Avinash Kumar

Role of Traffic and land-use on Driver' s Behavior

May 2024

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Master of Planning (Transport Planning and Logistics Management)

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Declaration

I **Avinash Kumar**, Scholar No. **2022MTPLM016** hereby declare that the thesis titled **"Role of Traffic and land-use on Driver's Behavior"** submitted by me in partial fulfillment for the award of **Master of Planning**, 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 **Avinash Kumar** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

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Signature of the Guide
Dr. Kshama Puntambekar

ACCEPTED

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Dr. Saurabh Popli
Head, Department of Transport Planning

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Abstract

Driving can be seen as a purposeful action aimed at reaching a destination. The primary goals of driving include arriving on time and ensuring safety. When these goals are hindered, emotions may arise, potentially influencing behavioral adjustments. Any obstruction to achieving these goals tends to elicit negative effects, whereas facilitating goal-directed behavior typically fosters positive outcomes.

Bhopal was chosen due to its diverse urban layout, encompassing a mix of planned and unplanned city forms, which significantly influence traffic dynamics and driver conduct. By analyzing variables such as age, gender, marital status, education, and driving experience, researchers uncovered distinct patterns in driver behavior across different urban zones. Notably, areas transitioning between planned and unplanned development exhibit higher rates of risky, aggressive, and negligent driving behaviors. Conversely, drivers in fully planned areas tend to demonstrate increased adherence to traffic rules, albeit with occasional tendencies towards violations.

The research employed a multifaceted approach combining surveys and statistical analysis to comprehensively assess driver behavior in Bhopal city. Surveys provided insights into demographic factors influencing driving habits, such as age, gender, marital status, education, and driving experience. Statistical analysis was utilized to identify significant correlations, such as between gender and marital status with critical driving behaviors and driving experience with aggressive driving tendencies. These findings underscore the complexity of driver behavior as influenced by both personal characteristics and environmental factors, necessitating nuanced strategies for enhancing road safety.

The research underscores the critical need for targeted interventions aimed at mitigating hazardous driving practices and promoting safer behaviors among Bhopal's motorists. By understanding the intricate relationship between urban form, demographic attributes, and driving conduct, policymakers can tailor interventions that address specific risk factors prevalent in different city sectors. Implementing effective traffic management strategies, educational campaigns, and enforcement measures emerges as imperative to curbing traffic incidents and fostering a safer driving culture citywide. Ultimately, the research advocates for a holistic approach to road safety that integrates urban planning considerations with behavioral insights to achieve lasting improvements in traffic management and public safety outcomes.

सारांश

गाड़ी चलाना एक उद्देश्यपूर्ण क्रिया के रूप में देखा जा सकता है जिसका लक्ष्य किसी गंतव्य तक पहुँचना होता है। गाड़ी चलाने के मुख्य उद्देश्यों में समय पर पहुँचना और सुरक्षा सुनिश्चित करना शामिल है। जब इन उद्देश्यों में बाधाएँ आती हैं, तो भावनाएँ उत्पन्न हो सकती हैं, जो व्यवहारिक समायोजन पर प्रभाव डाल सकती हैं। इन उद्देश्यों को हासिल करने में किसी भी बाधा का असर सामान्यत: नकारात्मक प्रभाव डालता है, जबकि उद्देश्य-निर्दिष्ट व्यवहार पर कुशल परिणामों को बढ़ावा देता है।

भोपाल को उसकी विविध शहरी अवस्था के कारण चुना गया था, जिसमें नियोजित और अनियोजित शहरी रूपों का मिश्रण है, जो यातायात गतिविधियों और ड्राइवर के व्यवहार पर महत्वपूर्ण प्रभाव डालते हैं। आयु, लिंग, वैवाहिक स्थिति, शिक्षा और ड्राइविंग अनुभव जैसे परिमाणों का विश्लेषण करके शोधकर्ताओं ने विभिन्न शहरी क्षेत्रों में ड्राइवर के व्यवहार में विशिष्ट पैटर्न्स पता लगