madurai, where heavy rainfall and flooding are common occurrences, investing in robust drainage systems, elevated roadways, and flood-resistant infrastructure can help maintain connectivity even during severe weather events. Additionally, measures such as reinforcing bridges and embankments can bolster the resilience of critical transportation corridors, ensuring uninterrupted mobility for residents and businesses alike.

By prioritizing these weather-responsive strategies, Coimbatore and Madurai can create a transportation network that remains reliable and functional across a range of weather conditions, ultimately enhancing the overall resilience and sustainability of their urban mobility systems.

6.1.2 Promotion of Weather–resilient Modes:

In Coimbatore and Madurai, promoting weather-resilient modes of transportation, such as walking, cycling, and public transport, is essential to ensure efficient mobility regardless of weather conditions.

To encourage adoption, highlighting the reliability and suitability of these modes across various weather conditions is crucial. This can be achieved through targeted campaigns and educational programs that emphasize the benefits of walking, cycling, and using public transport. By showcasing how these modes offer dependable transportation options even during inclement weather, residents can be motivated to incorporate them into their daily travel routines.

Investing in pedestrian and cycling infrastructure is another vital aspect of promoting weather-resilient modes in Coimbatore and Madurai. Constructing well-designed walkways, dedicated bike lanes, and pedestrian-friendly zones not only enhances safety but also encourages more people to opt for walking or cycling as viable transportation choices, regardless of weather conditions.

Improving public transport accessibility is equally important. This involves enhancing the connectivity and efficiency of public transportation networks, ensuring that residents have convenient and reliable alternatives to private vehicle usage, especially during adverse weather. This can include expanding bus routes, increasing the frequency of services, and providing amenities such as covered bus stops and shelters to protect commuters from the elements.

Additionally, providing weather-specific travel advisories can assist residents in making informed decisions about their transportation choices. By delivering timely information about weather conditions and any associated transportation disruptions, commuters can better plan their journeys and choose the most suitable mode of transportation based on prevailing weather conditions.

Overall, by emphasizing the reliability, safety, and accessibility of weather-resilient transportation modes, and investing in supporting infrastructure and informational resources, Coimbatore and Madurai can encourage greater adoption of walking, cycling, and public transport, leading to more sustainable and resilient urban mobility systems.

6.1.3 Infrastructure Investments:

In Coimbatore and Madurai, directing resources towards infrastructure investments tailored to bolstering the safety and convenience of non-motorized modes of transportation, especially in the face of adverse weather conditions, is imperative.

One pivotal avenue for such investments involves the construction of covered walkways, dedicated bike lanes, and shelters at public transport stops. These enhancements not only provide protection from inclement weather but also encourage the utilization of walking, cycling, and public transport options by ensuring a more comfortable and convenient experience for commuters. By offering sheltered spaces at bus stops and transit hubs, passengers can wait for their rides without being exposed to harsh sunlight, heavy rain, or extreme temperatures, thereby improving overall commuter satisfaction and encouraging greater uptake of public transportation.

Furthermore, developing well-designed bike lanes separated from motorized traffic not only enhances the safety of cyclists but also promotes cycling as a viable mode of transportation, even during adverse weather conditions. These dedicated lanes should be strategically planned to connect key destinations and residential areas, thereby facilitating seamless and safe cycling journeys across the city.

Moreover, investing in covered walkways along major pedestrian corridors and near key amenities can significantly enhance the pedestrian experience, making walking a more appealing and practical option for short-distance travel, regardless of weather fluctuations. These covered walkways not only shield pedestrians from rain and sun but also contribute to the overall beautification and urban aesthetics of the city.

By prioritizing infrastructure investments aimed at enhancing the safety and convenience of non-motorized modes of transportation, particularly during adverse weather conditions, Coimbatore and Madurai can foster a more sustainable, resilient, and inclusive urban mobility landscape that promotes active transportation and reduces reliance on private cars.

6.1.4 Integrating weather data into transportation planning

This process is paramount for Coimbatore and Madurai to proactively address the impact of weather on mode choice and ensure the resilience of their transportation systems.

Collaborating with meteorological agencies is essential to develop robust real-time weather monitoring systems tailored to the specific climatic conditions of Coimbatore and Madurai. These systems will provide transportation planners and operators with timely and accurate information on weather patterns, enabling them to anticipate potential disruptions and make informed decisions.

By incorporating weather forecasts into transportation planning, authorities can better allocate resources and adjust schedules to mitigate the effects of adverse weather conditions. For instance, during periods of heavy rainfall or extreme heat, flexible scheduling for public transport services can be implemented to accommodate fluctuations in commuter demand and ensure reliable transportation options are available to residents.

Moreover, decision support tools integrating weather data can aid transportation planners in optimizing route planning and infrastructure maintenance activities. By identifying vulnerable areas prone to weather-related disruptions, such as low-lying areas susceptible to flooding, authorities can prioritize infrastructure investments and implement targeted mitigation measures to enhance the resilience of the transportation network.

Overall, the integration of weather data in transportation planning processes will enable Coimbatore and Madurai to proactively address weather-related challenges, enhance the reliability of transportation services, and ensure the continued mobility of their residents in the face of changing weather patterns.

By implementing these tailored strategies, Coimbatore and Madurai can create a more resilient and efficient transportation system that adapts to the region's diverse weather conditions while promoting sustainable and weather-resilient modes of travel.

6.2 CONCLUSION

This paper successfully achieved its primary research objective by examining the influence of weather conditions on mode choice across different spatial areas. From the analysis, several key conclusions can be drawn. Firstly, while weather conditions do impact mode choice, their influence is generally overshadowed by more directly mobility-related factors like car availability and trip length. Notably, active modes of transportation such as walking and cycling are more susceptible to weather fluctuations compared to public transport and car usage.

Secondly, it was observed that the seasons of the year exert a stronger influence on mode choice than daily weather conditions such as temperature, precipitation, and wind speed. This suggests that individuals tend to adapt their mobility behaviour based on long-term changes in weather patterns rather than short-term fluctuations.

Moreover, the study found that weather conditions can affect mode choice differently across various spatial areas. In Coimbatore and Madurai, for instance, different demographic groups may exhibit varying mobility routines, leading to diverse reactions to weather changes. While warmer weather conditions in densely populated metropolises may result in increased shares of walking and cycling at the expense of public transport and car usage, there might be a substitution effect from walking to cycling in other areas.

Lastly, bicycle usage appears to be less affected by weather conditions in densely populated urban areas like metropolises compared to other spatial area types. In particular, factors such as precipitation and wind speed do not seem to deter cyclists in Coimbatore and Madurai, suggesting a higher resilience to adverse weather conditions among cyclists in these regions.

Overall, these findings underscore the complexity of the relationship between weather conditions and mode choice, highlighting the need for nuanced and context-specific transportation policies and interventions in Coimbatore and Madurai to effectively address weather-related impacts on mobility behaviour.

References

1. Akin, D. V. (2011). Impacts of weather on traffic flow characteristics of urban freeways in Istanbul.
2. Ben-Akiva, M. (1985). *Discrete choice analysis: Theory and application to travel demand.*
3. Bocker, L. M. (2011). Impact of everyday weather on individuals travel behaviours in perspective.
4. Chengxi Liu n, Y. (n.d.). The influence of weather characteristics variability on individual's travel mode choice in different seasons and regions in sweden.
5. keay.k, S. (2005). The association of rainfall and other weather variables.
6. Lars Böcker a, M. D. (2012). Impact of everyday weather on individual daily travel behaviour in perspective : A literature review.
7. M.Summala. (2007). Effects of weather and weather forecasts on drivers behaviour.
8. Manssour A. Abdulsalam Bin Miskeen, A. M. (2013). Modeling a Multinomial logit model of Intercity travel mode choice behaviour for all trips in Libya.
9. Nieland, A. G. (n.d.). The impact of weather conditions on mode choice in different spatial areas.
10. R.M. Faber a, b. O. (n.d.). Inferring modality styles by revealing mode choice heterogeneity in response to weather conditions.
11. Wu, J. (n.d.). Weather, travel mode choice, and impacts on subway ridership in Beijing.
12. Xiaowei Li, 1. Q. (n.d.). Influence of weather conditions on the intercity travel mode choice: A case of Xi'an.
13. Comprehensive Mobility Plan of Coimbatore: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://payment.ccmc.gov.in/DwnldForms/SMARTCITY/CITY_PLANS/a.%20Comprehensive%20Mobility%20Plan%20(Draft%20final%20report)-Final.pdf

Annexures

Annexure A – Survey Questionnaire

1. Location Name. ___________________________

2. Age. ____________________________________

3. Gender
   a. Male
   b. Female

4. Income per Month. __________________________

5. Mode of Transport
   a. Car
   b. Cycle
   c. Public Transport
   d. Two-Wheeler
   e. Walk

6. Origin. ____________________________________

7. Destination. ________________________________

8. Travel Distance. ____________________________

9. Travel Time. _______________________________

10. Travel Purpose
    a. Business Trips
    b. Commute Trips
    c. Leisure Trips

d. Social Visit

11. Trip Frequency
    a. Once per day
    b. Twice per day
    c. Once per week
    d. Twice per week
    e. Once per month
    f. Twice per month

12. Travel Cost. ________________________________

13. Car Ownership
    a. Yes
    b. No

14. Imagine it's a day with heavy rainfall. Which mode would you prefer among these?
    a. Car
    b. Cycle
    c. Public Transport
    d. Two-Wheeler
    e. Walk
    f. Cancel/ Postpone Trips

15. In case of extreme heat, where the temperature is significantly high, what mode of transportation would you be inclined to choose?
    a. Car
    b. Cycle
    c. Public Transport
    d. Two- Wheeler
    e. Walk
    f. Cancel/ Postpone Trips

16. If there are strong Winds making it challenging to walk or cycle comfortably, what mode of transportation would you prefer?
    a. Car
    b. Cycle
    c. Public Transport
    d. Two- Wheeler
    e. Walk
    f. Cancel/ Postpone Trips

17. In a scenario with dense fog reducing visibility. How would this influence your transportation mode preference?
    a. Car
    b. Cycle
    c. Public Transport
    d. Two- Wheeler
    e. Walk
    f. Cancel/ Postpone Trips

18. Do you use weather forecasting apps or other services to check weather before making transportation mode choice decisions?
    a. Yes
    b. No

19. Distance from origin of the trip to nearest public transport accessibility point

    ____

20. Level of accessibility during rainy days
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5

21. How often do you use public transport?
    a. Frequently
    b. Rarely
    c. Never

22. If you do use public transportation, then what is the Average waiting time
    a. <5 mins
    b. 5-10 mins
    c. 10-20 mins
    d. >20 mins

Annexure B- Multinomial Logit Model Results

Table 12 Model 1 (Coimbatore Business Trips)

Multinomial logistic regression	**Number of obs**	**=**	**244**
	LR chi2(37)	=	282.00
	Prob > chi2	=	0.0000
Log likelihood = -178.4102	Pseudo R2	=	0.4414

Mode	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0						
Weather condition						
1	-1.060538	2.292984	-0.46	0.644	-5.554704	3.433629
2	2.996516	2.08764	1.44	0.151	-1.095182	7.088215
3	-18.43581	5621.683	-0.00	0.997	-11036.73	10999.86
Age						
3	-12.13439	698.8317	-0.02	0.986	-1381.819	1357.551
4	-9.320402	2598.479	-0.00	0.997	-5102.246	5083.605
1.Gender	13.78893	745.6557	0.02	0.985	-1447.669	1475.247
Travel distance						
2	66.01581	1.23e+07	0.00	1.000	-2.40e+07	2.40e+07
3	52.63708	1.23e+07	0.00	1.000	-2.40e+07	2.40e+07
4	65.27311	1.23e+07	0.00	1.000	-2.40e+07	2.40e+07
5	49.025	1.23e+07	0.00	1.000	-2.40e+07	2.40e+07
6	68.54668	1.23e+07	0.00	1.000	-2.40e+07	2.40e+07
_cons	-41.27586	1.23e+07	-0.00	1.000	-2.40e+07	2.40e+07
1						
Weather condition						
1	1.192829	2.045892	0.58	0.560	-2.817044	5.202703
2	2.57043	2.049007	1.25	0.210	-1.445549	6.58641
3	.621282	2.050304	0.30	0.762	-3.39724	4.639804
Age						
3	-14.74853	698.8312	-0.02	0.983	-1384.433	1354.936
4	-9.978769	2598.479	-0.00	0.997	-5102.904	5082.946
1.Gender	14.62878	745.6554	0.02	0.984	-1446.829	1476.086
Travel distance						
2	67.9586	1.40e+07	0.00	1.000	-2.75e+07	2.75e+07

3 |	56.07722	1.40e+07	0.00	1.000	-2.75e+07	2.75e+07
4 |	46.92418	1.40e+07	0.00	1.000	-2.75e+07	2.75e+07
5 |	71.6108	1.40e+07	0.00	1.000	-2.75e+07	2.75e+07
6 |	49.8546	1.40e+07	0.00	1.000	-2.75e+07	2.75e+07
|						
_cons |	-41.26104	1.40e+07	-0.00	1.000	-2.75e+07	2.75e+07
-----------------+--						
3 |						
Weather condition |						
1 |	.0572221	1.972092	0.03	0.977	-3.808007	3.922452
2 |	2.050598	1.959058	1.05	0.295	-1.789085	5.890282
3 |	.0555898	1.971899	0.03	0.978	-3.809261	3.920441
|						
Age |						
3 |	-13.14431	698.8312	-0.02	0.985	-1382.828	1356.54
4 |	-12.54226	2598.479	-0.00	0.996	-5105.467	5080.383
|						
1.Gender |	14.25115	745.6553	0.02	0.985	-1447.206	1475.709
|						
Travel distance |						
2 |	30.53464	2405.807	0.01	0.990	-4684.761	4745.83
3 |	17.25536	2611.46	0.01	0.995	-5101.113	5135.623
4 |	31.13139	2720.909	0.01	0.991	-5301.753	5364.016
5 |	14.10114	9379.579	0.00	0.999	-18369.54	18397.74
6 |	33.32591	3161.597	0.01	0.992	-6163.29	6229.941
|						
_cons |	-3.511838	2703.347	-0.00	0.999	-5301.975	5294.952
-----------------+--						
4 |						
Weather condition |						
1 |	-.2160132	1.979436	-0.11	0.913	-4.095637	3.663611
2 |	-.4845531	2.03383	-0.24	0.812	-4.470786	3.50168
3 |	-.0964381	1.977549	-0.05	0.961	-3.972362	3.779486
|						
Age |						
3 |	-12.66827	698.8311	-0.02	0.986	-1382.352	1357.016
4 |	-12.45114	2598.479	-0.00	0.996	-5105.376	5080.474
|						
1.Gender |	12.6147	745.6553	0.02	0.987	-1448.843	1474.072
|						
Travel distance |						
2 |	65.50452	1.32e+07	0.00	1.000	-2.58e+07	2.58e+07
3 |	52.18907	1.32e+07	0.00	1.000	-2.58e+07	2.58e+07
4 |	63.78834	1.32e+07	0.00	1.000	-2.58e+07	2.58e+07
5 |	67.64351	1.32e+07	0.00	1.000	-2.58e+07	2.58e+07
6 |	46.24931	1.32e+07	0.00	1.000	-2.58e+07	2.58e+07
|						
_cons |	-36.69552	1.32e+07	-0.00	1.000	-2.58e+07	2.58e+07

```
-----------------+----------------------------------------------------------------
5                |  (base outcome)
--------------------------------------------------------------------------------
Note: 5 observations completely determined.  Standard errors questionable.
```

Table 13 Model 2 (Coimbatore Commute trips)

```
Multinomial logistic regression                    Number of obs =    212
                                     LR chi2(30)   = 233.75
                                     Prob > chi2   = 0.0000
Log likelihood = -144.80466                   Pseudo R2     = 0.4466

--------------------------------------------------------------------------------
       mode | Coefficient   Std. err.      z      P>|z|       [95% conf. interval]
-----------------+----------------------------------------------------------------
0                |
Weather condition |
    1  |   3.523041    5.83874     0.60   0.546    -7.920679    14.96676
    2  |   7.122126   6.013077     1.18   0.236    -4.663289    18.90754
    3  |  -151.4246          .        .       .            .           .
                 |
             age |
    2  |   .6398353   23.36813     0.03   0.978    -45.16085    46.44053
   3  |   5.190651   23.60005     0.22   0.826    -41.0646    51.4459
   4  |   9.355737   24.16385     0.39   0.699    -38.00453     56.716
                 |
Travel distance |
  2  |   2.115925   6.008655     0.35   0.725    -9.660823    13.89267
  3  |   11.35284   6.836532     1.66   0.097    -2.046519    24.75219
  4  |   12.55166   7.536562     1.67   0.096    -2.219736    27.32305
                 |
_cons |  -14.54311   24.79988    -0.59   0.558    -63.14998    34.06375
-----------------+----------------------------------------------------------------
1                |
Weather condition |
  1  |  -151.3808          .        .       .            .           .
  2  |   8.206338   10.38502     0.79   0.429    -12.14793    28.56061
  3  |   -151.013          .        .       .            .           .
                 |
  age |
    2  |    -153.621          .        .       .            .           .
    3  |    7.43973   25.40533     0.29   0.770    -42.3538    57.23326
    4  |  -147.7281          .        .       .            .           .
                 |
Travel distance |
```

2 |	-137.0373	.	.	.	.	.
3 |	28.20247	.	.	.	.	.
4 |	28.22552	4.957434	5.69	0.000	18.50913	37.94191
|						
cons |	-31.9687	27.18012	-1.18	0.240	-85.24076	21.30336
-----------------+--						
2 |						
Weather condition |						
1 |	-39.94387	2.54e+08	-0.00	1.000	-4.97e+08	4.97e+08
2 |	-175.9595	.	.	.	.	.
3 |	.4632451	3.968792	0.12	0.907	-7.315444	8.241935
|						
age |						
2 |	-170.3483	.	.	.	.	.
3 |	-166.7414	.	.	.	.	.
4 |	11.13585	82.68717	0.13	0.893	-150.928	173.1997
|						
Travel distance |						
2 |	102.327	.	.	.	.	.
3 |	34.24052	.	.	.	.	.
4 |	-113.8748	.	.	.	.	.
|						
_cons |	-34.63222	82.51912	-0.42	0.675	-196.3667	127.1023
-----------------+--						
3 |						
Weather condition |						
1 |	-.3466538	3.250738	-0.11	0.915	-6.717983	6.024675
2 |	2.214294	3.616022	0.61	0.540	-4.872978	9.301566
3 |	.468868	3.784989	0.12	0.901	-6.949573	7.887309
|						
age |						
2 |	-4.243293	21.87543	-0.19	0.846	-47.11834	38.63176
3 |	2.115877	22.11729	0.10	0.924	-41.23321	45.46496
4 |	2.096678	22.70412	0.09	0.926	-42.40258	46.59594
|						
Travel distance |						
2 |	21.33685	3.826687	5.58	0.000	13.83669	28.83702
3 |	32.10607	.	.	.	.	.
4 |	31.22844	4.853165	6.43	0.000	21.71641	40.74047
|						
_cons |	-23.0608	22.0827	-1.04	0.296	-66.3421	20.22049
-----------------+--						
4 |						
Weather condition |						
1 |	-.4215717	3.237329	-0.13	0.896	-6.76662	5.923477
2 |	.941539	3.603688	0.26	0.794	-6.12156	8.004638
3 |	.4639635	3.769471	0.12	0.902	-6.924064	7.851991

|						
age |						
2 |	1.27498	22.21618	0.06	0.954	-42.26794	44.8179
3 |	7.228634	22.45439	0.32	0.748	-36.78117	51.23843
4 |	6.346804	23.03118	0.28	0.783	-38.79349	51.4871
|						
Travel distance |						
2 |	23.36196	22.45928	1.04	0.298	-20.65742	67.38135
3 |	31.61939	22.41986	1.41	0.158	-12.32272	75.56151
4 |	31.23419	22.0713	1.42	0.157	-12.02475	74.49313
|						
_cons |	-27.90231	.	.	.	.	.
-----------------+	---					
5 |	(base outcome)					

Table 14 Model 3 (Coimbatore Leisure Trips)

Multinomial logistic regression				**Number of obs =**	**312**	
				LR chi2(41)	= 412.16	
				Prob > chi2	= 0.0000	
Log likelihood = -242.28071				Pseudo R2	= 0.4596	
--						
mode |	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
-----------------+	---					
0 |						
Weather condition |						
1 |	2.289312	1.375109	1.66	0.096	-.4058527	4.984477
2 |	15.06619	381.2811	0.04	0.968	-732.231	762.3634
3 |	-2.044366	1.12747	-1.81	0.070	-4.254166	.1654345
|						
age |						
2 |	-9.673595	13432.54	-0.00	0.999	-26336.98	26317.63
3 |	-21.48987	13429.41	-0.00	0.999	-26342.66	26299.68
4 |	-8.178892	13432.54	-0.00	1.000	-26335.48	26319.12
5 |	-5.274432	13904.12	-0.00	1.000	-27256.85	27246.31
|						
1.gender |	-1.529041	.9605565	-1.59	0.111	-3.411697	.3536151
|						
Travel distance |						
2 |	14.31344	358.2584	0.04	0.968	-687.8602	716.4871
3 |	27.66385	557.8379	0.05	0.960	-1065.678	1121.006

4	25.77061	736.6406	0.03	0.972	-1418.018	1469.56
6	31.34613	6044.187	0.01	0.996	-11815.04	11877.74
7	29.92796	3961.635	0.01	0.994	-7734.733	7794.589
_cons	8.663832	13432.54	0.00	0.999	-26318.64	26335.97
-----------------+---						
1						
Weather condition						
1	1.374124	1.430669	0.96	0.337	-1.429936	4.178184
2	12.25858	381.2814	0.03	0.974	-735.0393	759.5565
3	-.6224473	1.077571	-0.58	0.564	-2.734447	1.489553
age						
2	10.93239	14458.73	0.00	0.999	-28327.66	28349.53
3	-1.360632	14456.15	-0.00	1.000	-28334.89	28332.17
4	-121.8787	.	.	.	.	.
5	-119.4412	.	.	.	.	.
1.gender	-.9760436	.9882493	-0.99	0.323	-2.912977	.9608895
Travel distance						
2	35.06077	14456.15	0.00	0.998	-28298.47	28368.59
3	48.2831	14462.47	0.00	0.997	-28297.64	28394.21
4	49.54394	14470.48	0.00	0.997	-28312.07	28411.15
6	54.08749	15664.74	0.00	0.997	-30648.24	30756.42
7	52.61828	14984.87	0.00	0.997	-29317.2	29422.43
_cons	-32.57937	.	.	.	.	.
-----------------+---						
2						
Weather condition						
1	.7515418	1.652255	0.45	0.649	-2.486819	3.989903
2	-118.6617	.	.	.	.	.
3	-2.172207	1.434427	-1.51	0.130	-4.983632	.6392183
age						
2	-8.135808	13432.54	-0.00	1.000	-26335.44	26319.17
3	-34.09199	13432.94	-0.00	0.998	-26362.16	26293.98
4	-152.4122	.	.	.	.	.
5	-140.4833	.	.	.	.	.
1.gender	-142.4253	.	.	.	.	.

Travel distance |						
2 |	36.52347	713.4155	0.05	0.959	-1361.745	1434.792
3 |	-83.18676	.	.	.	.	.
4 |	61.71853	.	.	.	.	.
6 |	-37.15244	.	.	.	.	.
7 |	-70.12483	.	.	.	.	.
|						
_cons |	-13.51538	13448.35	-0.00	0.999	-26371.8	26344.77
----------------+--						
3 |						
Weather condition |						
1 |	1.001332	1.354132	0.74	0.460	-1.652717	3.655381
2 |	12.77844	381.2811	0.03	0.973	-734.5188	760.0757
3 |	-.8253366	.9883927	-0.84	0.404	-2.762551	1.111877
|						
age |						
2 |	-6.817729	13432.54	-0.00	1.000	-26334.12	26320.49
3 |	-20.90592	13429.41	-0.00	0.999	-26342.07	26300.26
4 |	-6.365178	13432.54	-0.00	1.000	-26333.67	26320.94
5 |	-138.5814	.	.	.	.	.
|						
1.gender |	-1.870606	.9465069	-1.98	0.048	-3.725725	-.015486
|						
Travel distance |						
2 |	13.16011	358.2578	0.04	0.971	-689.0124	715.3326
3 |	25.72633	557.8377	0.05	0.963	-1067.615	1119.068
4 |	-106.1418	.	.	.	.	.
6 |	-103.0894	.	.	.	.	.
7 |	-104.8751	.	.	.	.	.
|						
_cons |	8.112189	13432.54	0.00	1.000	-26319.19	26335.42
----------------+--						
4 |						
Weather condition |						
1 |	1.265675	1.36796	0.93	0.355	-1.415478	3.946828
2 |	-121.1897	.	.	.	.	.
3 |	-.5354366	.982995	-0.54	0.586	-2.462071	1.391198
|						
age |						
2 |	12.48878	14332.35	0.00	0.999	-28078.4	28103.38
3 |	-.0760793	14329.42	-0.00	1.000	-28085.22	28085.07
4 |	12.85943	14332.35	0.00	0.999	-28078.03	28103.75
5 |	13.76581	14775.24	0.00	0.999	-28945.17	28972.7

|						
1.gender |	-.6542919	.9291332	-0.70	0.481	-2.47536	1.166776
|						
Travel distance |						
2 |	38.14138	643.7352	0.06	0.953	-1223.556	1299.839
3 |	50.4869	772.8059	0.07	0.948	-1464.185	1565.159
4 |	51.55552	.	.	.	.	.
6 |	-80.17634	.	.	.	.	.
7 |	-80.79875	.	.	.	.	.
|						
_cons |	-35.22356	14343.87	-0.00	0.998	-28148.69	28078.25
-----------------+---						
5 |	(base outcome)					

Note: 3 observations completely determined. Standard errors questionable.						

Table 15 Model 4 (Coimbatore Leisure Trips)

Multinomial logistic regression			**Number of obs**	**=**	**52**	
			LR chi2(20)	=	63.42	
			Prob > chi2	=	0.0000	
Log likelihood = -27.685769			Pseudo R2	=	0.5339	
---						
mode |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
-----------------+---						
0 |						
Weather condition |						
1 |	17.39518	3528.119	0.00	0.996	-6897.591	6932.381
2 |	18.71193	5202.134	0.00	0.997	-10177.28	10214.71
3 |	-16.91799	4800.989	-0.00	0.997	-9426.683	9392.847
|						
age |						
2 |	29.93658	19962.3	0.00	0.999	-39095.46	39155.33
3 |	31.24568	14952.94	0.00	0.998	-29275.98	29338.47
4 |	32.43559	15687.09	0.00	0.998	-30713.7	30778.57
|						
1.gender |	-14.82832	13834.78	-0.00	0.999	-27130.49	27100.84
|						
Travel distance |						
2 |	18.30198	6665.43	0.00	0.998	-13045.7	13082.3
3 |	17.96521	3562.304	0.01	0.996	-6964.022	6999.952

4	16.84351	4546.31	0.00	0.997	-8893.76	8927.447
_cons	-15.64763	14322.24	-0.00	0.999	-28086.72	28055.42
-----------------+--						
1						
Weather condition						
1	16.72968	3528.119	0.00	0.996	-6898.256	6931.715
2	17.3065	5202.134	0.00	0.997	-10178.69	10213.3
3	-.0572888	1.719392	-0.03	0.973	-3.427235	3.312657
age						
2	26.59596	19250.54	0.00	0.999	-37703.77	37756.96
3	15.63536	13657.83	0.00	0.999	-26753.22	26784.49
4	13.25604	14457.89	0.00	0.999	-28323.69	28350.21
1.gender	-29.10526	14161.39	-0.00	0.998	-27784.92	27726.71
Travel distance						
2	39.98097	21857.17	0.00	0.999	-42799.29	42879.25
3	39.57521	21118.66	0.00	0.999	-41352.25	41431.4
4	39.21577	21306.73	0.00	0.999	-41721.21	41799.65
_cons	3.185687	12964.27	0.00	1.000	-25406.32	25412.69
-----------------+--						
4						
Weather condition						
1	15.06795	3528.119	0.00	0.997	-6899.918	6930.054
2	-16.11081	6442.316	-0.00	0.998	-12642.82	12610.6
3	.3906368	1.743789	0.22	0.823	-3.027128	3.808401
age						
2	-20.23787	18911.08	-0.00	0.999	-37085.27	37044.79
3	-19.22935	13934.3	-0.00	0.999	-27329.95	27291.49
4	-1.115802	14416.23	-0.00	1.000	-28256.4	28254.17
1.gender	.9333448	13748.04	0.00	1.000	-26944.73	26946.6
Travel distance						
2	23.14478	29248.76	0.00	0.999	-57303.38	57349.67
3	39.16465	28590.3	0.00	0.999	-55996.79	56075.12
4	40.24022	28729.5	0.00	0.999	-56268.55	56349.03
_cons	19.67594	12917.79	0.00	0.999	-25298.72	25338.07
-----------------+--						
5	(base outcome)					

Note: 12 observations completely determined. Standard errors questionable.

Table 16 Model 5 (Coimbatore Full Datasets)

Multinomial logistic regression **Number of obs = 205**

LR chi2(35) = 248.08

Prob > chi2 = 0.0000

Log likelihood = -153.87213 Pseudo R2 = 0.4463

mode	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
1						
age						
2	36.54577	2713.386	0.01	0.989	-5281.593	5354.685
3	36.95896	2713.386	0.01	0.989	-5281.18	5355.098
4	44.6394	2709.307	0.02	0.987	-5265.505	5354.784
5	-104.4583	.	.	.	.	.
1.gender	.5985537	.9248491	0.65	0.518	-1.214117	2.411225
Travel distance						
2	34.43758	2714.417	0.01	0.990	-5285.723	5354.598
3	36.14592	2714.417	0.01	0.989	-5284.014	5356.306
4	43.76749	2714.721	0.02	0.987	-5276.989	5364.524
5	-89.94912	.	.	.	.	.
6	45.74087	2735.786	0.02	0.987	-5316.301	5407.783
7	72.23033	.	.	.	.	.
Travel purpose						
2	-141.9784	.	.	.	.	.
3	-9.859284	75.94926	-0.13	0.897	-158.7171	138.9985
4	4.570074	229.8671	0.02	0.984	-445.9611	455.1012
_cons	-61.75565	.	.	.	.	.
2						
age						
2	-8.224529	23.09898	-0.36	0.722	-53.49771	37.04865
3	-138.4473	.	.	.	.	.
4	16.84959	154.0469	0.11	0.913	-285.0767	318.7759
5	-150.5188	.	.	.	.	.
1.gender	-137.802	.	.	.	.	.
Travel distance						
2	40.40826	2754.865	0.01	0.988	-5359.029	5439.845
3	25.34615	2754.605	0.01	0.993	-5373.58	5424.272

4 |	-95.70375	.	.	.	.	.
5 |	-46.59076	.	.	.	.	.
6 |	-59.27936	.	.	.	.	.
7 |	-59.91685	.	.	.	.	.
|						
Travel purpose |						
2 |	15.34194	103.2428	0.15	0.882	-187.0102	217.694
3 |	13.2197	103.2139	0.13	0.898	-189.0757	215.5151
4 |	-104.0516	.	.	.	.	.
|						
_cons |	-45.90833	2757.031	-0.02	0.987	-5449.59	5357.773
---------------+---						
3 |						
age |						
2 |	.3593364	1.961259	0.18	0.855	-3.48466	4.203333
3 |	.0207003	1.949589	0.01	0.992	-3.800423	3.841824
4 |	9.772772	151.0844	0.06	0.948	-286.3472	305.8927
5 |	-138.7181	.	.	.	.	.
|						
1.gender |	1.517336	.9424302	1.61	0.107	-.3297928	3.364466
|						
Travel distance |						
2 |	36.89577	2888.145	0.01	0.990	-5623.765	5697.557
3 |	38.27805	2888.145	0.01	0.989	-5622.382	5698.938
4 |	46.97945	2888.439	0.02	0.987	-5614.257	5708.216
5 |	-86.7014	.	.	.	.	.
6 |	49.83955	2908.238	0.02	0.986	-5650.201	5749.881
7 |	-75.02113	.	.	.	.	.
|						
Travel purpose |						
2 |	-9.003552	75.9568	-0.12	0.906	-157.8761	139.869
3 |	-11.81384	75.95092	-0.16	0.876	-160.6749	137.0472
4 |	-142.5357	.	.	.	.	.
|						
_cons |	-27.91663	2887.147	-0.01	0.992	-5686.622	5630.788
---------------+---						
4 |						
age |						
2 |	12.97729	187.2274	0.07	0.945	-353.9816	379.9362
3 |	13.03342	187.2271	0.07	0.945	-353.925	379.9918
4 |	22.38279	240.5819	0.09	0.926	-449.149	493.9146
5 |	-128.7602	.	.	.	.	.
|						
1.gender |	.5615114	.8566476	0.66	0.512	-1.117487	2.24051
|						
Travel distance |						
2 |	37.00125	2183.596	0.02	0.986	-4242.768	4316.77
3 |	37.59938	2183.595	0.02	0.986	-4242.169	4317.368

4 |	45.54179	2183.984	0.02	0.983	-4234.988	4326.072
5 |	63.43277	.	.	.	.	.
6 |	-86.45607	.	.	.	.	.
7 |	-78.03451	.	.	.	.	.
|						
Travel purpose |						
2 |	-8.694996	75.95593	-0.11	0.909	-157.5659	140.1759
3 |	-9.903471	75.94851	-0.13	0.896	-158.7598	138.9529
4 |	2.814274	229.8658	0.01	0.990	-447.7144	453.343
|						
_cons |	-39.00973	2190.305	-0.02	0.986	-4331.929	4253.91
---------------+---						
5 |	(base outcome)					

Table 17 Model 6 (Madurai Business Trips)

Multinomial logistic regression			**Number of obs**	**=**	**176**	
		LR chi2(34)	=	148.25		
		Prob > chi2	=	0.0000		
Log likelihood = -161.94916		Pseudo R2	=	0.3140		
--						
mode |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
-----------------+--						
0 |						
Weather condition |						
1 |	-.6180575	6667.555	-0.00	1.000	-13068.79	13067.55
2 |	18.99303	10261.14	0.00	0.999	-20092.48	20130.46
3 |	15.2332	9105.3	0.00	0.999	-17830.83	17861.29
|						
age |						
2 |	13.74576	8103.203	0.00	0.999	-15868.24	15895.73
3 |	-.8214236	8053.734	-0.00	1.000	-15785.85	15784.21
4 |	15.85201	8482.693	0.00	0.999	-16609.92	16641.63
|						
1.gender |	16.85963	2873.24	0.01	0.995	-5614.586	5648.306
|						
Travel distance |						
3 |	-15.76549	7257.395	-0.00	0.998	-14240	14208.47
4 |	-1.164541	7993.146	-0.00	1.000	-15667.44	15665.11
5 |	-15.2574	17815.4	-0.00	0.999	-34932.79	34902.28
6 |	-15.12916	30756.34	-0.00	1.000	-60296.44	60266.18
7 |	-15.12916	30756.33	-0.00	1.000	-60296.43	60266.18
|						
_cons |	16.10385	9855.243	0.00	0.999	-19299.82	19332.03
-----------------+--						
1 |						

Weather Condition |						
1 |	-16.75387	6355.13	-0.00	0.998	-12472.58	12439.07
2 |	1.207259	10060.94	0.00	1.000	-19717.86	19720.28
3 |	.087894	8879.07	0.00	1.000	-17402.57	17402.75
|						
age |						
2 |	14.50745	7967.473	0.00	0.999	-15601.45	15630.47
3 |	1.030475	7917.156	0.00	1.000	-15516.31	15518.37
4 |	-1.269156	8474.004	-0.00	1.000	-16610.01	16607.47
|						
1.gender |	16.00034	2873.24	0.01	0.996	-5615.446	5647.446
|						
Travel distance |						
3 |	2.169331	7805.667	0.00	1.000	-15296.66	15301
4 |	18.38869	8494.059	0.00	0.998	-16629.66	16666.44
5 |	20.60141	17235.95	0.00	0.999	-33761.24	33802.44
6 |	1.934423	30351.94	0.00	1.000	-59486.78	59490.65
7 |	1.934423	30351.94	0.00	1.000	-59486.78	59490.65
|						
_cons |	16.12558	10065.58	0.00	0.999	-19712.04	19744.3
-----------------+---						
3 |						
Weather condition |						
1 |	-17.43965	6355.13	-0.00	0.998	-12473.27	12438.39
2 |	.809777	10060.94	0.00	1.000	-19718.26	19719.88
3 |	-.1084009	8879.07	-0.00	1.000	-17402.77	17402.55
|						
age |						
2 |	-3.172331	7627.565	-0.00	1.000	-14952.93	14946.58
3 |	-16.58448	7574.991	-0.00	0.998	-14863.29	14830.12
4 |	-1.218556	8029.566	-0.00	1.000	-15738.88	15736.44
|						
1.gender |	15.74197	2873.24	0.01	0.996	-5615.704	5647.188
|						
Travel distance |						
3 |	2.128378	8070.474	0.00	1.000	-15815.71	15819.97
4 |	18.1896	8738.029	0.00	0.998	-17108.03	17144.41
5 |	1.579636	18097.23	0.00	1.000	-35468.33	35471.49
6 |	21.64803	29174.68	0.00	0.999	-57159.67	57202.97
7 |	21.64803	29174.68	0.00	0.999	-57159.67	57202.96
|						
_cons |	16.27412	10272.29	0.00	0.999	-20117.05	20149.6
-----------------+---						
4 |						
Weather condition |						
1 |	-18.15241	6355.13	-0.00	0.998	-12473.98	12437.67
2 |	-1.466258	10060.94	-0.00	1.000	-19720.54	19717.6
3 |	-.0851195	8879.07	-0.00	1.000	-17402.74	17402.57

|						
age |						
2 |	13.72222	7988.759	0.00	0.999	-15643.96	15671.4
3 |	1.339897	7938.577	0.00	1.000	-15557.98	15560.66
4 |	-1.391726	8491.141	-0.00	1.000	-16643.72	16640.94
|						
1.gender |	14.18842	2873.24	0.00	0.996	-5617.258	5645.634
|						
Travel distance |						
3 |	-16.82018	7257.395	-0.00	0.998	-14241.05	14207.41
4 |	-2.146505	7993.146	-0.00	1.000	-15668.42	15664.13
5 |	-18.03725	17528.26	-0.00	0.999	-34372.79	34336.72
6 |	-17.80177	30298.46	-0.00	1.000	-59401.69	59366.09
7 |	-17.80177	30298.46	-0.00	1.000	-59401.69	59366.08
|						
_cons |	36.57336	9646.616	0.00	0.997	-18870.45	18943.59
-----------------+--						
5 |	(base outcome)					

Table 18 Model 7 (Madurai Commute Trips)

Multinomial logistic regression			**Number of obs**	**=**	**260**	
			LR chi2(52)	=	341.98	
			Prob > chi2	=	0.0000	
Log likelihood = -189.49365			Pseudo R2	=	0.4743	
--						
mode |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
-----------------+--						
0 |						
Weather condition |						
1 |	17.11416	4266.842	0.00	0.997	-8345.743	8379.971
2 |	37.5361	5683.287	0.01	0.995	-11101.5	11176.57
3 |	18.94158	4266.842	0.00	0.996	-8343.915	8381.799
|						
age |						
2 |	32.96088	11496.83	0.00	0.998	-22500.4	22566.32
3 |	33.04539	11496.83	0.00	0.998	-22500.32	22566.41
4 |	52.16135	12423.22	0.00	0.997	-24296.91	24401.23
5 |	21.92263	26576.28	0.00	0.999	-52066.63	52110.48
|						
1.gender |	-17.11807	2420.269	-0.01	0.994	-4760.757	4726.521
|						
Travel distance |						

3 |	17.45589	2837.535	0.01	0.995	-5544.01	5578.921
4 |	-4.694009	6834.014	-0.00	0.999	-13399.12	13389.73
6 |	-.4443577	14949.54	-0.00	1.000	-29301	29300.12
|						
_cons |	-35.30411	12021.86	-0.00	0.998	-23597.73	23527.12
-----------------+---						
1 |						
Weather condition |						
1 |	1.444119	1.464981	0.99	0.324	-1.427191	4.315429
2 |	18.29415	3754.173	0.00	0.996	-7339.75	7376.338
3 |	1.181395	1.621539	0.73	0.466	-1.996764	4.359554
|						
age |						
2 |	15.03804	10998.2	0.00	0.999	-21541.04	21571.12
3 |	15.7456	10998.2	0.00	0.999	-21540.34	21571.83
4 |	34.56676	11963.27	0.00	0.998	-23413.02	23482.15
5 |	3.944344	32173.73	0.00	1.000	-63055.42	63063.31
|						
1.gender |	-16.37448	2420.269	-0.01	0.995	-4760.014	4727.265
|						
Travel distance |						
3 |	19.3389	2837.535	0.01	0.995	-5542.127	5580.804
4 |	-3.405407	9523.161	-0.00	1.000	-18668.46	18661.65
6 |	-.7077413	18397.97	-0.00	1.000	-36060.06	36058.65
|						
_cons |	-1.721306	10728.6	-0.00	1.000	-21029.38	21025.94
-----------------+---						
2 |						
Weather condition |						
1 |	-.0413899	1.403365	-0.03	0.976	-2.791934	2.709154
2 |	-2.8181	6248.442	-0.00	1.000	-12249.54	12243.9
3 |	.8997626	1.47269	0.61	0.541	-1.986657	3.786182
|						
age |						
2 |	33.66632	12157.43	0.00	0.998	-23794.45	23861.78
3 |	36.30826	12157.43	0.00	0.998	-23791.81	23864.43
4 |	54.50447	13036.97	0.00	0.997	-25497.48	25606.49
5 |	22.41876	29900.49	0.00	0.999	-58581.46	58626.29
|						
1.gender |	-20.8066	2420.269	-0.01	0.993	-4764.446	4722.833
|						
Travel distance |						
3 |	18.44159	2837.535	0.01	0.995	-5543.024	5579.907

4 |	-4.813504	8134.194	-0.00	1.000	-15947.54	15937.91
6 |	-2.393809	15829.8	-0.00	1.000	-31028.23	31023.45
|						
_cons |	-17.25583	11914.08	-0.00	0.999	-23368.42	23333.91
-----------------+---						
3 |						
Weather condition |						
1 |	.5347212	1.225166	0.44	0.663	-1.86656	2.936003
2 |	17.38989	3754.173	0.00	0.996	-7340.654	7375.433
3 |	1.049337	1.312048	0.80	0.424	-1.522231	3.620905
|						
age |						
2 |	12.87771	10998.2	0.00	0.999	-21543.2	21568.96
3 |	15.87407	10998.2	0.00	0.999	-21540.21	21571.96
4 |	31.53943	11963.27	0.00	0.998	-23416.05	23479.13
5 |	2.108986	24205.84	0.00	1.000	-47440.47	47444.68
|						
1.gender |	-17.07599	2420.269	-0.01	0.994	-4760.715	4726.563
|						
Travel distance |						
3 |	18.78746	2837.535	0.01	0.995	-5542.678	5580.253
4 |	17.30971	5662.304	0.00	0.998	-11080.6	11115.22
6 |	17.58568	13955.21	0.00	0.999	-27334.12	27369.29
|						
_cons |	1.834532	10728.59	0.00	1.000	-21025.83	21029.49
-----------------+---						
4 |						
Weather condition |						
1 |	-.2900281	1.298402	-0.22	0.823	-2.834848	2.254792
2 |	14.53952	3754.173	0.00	0.997	-7343.504	7372.583
3 |	1.07569	1.361895	0.79	0.430	-1.593575	3.744955
|						
age |						
2 |	15.35261	10998.2	0.00	0.999	-21540.73	21571.43
3 |	18.03379	10998.2	0.00	0.999	-21538.05	21574.11
4 |	36.66922	11963.27	0.00	0.998	-23410.92	23484.26
5 |	-12.88926	25374.04	-0.00	1.000	-49745.09	49719.31
|						
1.gender |	-21.07456	2420.269	-0.01	0.993	-4764.714	4722.565
|						
Travel distance |						
3 |	18.9752	2837.535	0.01	0.995	-5542.49	5580.441
4 |	12.78605	5662.304	0.00	0.998	-11085.13	11110.7

6	15.74731	13955.21	0.00	0.999	-27335.96	27367.45
_cons	1.86334	10728.59	0.00	1.000	-21025.8	21029.52
5	(base outcome)					

Note: 8 observations completely determined. Standard errors questionable.

Table 19 Model 8 (Madurai Leisure Trips)

Multinomial logistic regression **Number of obs = 264**

LR chi2(45) = 355.77

Prob > chi2 = 0.0000

Log likelihood = -221.38299 Pseudo R2 = 0.4455

mode	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
0						
Weather condition						
1	25.98662	79.29569	0.33	0.743	-129.4301	181.4033
2	23.58444	32.71338	0.72	0.471	-40.5326	87.70148
3	14.33043	29.34618	0.49	0.625	-43.18702	71.84789
age						
2	3.51411	40.74875	0.09	0.931	-76.35196	83.38018
3	3.639985	38.81964	0.09	0.925	-72.44512	79.72509
4	-4.374524	36.5341	-0.12	0.905	-75.98004	67.23099
5	-4.454621	48.0179	-0.09	0.926	-98.56797	89.65873
1.gender	6.490373	13.41115	0.48	0.628	-19.79501	32.77575
Travel distance						
2	-3.330819	32.81671	-0.10	0.919	-67.65039	60.98875
3	3.229998	35.65038	0.09	0.928	-66.64346	73.10346
4	-5.032551	45.6095	-0.11	0.912	-94.42552	84.36042
5	-162.6154	.	.	.	.	.
7	-166.5731	.	.	.	.	.
_cons	-9.200712	51.3251	-0.18	0.858	-109.7961	91.39464
1						

Weather condition |						
1 |	10.99181	73.66762	0.15	0.881	-133.3941	155.3777
2 |	7.544859	14.47101	0.52	0.602	-20.8178	35.90752
3 |	.332282	1.573811	0.21	0.833	-2.75233	3.416894
|						
age |						
2 |	13.93104	83.0075	0.17	0.867	-148.7607	176.6228
3 |	14.45107	82.07866	0.18	0.860	-146.4201	175.3223
4 |	4.943048	81.02434	0.06	0.951	-153.8617	163.7478
5 |	-149.2383	.	.	.	.	.
|						
1.gender |	5.719107	13.41451	0.43	0.670	-20.57285	32.01107
|						
Travel distance |						
2 |	32.29836	13.66421	2.36	0.018	5.516994	59.07972
3 |	40.72556	.	.	.	.	.
4 |	34.7987	34.46239	1.01	0.313	-32.74634	102.3437
5 |	-126.8389	.	.	.	.	.
7 |	-129.0247	.	.	.	.	.
|						
_cons |	-41.68308	81.69393	-0.51	0.610	-201.8003	118.4341
-----------------+---						
2 |						
Weather condition |						
1 |	9.321065	73.66692	0.13	0.899	-135.0635	153.7056
2 |	-164.3521	.	.	.	.	.
3 |	-.2094403	1.519258	-0.14	0.890	-3.187131	2.768251
|						
age |						
2 |	-155.6167	.	.	.	.	.
3 |	13.05237	87.55923	0.15	0.881	-158.5606	184.6653
4 |	8.298193	86.56681	0.10	0.924	-161.3696	177.966
5 |	-147.1141	.	.	.	.	.
|						
1.gender |	7.612259	13.39881	0.57	0.570	-18.64892	33.87344
|						
Travel distance |						
2 |	38.88013	.	.	.	.	.
3 |	-126.0767	.	.	.	.	.
4 |	-129.6688	.	.	.	.	.
5 |	-118.9345	.	.	.	.	.
7 |	-125.154	.	.	.	.	.
|						

_cons |	-47.92674	86.57209	-0.55	0.580	-217.6049	121.7514
-----------------+---						
3 |						
Weather condition |						
1 |	10.47077	73.66791	0.14	0.887	-133.9157	154.8572
2 |	6.726948	14.47554	0.46	0.642	-21.64459	35.09849
3 |	.2025793	1.570666	0.13	0.897	-2.87587	3.281028
|						
age |						
2 |	14.64345	93.20028	0.16	0.875	-168.0257	197.3126
3 |	14.18639	92.37392	0.15	0.878	-166.8632	195.2359
4 |	-4.720876	137.8538	-0.03	0.973	-274.9094	265.4677
5 |	-153.5882	.	.	.	.	.
|						
1.gender |	6.335956	13.41809	0.47	0.637	-19.96301	32.63492
|						
Travel distance |						
2 |	29.11791	31.65184	0.92	0.358	-32.91855	91.15438
3 |	37.21698	34.4654	1.08	0.280	-30.33396	104.7679
4 |	30.4507	.	.	.	.	.
5 |	61.95536	.	.	.	.	.
7 |	51.91359	155.6177	0.33	0.739	-253.0914	356.9186
|						
_cons |	-38.40169	96.76013	-0.40	0.691	-228.0481	151.2447
-----------------+---						
4 |						
Weather condition |						
1 |	9.503375	73.66565	0.13	0.897	-134.8787	153.8854
2 |	3.196627	14.49227	0.22	0.825	-25.20769	31.60095
3 |	.0274067	1.471529	0.02	0.985	-2.856737	2.91155
|						
age |						
2 |	4.525746	40.74049	0.11	0.912	-75.32414	84.37563
3 |	3.959249	38.81278	0.10	0.919	-72.1124	80.0309
4 |	-3.555867	36.52475	-0.10	0.922	-75.14306	68.03132
5 |	-156.3927	.	.	.	.	.
|						
1.gender |	5.994466	13.40475	0.45	0.655	-20.27836	32.26729
|						
Travel distance |						
2 |	37.40518	31.64342	1.18	0.237	-24.61478	99.42515
3 |	44.55568	34.45855	1.29	0.196	-22.98185	112.0932
4 |	39.11242	.	.	.	.	.

5 |	-121.5065	.	.	.	.	.
7 |	47.83689	116.5014	0.41	0.681	-180.5017	276.1755
|						
_cons |	-34.50123	48.32814	-0.71	0.475	-129.2226	60.22018
-----------------+--						
5 |	(base outcome)					
--						
Note: 7 observations completely determined. Standard errors questionable.						

Table 20 Model 9 (Madurai Social visit)

Multinomial logistic regression			**Number of obs**	**=**	**48**	
		LR chi2(26)	=	98.29		
		Prob > chi2	=	0.0000		
Log likelihood = -1.9095425			Pseudo R2	=	0.9626	
--						
mode |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
-----------------+--						
0 |						
Weather condition |						
1 |	2.528758	388411.3	0.00	1.000	-761269.7	761274.7
2 |	42.02498	389301.4	0.00	1.000	-762974.7	763058.8
3 |	48.13509	1612568	0.00	1.000	-3160528	3160624
|						
age |						
3 |	-126.3907	222097.1	-0.00	1.000	-435428.6	435175.8
4 |	-41.39943	210296.5	-0.00	1.000	-412215	412132.2
|						
1.gender |	84.13496	167897.6	0.00	1.000	-328989.2	329157.5
|						
Travel distance |						
2 |	-20.04725	212760.2	-0.00	1.000	-417022.3	416982.2
3 |	40.63398	246771.3	0.00	1.000	-483622.3	483703.5
4 |	64.94404	243125.1	0.00	1.000	-476451.5	476581.4
|						
_cons |	21.23328	397269.8	0.00	1.000	-778613.3	778655.7
-----------------+--						
1 |	(base outcome)					
-----------------+--						
3 |						
Weather condition |						

1	-88.11082	400085.5	-0.00	1.000	-784241.2	784065
2	-48.72376	401821.9	-0.00	1.000	-787605.2	787507.7
3	3.080287	1612399	0.00	1.000	-3160242	3160248
age						
3	-47.00622	392954.7	-0.00	1.000	-770224	770130
4	-1.083094	320731.3	-0.00	1.000	-628622.9	628620.8
1.gender	44.72979	269873.5	0.00	1.000	-528897.5	528987
Travel distance						
2	.5998506	255794.2	0.00	1.000	-501346.7	501347.9
3	45.8792	355636.7	0.00	1.000	-696989.2	697080.9
4	46.52297	360014.6	0.00	1.000	-705569.1	705662.1
_cons	43.04535	393513.5	0.00	1.000	-771229.3	771315.4
4						
Weather condition						
1	-43.75377	381404.3	-0.00	1.000	-747582.4	747494.9
2	-45.44932	381797.4	-0.00	1.000	-748354.6	748263.7
3	2.823824	1611081	0.00	1.000	-3157659	3157664
age						
3	-42.40368	194316.5	-0.00	1.000	-380895.8	380811
4	.4743334	206629.6	0.00	1.000	-404986	404987
1.gender	41.88968	162871.6	0.00	1.000	-319180.7	319264.4
Travel distance						
2	24.3681	216964.5	0.00	1.000	-425218.3	425267
3	.526585	255752.2	0.00	1.000	-501264.5	501265.6
4	67.24611	228110.1	0.00	1.000	-447020.3	447154.8
_cons	43.73833	393513.5	0.00	1.000	-771228.6	771316.1

Note: 45 observations completely determined. Standard errors questionable.

Table 21 Model 10 (Madurai Full Datasets)

Multinomial logistic regression	**Number of obs**	**=**	**187**
	LR chi2(32)	=	92.78

Prob > chi2 = 0.0000						
Log likelihood = -204.83749	Pseudo R2 = 0.1847					
mode	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
1						
1.gender	-1.694145	.8525027	-1.99	0.047	-3.36502	-.0232706
Trip purpose						
1	20.96502	3673.362	0.01	0.995	-7178.693	7220.623
2	2.313008	3905.399	0.00	1.000	-7652.128	7656.754
3	18.47741	3673.362	0.01	0.996	-7181.18	7218.135
Travel distance						
2	23.62705	165393	0.00	1.000	-324140.8	324188
3	41.98321	165395.5	0.00	1.000	-324127.2	324211.1
4	42.04589	165399.7	0.00	1.000	-324135.5	324219.6
5	48.82136	174909.4	0.00	1.000	-342767.2	342864.9
6	26.1873	165494.1	0.00	1.000	-324336.2	324388.6
7	25.82332	165393	0.00	1.000	-324138.6	324190.2
age						
2	-1.197016	3722.705	-0.00	1.000	-7297.565	7295.171
3	.6911324	3722.705	0.00	1.000	-7295.677	7297.059
4	-1.87948	3722.705	-0.00	1.000	-7298.248	7294.489
5	-23.60991	97006.04	-0.00	1.000	-190152	190104.7
_cons	-16.63072	5229.925	-0.00	0.997	-10267.1	10233.83
2						
1.gender	-2.061698	.9754951	-2.11	0.035	-3.973634	-.1497629
Trip purpose						
1	3.766999	4793.101	0.00	0.999	-9390.537	9398.071
2	19.44355	4221.768	0.00	0.996	-8255.07	8293.958
3	18.32081	4221.768	0.00	0.997	-8256.193	8292.835
Travel distance						
2	26.44519	239200.5	0.00	1.000	-468798	468850.9
3	41.25549	239202.2	0.00	1.000	-468786.5	468869
4	26.18831	239211.9	0.00	1.000	-468820.5	468872.9
5	26.18831	255275.9	0.00	1.000	-500305.3	500357.7

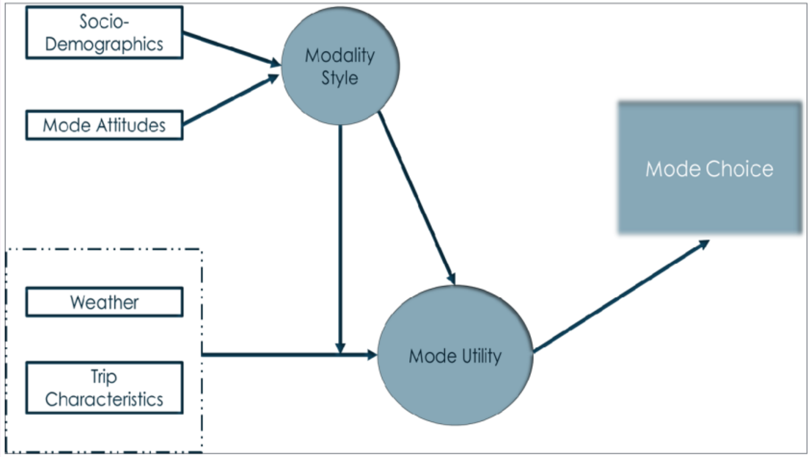
6	26.18831	239301.7	0.00	1.000	-468996.4	469048.8
7	5.508664	242092.2	0.00	1.000	-474486.4	474497.4
age						
2	-.7669176	4974.123	-0.00	1.000	-9749.869	9748.336
3	1.872382	4974.123	0.00	1.000	-9747.23	9750.975
4	1.878199	4974.123	0.00	1.000	-9747.224	9750.981
5	-23.61397	135399.7	-0.00	1.000	-265402.1	265354.9
_cons	-18.61373	6524.203	-0.00	0.998	-12805.82	12768.59
-------------+						
3						
1.gender	-1.410968	.7557995	-1.87	0.062	-2.892307	.0703722
Trip purpose						
1	3.739707	1.518383	2.46	0.014	.7637311	6.715683
2	2.728979	1.143517	2.39	0.017	.4877267	4.97023
3	1.116033	1.119432	1.00	0.319	-1.078014	3.310081
Travel distance						
2	24.64261	112157.3	0.00	1.000	-219799.6	219848.9
3	41.82	112160.8	0.00	1.000	-219789.4	219873
4	42.49338	112167.2	0.00	1.000	-219801.1	219886.1
5	26.18751	129822.9	0.00	1.000	-254422	254474.4
6	42.94357	112245.1	0.00	1.000	-219953.4	220039.3
7	5.507864	113514	0.00	1.000	-222477.9	222488.9
age						
2	-17.67585	2947.19	-0.01	0.995	-5794.062	5758.71
3	-16.06615	2947.19	-0.01	0.996	-5792.452	5760.32
4	-16.67261	2947.19	-0.01	0.995	-5793.058	5759.713
5	-17.9497	2947.19	-0.01	0.995	-5794.336	5758.437
_cons	16.73339	2947.19	0.01	0.995	-5759.653	5793.119
-------------+						
4						
1.gender	-2.160584	.7387871	-2.92	0.003	-3.608581	-.7125884
Trip purpose						
1	3.135245	1.396457	2.25	0.025	.3982395	5.872251
2	1.656891	.9813294	1.69	0.091	-.266479	3.580262
3	1.390183	.9077821	1.53	0.126	-.3890369	3.169403

Travel distance						
2	25.62941	85094.56	0.00	1.000	-166756.6	166807.9
3	41.87255	85099.27	0.00	1.000	-166749.6	166833.4
4	41.6715	85107.59	0.00	1.000	-166766.1	166849.5
5	26.18781	105238.2	0.00	1.000	-206237	206289.3
6	41.98441	85210.32	0.00	1.000	-166967.2	167051.1
7	5.508163	86122.29	0.00	1.000	-168791.1	168802.1
age						
2	-17.27694	2947.19	-0.01	0.995	-5793.663	5759.109
3	-15.29144	2947.19	-0.01	0.996	-5791.677	5761.094
4	-16.64129	2947.19	-0.01	0.995	-5793.027	5759.745
5	-40.36091	52612.24	-0.00	0.999	-103158.5	103077.7
_cons	17.64751	2947.19	0.01	0.995	-5758.738	5794.033
-------------+---						
5	(base outcome)					

Annexure C- Sheets

INTRODUCTION

INTRODUCTION



Aim

To assess the influence of weather changes on individual's mode choice decision by comparing with two cities.

Objective

- To investigate the impact of weather characteristics on individual's mode choice by doing descriptive analysis.
- To estimate multinomial logit model and to examine the marginal effects of weather characteristics on mode choices.
- To compare model results for different weather & regions to interpret individual behaviors due to difference in weather impacts.

Scope

This study covers a broad geographical region and different weather conditions, and investigates the marginal effects of weather characteristics on different travel modes in different regions.

Limitation

- The data regarding weather is gathered through the formulation of scenario-based questions, rather than reflecting the real-time weather conditions.
- This study is completely based on the primary survey, which may lead to recall bias.

Outcome

- The expected outcome out of this study is to provide a better understanding of the impacts of weather on travel behavior and mode choice.
- It can be used to provide recommendations that can be implemented during particular weather conditions for particular geographical locations.

LITERARTURE REVIEW:

Authors and year	Travel Mode	Weather condition	Modelling Approach	Main Findings
Hagen Auer and Helbich [13]	Walking, bike, car, Public transport	Precipitation, Temperature, Wind speed	Machine learning, Multinomial logit, Support vector machine	Temperature is crucial for predicting bike and public transit trips, often outweighing precipitation and wind speed in transportation mode decisions.
Bocker et al [12]	Walking, Cycling, car, Public transport	Precipitation, temperature	Multinomial logit model	Car use appears less appealing in spring, with walking and cycling experiencing less pronounced boosts compared to winter.
Ton et al [19]	Car, public transport, bicycle, walking	Season and weather characteristics	Mixed multinomial logit	The weather has a limited impact on active mode choice

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

1

Seal and Signature:

METHODOLOGY

Authors and year	Travel Mode	Weather condition	Modelling Approach	Main Findings
Ma et al. [14]	Walking, bicycle, car, public transport	Wind speed, Temperature, air quality index, Humidity	Multinomial probit (MNP) and multinomial logit (MNL) model	During periods of poor air quality, students prefer public transportation over cars, possibly due to Beijing's traffic regulations restricting family car ownership and usage.
Arana et al. [15]	Bus	Temperature, relative air humidity, rain, wind	Multiple linear regression	Wind and rain could decrease the number of trips, while the rise of temperature could make the number of trips increase.

METHODOLOGY

Topic Identification

Literature Review

Aim & Objective

Formulation of aim and objective of the study.

To investigate the impact of weather characteristics on individual's mode choice decision by doing descriptive analysis.

To estimate multinomial logit model and to examine the marginal effects of weather characteristics on mode choices.

To compare model results for different weather & regions to interpret individual behaviors due to difference in weather impacts.

Site Selection

Study area is selected on the basis of cities with similar characteristics (topography, population, availability of travel modes with difference in weather condition

Survey &Data Collection

Primary Survey – OD Data Collected
- Socio demographic data
- travel behavior
- Mode choices for different weather

Objective 1

- Understand the distribution of each variable (e.g., mode choices, weather conditions) through descriptive statistics.

Objective 2

- Model Specification
- Model Estimation
- Model Validation
- Marginal effect analysis

Objective 3

compare model results for different weather & regions to interpret individual behaviors due to difference in weather impacts.

Conclusion

Recommendations and way forwarding

Study Area

Coimbatore

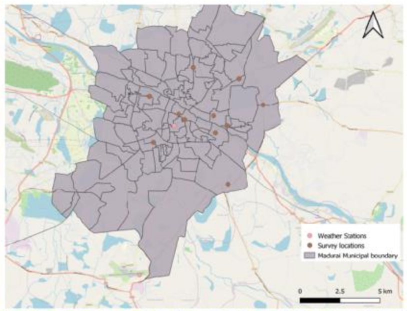
21,36,916

246 sq.km

9 locations, 204 samples

Coimbatore, a city in Tamil Nadu, experiences a wet season from September to November due to the northeast monsoon. Summers are hot and humid from March to June, with temperatures ranging from 25°C to 36°C. The monsoon season lasts from July to October, receiving moderate rainfall. Winters, from November to February, have temperatures ranging from 18°C to 30°C.The city's average annual rainfall is around 600 mm, with contributions from the northeast and southwest monsoons

Madurai



14,65,625

148 sq.km

11 locations, 187 samples

Madurai, a significant city in South Tamil Nadu, experiences a tropical climate, bordering on a hot semi-arid climate, with hot and dry conditions for eight months of the year. The hottest months are from March to July, with temperatures reaching up to 42°C (107.6°F). Madurai receives an average annual rainfall of about 857.6 mm

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

2

Seal and Signature:

DATA COLLECTION

Socio Economic Parameters

Variables	Category	Code	Coimbatore N	Coimbatore Percentage	Madurai N	Madurai Percentage
Age	<15	1	8	3.9%	17	9.1%
	15-30	2	62	30.4%	60	32.1%
	30-50	3	104	51.0%	81	43.3%
	50-70	4	29	14.2%	25	13.4%
	>70	5	1	0.5%	4	2.1%
Gender	Male	0	120	58.8%	118	63.1%
	Female	1	84	41.2%	69	36.9%
Income per Month	<10000	1	29	14.2%	32	17.1%
	10000-50000	2	157	77.0%	128	68.4%
	50000-100000	3	18	8.8%	27	14.4%

Travel behavior Parameters

Variables	Category	Code	Coimbatore N	Coimbatore Percentage	Madurai N	Madurai Percentage
Mode	Car	1	37	18.1%	23	12.3%
	Cycle	2	9	4.4%	11	5.9%
	Public Transport	3	42	20.6%	50	26.7%
	Twp wheeler	4	97	47.5%	87	46.5%
	Walk	5	19	9.3%	16	8.6%
Travel Distance	<1Km	1	10	4.9%	6	3.2%
	1-5Km	2	54	26.5%	52	27.8%
	5-10Km	3	75	36.8%	84	44.9%
	10-20Km	4	53	26.0%	35	18.7%
	20-30Km	5	2	1.0%	3	1.6%
	30-50Km	6	7	3.4%	5	2.7%
	>50Km	7	3	1.5%	2	1.1%
Travel Time	<5Mins	1	3	1.5%	3	1.6%
	5-10Mins	2	21	10.3%	20	10.7%
	10-20Mins	3	62	30.4%	83	44.4%
	20-30Mins	4	77	37.7%	35	18.7%
	30-1hr	5	27	13.2%	42	22.5%
	>1hr	6	14	6.9%	4	2.1%
Travel Purpose	Business	1	61	29.9%	44	23.5%
	Commute Trips	2	53	26.0%	65	34.8%
	Leisure Trips	3	77	37.7%	66	35.3%
	Social Visit	4	13	6.4%	12	6.4%

Distribution of motorized modes in the datasets used

Mode		Car		Public Transport		Two Wheelers	
Data base	**Category**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**
Number of Trips		37	23	42	50	97	87
Average Trip Distance(KM) (S.E in parenthesis)		17.7 (0.231)	12.2 (0.224)	13.7% (0.160)	14.0(0.131)	12.1 (0.082)	9.4(0.088)
Percentage of having a car		100%	100%	2.40%	8%	28.90%	31%
Percentage of Male		62.20%	56.50%	43.90%	62.00%	61.90%	70.10%
Percentage of trip purpose	Commute Trips	0%	0%	43.90%	54.00%	28.90%	32.20%
	Business Trips	32.40%	56.50%	48.80%	22.00%	27.80%	21.80%
	Leisure Trips	48.60%	43.50%	7.30%	20.00%	38.10%	37.90%
	Social Visit	18.90%	0.00%	0%	4.00%	5.20%	8.00%

Distribution of non-motorized modes in the datasets used

Mode		Cycle		Walk	
Data base	**Category**	**Coimbatore**	**Madurai**	**Coimbatore**	**Madurai**
Number of Trips		10	11	19	16
Average Trip Distance(KM) (S.E in parenthesis)		1.8 (0.133)	2.3 (0.141)	3.32 (0.159)	1.3(0.359)
Percentage of having a car		0%	0%	11.10%	0%
Percentage of Male		100%	63.60%	50%	37.50%
Percentage of trip purpose	Commute Trips	62.50%	54.50%	11.10%	25.00%
	Business Trips	0%	0%	11.10%	6.30%
	Leisure Trips	37.50%	45.50%	72.20%	50.00%
	Social Visit	0%	0.00%	5.60%	18.80%

Date Interpretation

- From the collected data it is observed that 34.6% of the respondents in Coimbatore and 26.2% of the respondents in Madurai owns a private car.
- People use PT more for commute trips and business trips than leisure trips and social visit.

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

3

Seal and Signature:

ANALYSIS

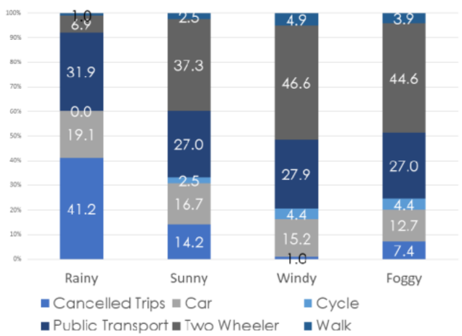
Average number of trips made per individual per day across different weather condition

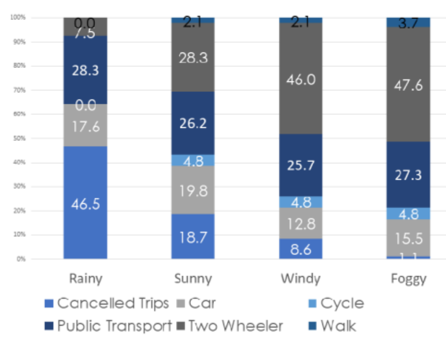
Mode	Car		Cycle		Public Transport		Two Wheelers		Walk	
weather	Coimbatore	Madurai	Coimbatore	Madurai	Coimbatore	Madurai	Coimbatore	Madurai	Coimbatore	Madurai
Sunny	0.33 (19.4%)	0.41 (24.3%)	0.91 (2.8%)	1.42 (5.92%)	0.68 (31.4%)	0.909 (32.2%)	0.55 (43.4%)	0.66 (34.86 %)	1 (2.8%)	1.5 (2.63 %)
Rainy	0.52 (32.5%)	0.45 (33%)	-	-	0.71 (54.1)	1.13 (53%)	0.97 (11.6%)	0.52 (14%)	0.78 (1.6%)	-
Windy	0.17 (15.5%)	0.35 (13.9%)	0.93 (3.5%)	1.31 (5.2%)	0.69 (28.5%)	0.85 (27.9%)	0.5 (47.5%)	0.61 (50%)	0.74 (5%)	0.89 (2.3%)
Foggy	0.19 (13.7%)	0.36 (11.7%)	0.79 (4.7%)	1.34 (5.8%)	0.65 (29%)	0.84 (26.5%)	0.56 (48.1%)	0.57 (50.5%)	0.78 (4.2%)	0.93 (4.7%)

Inference

- Car trips and public transport increases in rainy days, in corresponding to that walk and two wheeler's daily trips have dropped.
- Average daily trips for all the modes remains almost similar during heavy windy and foggy days.

Modal split per categorized weather conditions

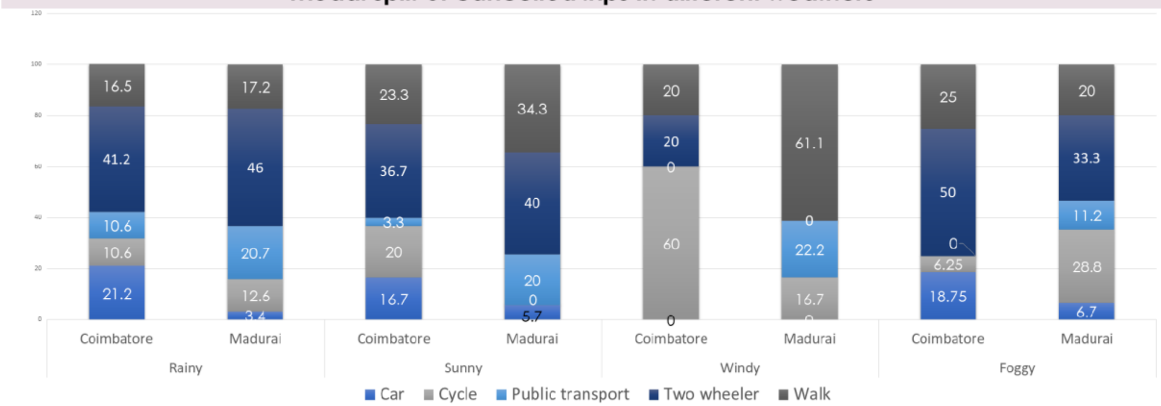




Inference

- During rainy nearly 42% trips tend to either cancel / postpone their trips in Coimbatore and 47% in Madurai city.
- Modal share in public transport in rainy day is increased when compared to other observed mode share.
- Precipitation has a huge negative impact on two wheelers and bicycles. Around 40% of the two wheeler share is reduced from the normal modal share.

Modal split of cancelled trips in different weathers



Inference

- Upon the cancelled trips major share is produced from two wheelers. So, weather has a huge impact on two wheelers than all other modes.
- Bicycle trips are affected during heavy winds.
- Individuals cancelling their trips are observed majorly from leisure trips and social visits, others tend to change their modes.
- During heavy rain, daily commuters whose distance to the bus stop is high are cancelling their trips since they do not have the last mile connectivity.

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

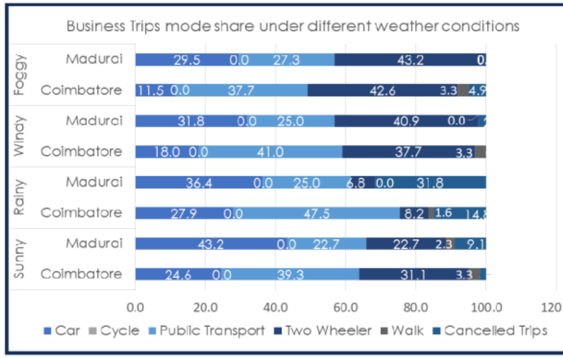
Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

4

Seal and Signature:

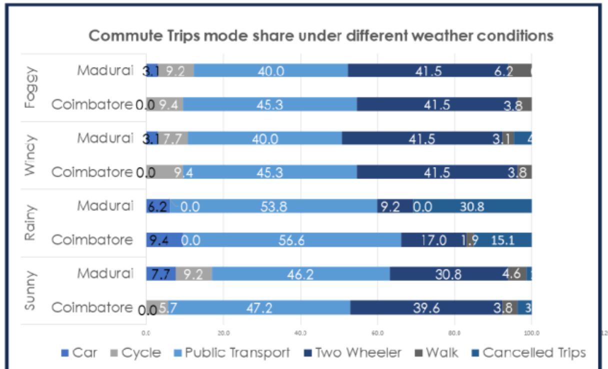
DESCRIPTIVE ANALYSIS

Purpose oriented mode share under different weather conditions



Inference

- For business trips during rainy days people prefer to shift to different modes rather than cancelling/ postponing their trips in Coimbatore city, whereas in Madurai they tend to cancel their trips.
- During extreme temperature, in Madurai around 14% of the car trips are increased at the expense of two wheeler trips.

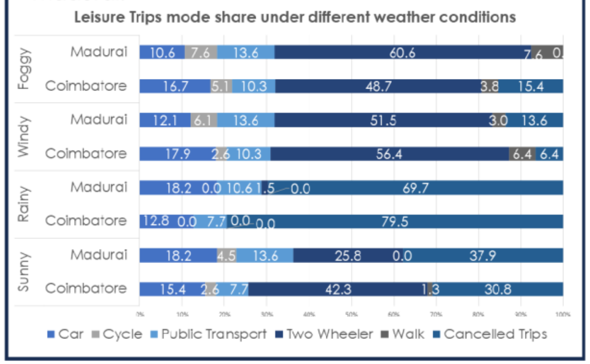


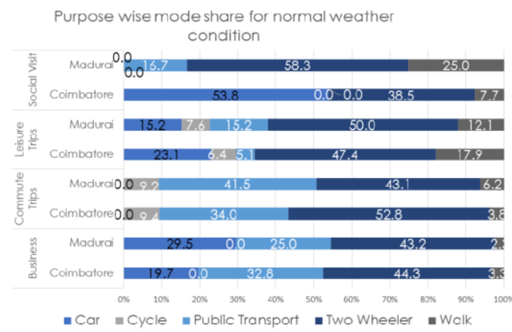
Inference

- It can be evidently seen that public transportation is highly preferred for daily commute trips. Usage of pt in rainy days in Coimbatore is increased to 22% when compared usual mode.
- The commuters who rely on their private car for daily trips the usage of car trips is rapidly reduced when compared to other trips purposes.

Inference

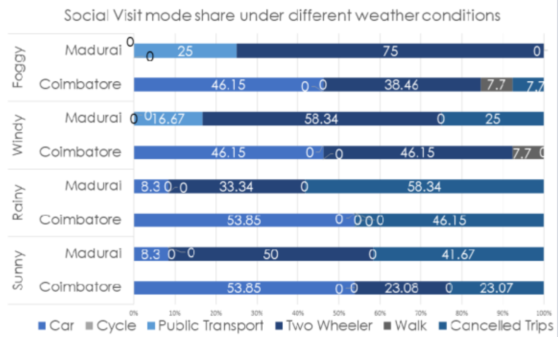
- Most of the cancelled/ postponed trips in sunny and rainy weather condition are observed only from leisure trips. Two wheeler trips and walk trips are completely getting cancelled in leisure trips during rainy days.
- Usage of public transport is slightly increased during all extreme weather conditions in Coimbatore, whereas the opposite results can be inferred in Madurai.





Inference

- There is a slight shift from public transport to private cars during sunny and rainy days in Madurai whereas the two wheeler trips tend to cancel / postpone their trips in Coimbatore.
- walk and bicycle modes have cancelled/ postponed their trips during heavy winds in Madurai.



योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

5

Seal and Signature:

MULTINIMIAL LOGIT MODEL

MNL Methodology

Data Preparation

Input Data

Declare Variable
- Dependent variable (Mode of transportation)
- Independent Variable(Age, Gender, Travel Distance, Travel Purpose, Weather Condition)

Estimate multinomial logit model
- Command-mlogit dependent variable independent variable, base category(base)
- Interpret the results

$$P_{iq} = \frac{e^{B_{ki}X_{miq}}}{\sum A_j . A_{(q)} \, e^{B_{ki}X_{miq}}}$$

Calculate Marginal Effects
- Command- margins, dydx(independent variables)

Multinomial Logit Model Test Results

Region	Purpose	Models	Number of Obs	LR chi^2	Pseudo R^2	Log likelihood
Coimbatore	Business Trips	Model 1	244	282	0.4414	-178.4102
	Commute Trips	Model 2	212	162.4	0.3103	-180.47978
	Leisure Trips	Model 3	312	168.76	0.1882	-363.98373
	Social Visit	Model 4	52	27.21	0.2291	-45.788788
		Model 5	205	87.97	0.1583	-233.93042
Madurai	Business Trips	Model 6	172	148.25	0.314	-161.94916
	Commute Trips	Model 7	260	263.82	0.3659	-228.57444
	Leisure Trips	Model 8	264	355.77	0.4455	-221.38299
	Social Visit	Model 9	48	85.47	0.8371	-8.3177662
		Model 10	187	92.78	0.1847	-204.83749

Marginal Effects of Models with Full Datasets

Region	Variable	Category	Car	Cycle	Public Transport	Two Wheeler	Walk
Coimbatore	Trip Purpose	Business Trips	-0.3429	0.0000	0.3279	0.0569	-0.0418
		Commute Trips	-0.5396	0.1018	0.3312	0.1444	-0.0378
		Leisure Trips	-0.3092	0.0602	0.0525	0.0874	0.1090
	Gender	female	-0.0170	-0.0834	0.1034	-0.0567	0.0538
	Age	15-30	0.1599	-0.1120	-0.3752	0.4281	-0.1007
		30-50	0.2123	-0.1318	-0.4294	0.4499	-0.1010
		50-70	0.0621	0.0300	-0.3607	0.4127	-0.1441
		>70	-0.0095	-0.1318	0.6051	-0.0608	0.8071
	Travel Distance	1-5km	0.1160	0.1228	0.0928	0.5941	-0.9257
		5-10km	0.2434	0.0161	0.1779	0.5057	-0.9431
		10-20km	0.1887	0.0000	0.3205	0.4860	-0.9951
		20-30km	0.0000	0.0000	0.0000	0.9951	-0.9951
		30-50km	0.2925	0.0000	0.6977	0.0000	-0.9902
		>50km	0.7286	0.0000	0.0000	0.0000	-0.7286
Madurai	Trip Purpose	Business Trips	0.2612	0.0000	0.1221	-0.0901	-0.2933
		Commute Trips	0.0000	0.1137	0.2365	-0.1062	-0.2439
		Leisure Trips	0.1523	0.0650	-0.0246	0.0055	-0.1982
	Gender	female	0.0093	-0.0186	0.0671	-0.1894	0.1316
	Age	15-30	0.1334	0.0303	-0.2042	-0.1324	0.1729
		30-50	0.1526	0.0718	-0.2363	-0.0259	0.0378
		50-70	0.0393	0.1720	-0.1417	-0.1649	0.0953
		>70	0.0000	0.0000	0.1382	-0.5500	0.4118
	Travel Distance	1-5km	0.0192	0.1538	0.1154	0.5385	-0.8269
		5-10km	0.1548	0.0357	0.2857	0.5238	-1.0000
		10-20km	0.1429	0.0000	0.4857	0.3714	-1.0000
		20-30km	1.0000	0.0000	0.0000	0.0000	-1.0000
		30-50km	0.0000	0.0000	0.6000	0.4000	-1.0000
		>50km	0.4997	0.0000	0.0000	0.0000	-0.4997

Inferences
- From this model, it can be observed that, due to change in purpose there is a significant difference in probability of choosing each modes.
- With increase in travel distance the probability of choosing car and public transport increases gradually, whereas probability of choosing walk is decreased.
- For both cities, the result shows that there are few similarities and variations in terms of mode choice probability.

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

6

Seal and Signature:

Marginal Effects

Marginal Effects of Purpose Oriented Model

Purpose	Region	Mode of Transport	Weather			Gender	Travel Distance						Age			
			Sunny	Rainy	Windy	Female	1-5km	5-10km	10-20km	20-30km	30-50km	>50km	15-30	30-50	50-70	>70
Business	Coimbatore	Cancelled Trips	-0.033	0.098	-0.049	0.011	0.060	0.034	0.062	0.000	0.145			0.039	0.122	
		Car	0.131	0.164	0.066	-0.059	0.245	0.462	0.000	0.583	0.000			-0.189	0.189	
		Public Transport	0.016	0.098	0.033	0.231	0.095	0.024	0.601	-0.123	0.732			-0.029	-0.186	
		Two Wheeler	-0.115	-0.344	-0.049	-0.236	0.477	0.347	0.214	0.417	0.000			0.144	-0.151	
	Madurai	Cancelled Trips	0.091	0.318	0.023	0.092		-0.090	-0.177	-0.220	-0.220	-0.220	0.141	0.054	0.313	
		Car	0.136	0.068	0.023	0.108		0.305	0.503	1.000	0.000	0.000	0.453	0.359	0.000	
		Public Transport	-0.045	-0.023	-0.023	0.029		0.216	0.312	0.000	1.000	1.000	-0.797	-0.826	-0.313	
		Two Wheeler	-0.205	-0.364	-0.023	-0.219		-0.442	-0.639	-0.780	-0.780	-0.780	0.203	0.402	0.000	
Commute Trips	Coimbatore	Cancelled Trips	0.038	0.151	0.000	-0.029	-0.027	-0.023	0.048				0.035	0.008	0.205	
		Car	0.000	0.094	0.000	-0.005	0.000	0.018	0.032				0.000	0.065	0.000	
		Cycle	-0.038	-0.094	0.000	-0.112	0.184	0.031	0.000				0.000	0.000	0.198	
		Public Transport	0.019	0.113	0.000	0.083	0.079	0.580	0.446				-0.547	-0.521	-0.623	
		Two Wheeler	-0.019	-0.245	0.000	0.066	0.408	0.332	0.412				0.444	0.448	0.104	
	Madurai	Cancelled Trips	0.015	0.308	0.046	0.041		-0.103	-0.181		-0.181		0.166	0.056	0.130	0.177
		Car	0.046	0.031	0.000	0.103		0.056	-0.033		-0.033		0.030	-0.017	0.032	0.048
		Cycle	0.000	-0.092	-0.015	-0.076		-0.090	-0.159		-0.159		0.081	0.086	0.079	0.208
		Public Transport	0.062	0.138	0.000	0.211		0.167	0.771		0.624		-0.352	-0.184	-0.492	-0.233
		Two Wheeler	-0.108	-0.323	0.000	-0.342		0.026	-0.341		-0.196		0.124	0.161	0.376	-0.189
Leisure Trips	Coimbatore	Cancelled Trips	0.154	0.641	-0.090	-0.059	0.076	0.120	-0.131		-0.042	0.042	-0.520	-0.432	-0.317	-0.031
		Car	-0.013	-0.039	0.013	0.011	0.069	0.118	0.304		0.750	0.667	0.147	0.183	0.000	0.000
		Cycle	-0.026	-0.051	-0.026	-0.041	0.049	0.000	0.018		0.000	0.000	-0.035	-0.163	-0.167	-0.167
		Public Transport	-0.026	-0.026	0.000	-0.033	-0.382	-0.370	-0.458		-0.458	-0.458	0.052	-0.064	0.036	-0.086
		Two Wheeler	-0.064	-0.487	0.077	0.086	0.417	0.382	0.518		0.000	0.000	0.334	0.395	0.431	0.275
	Madurai	Cancelled Trips	0.379	0.697	0.136	0.146		-0.411	-0.529	-0.715		-0.807	-0.257	-0.235	-0.142	0.257
		Car	0.076	0.076	0.015	-0.026		0.060	0.200	0.291		0.000	0.172	0.219	0.037	0.000
		Cycle	-0.030	-0.076	-0.015	0.040		0.096	0.000	0.000		0.000	0.000	0.021	0.184	0.000
		Public Transport	0.000	-0.030	0.000	-0.031		0.066	0.146	0.079		0.970	0.156	0.185	0.037	0.000
		Two Wheeler	-0.348	-0.591	-0.091	-0.118		0.345	0.368	0.516		0.000	-0.071	-0.189	-0.206	-0.507
Social Visit	Coimbatore	Cancelled Trips	0.154	0.385	-0.077	0.107	-0.250	-0.292	-0.438				0.115	0.282	0.317	
		Car	0.077	0.077	0.000	-0.232	0.750	0.583	0.375				0.612	0.370	-0.067	
		Two Wheeler	-0.154	-0.385	0.077	0.042	0.000	0.208	0.562				-0.772	-0.684	-0.249	
	Madurai	Cancelled Trips	0.417	0.583	0.250	0.146	-0.646	-0.250	-0.708					-0.562	-0.354	
		Car	0.083	0.083	0.000	0.000	0.125	0.000	0.000					0.347	0.024	
		Public Transport	-0.250	-0.250	-0.083	0.208	-0.028	0.389	-0.111					0.042	0.034	
		Two Wheeler	-0.250	-0.417	-0.167	-0.354	0.549	-0.139	0.819					0.173	0.296	

योजना एवं वास्तुकला विद्यालय, भोपाल
राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार
School of Planning and Architecture, Bhopal
An Institute of National Importance, Ministry of Education, Government of India

IMPACT OF WEATHER ON MODE CHOICE

Name: V VIMAL
Scholar no. 2022MTPLM015
MTPLM, Batch- 2022-24
Dept. of Transport Planning, SPA Bhopal

7

Seal and Signature:

Recommendations

Inferences

- The above model illustrates that, during rainy days individuals making leisure trips tend to cancel their trips the most(C 0.641, M 0.7), next to it social visit and business trips has the least probability of cancelling their trips (C- 0.098, M- 0.318).
- The probability of choosing public transportation is always higher in rainy days when compared with other two weather condition, Whereas two wheeler always shows negative impact during rainy days.
- Public transportation and private cars are the most preferred modes of transportation during extreme temperature and precipitation for business and commute trips. It always shows the positive effect for both the cities. In case of leisure and social visit, the result shows negative effect on these two modes.
- Usage of two- wheelers and bicycle's appears to have negative impact for all the extreme weather condition regardless of it travel purpose.

Challenges

- Extreme weather conditions such as heavy rainfall, high temperature poses safety risks for daily commuters, especially for non- motorized transport.
- Adverse weather events, such as heavy rain or storms, disrupts the public transport services, leading to delays, cancellations, and reduced service frequency. This affects commuters who rely on public transit for their daily travel needs, potentially causing inconvenience, longer travel times, and disruptions to work and other activities.
- During the periods of heavy rain and extreme heat, some commuters chooses private cars over other modes which leads to congestion on roads and decreases the efficiency of the transportation network.
- Poor weather conditions creates accessibility challenge for elderly people and those who live far from the bus stop.

Recommendations

Weather Informed Transportation Strategies →	To Develop weather-responsive transportation strategies that consider the impact of weather conditions on mode choice.
Promotion of Weather-Resilient Modes →	Encourage the adoption of weather-resilient transportation modes such as walking, cycling, and public transport by highlighting their reliability and suitability across various weather conditions. This could involve investing in pedestrian and cycling infrastructure, improving public transport accessibility, and providing weather-specific travel advisories.
Infrastructure Investments →	Allocate resources for infrastructure investments aimed at enhancing the safety and convenience of non-motorized modes of transportation, particularly during adverse weather conditions. This may include constructing covered walkways, bike lanes, and shelters at public transport stops.
Integration of Weather Data in Transportation Planning →	Integrate weather data and forecasts into transportation planning processes to anticipate and mitigate the effects of weather on mode choice. Collaborate with meteorological agencies to develop real-time weather monitoring systems and decision support tools for transportation planners and operators.

Conclusion

- Contextual intervention are required to incorporate in the framework, as the common framework cannot be used in the different system.
- Change of weather is actually influencing to commuters or users to shift from one mode to other mode with respect to travel purpose in different climatic zones.

योजना एवं वास्तुकला विद्यालय, भोपाल राष्ट्रीय महत्व का संस्थान, शिक्षा मंत्रालय, भारत सरकार School of Planning and Architecture, Bhopal An Institute of National Importance, Ministry of Education, Government of India	**IMPACT OF WEATHER ON MODE CHOICE**	Name: V VIMAL Scholar no. 2022MTPLM015 MTPLM, Batch- 2022-24 Dept. of Transport Planning, SPA Bhopal	**8** Seal and Signature:

Acknowledgements.pdf

ORIGINALITY REPORT

8%	7%	5%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ncbi.nlm.nih.gov Internet Source	1 %
2	www2.mdpi.com Internet Source	1 %
3	www.hindawi.com Internet Source	1 %
4	Chengxi Liu, Yusak O. Susilo, Anders Karlström. "The influence of weather characteristics variability on individual's travel mode choice in different seasons and regions in Sweden", Transport Policy, 2015 Publication	<1 %
5	econpapers.repec.org Internet Source	<1 %
6	Lu Ma, Hui Xiong, Zhong Wang, Kaiqiang Xie. "Impact of weather conditions on middle school students' commute mode choices: Empirical findings from Beijing, China", Transportation Research Part D: Transport and Environment, 2018 Publication	<1 %

7	Saneinejad, S.. "Modelling the impact of weather conditions on active transportation travel behaviour", Transportation Research Part D, 201203 Publication	<1 %
8	Submitted to University of Sheffield Student Paper	<1 %
9	mdpi-res.com Internet Source	<1 %
10	abtxtravels.com Internet Source	<1 %
11	oai.repec.org Internet Source	<1 %
12	text-id.123dok.com Internet Source	<1 %
13	timesofindia.indiatimes.com Internet Source	<1 %
14	www.tandfonline.com Internet Source	<1 %
15	Xiaowei Li, Qiangqiang Ma, Wenbo Wang, Baojie Wang. "Influence of Weather Conditions on the Intercity Travel Mode Choice: A Case of Xi'an", Computational Intelligence and Neuroscience, 2021 Publication	<1 %

16	fastercapital.com Internet Source	<1%
17	library.cept.ac.in Internet Source	<1%
18	noexperiencenecessarybook.com Internet Source	<1%
19	pearl.plymouth.ac.uk Internet Source	<1%
20	scholarcommons.usf.edu Internet Source	<1%
21	Jingwen Wu, Hua Liao. "Weather, travel mode choice, and impacts on subway ridership in Beijing", Transportation Research Part A: Policy and Practice, 2020 Publication	<1%
22	Singhal, Abhishek, Camille Kamga, and Anil Yazici. "Impact of weather on urban transit ridership", Transportation Research Part A Policy and Practice, 2014. Publication	<1%
23	Johnson STANLEY. "Baseline toxicity of emamectin and spinosad to *Helicoverpa armigera* (Lepidoptera: Noctuidae) for resistance monitoring", Entomological Research, 09/2009 Publication	<1%

24	Resilient Cities, 2011. Publication	<1%
25	Submitted to University of Hong Kong Student Paper	<1%
26	www.iso-ne.com Internet Source	<1%
27	Submitted to University of Hertfordshire Student Paper	<1%
28	elib.dlr.de Internet Source	<1%
29	Nanda Kaji Budhathoki, Kerstin K. Zander. "Nepalese farmers’ climate change perceptions, reality and farming strategies", Climate and Development, 2019 Publication	<1%
30	Submitted to University of Bradford Student Paper	<1%
31	gupea.ub.gu.se Internet Source	<1%
32	www.coursehero.com Internet Source	<1%
33	www.mdpi.com Internet Source	<1%
34	www.mlit.go.jp Internet Source	<1%

35	Submitted to University of Cincinnati Student Paper	<1%
36	eprints.qut.edu.au Internet Source	<1%
37	pure.tue.nl Internet Source	<1%
38	www.newvision.co.ug Internet Source	<1%
39	www.thersa.org Internet Source	<1%
40	www.theseus.fi Internet Source	<1%

Exclude quotes	On	Exclude matches	< 10 words
Exclude bibliography	On		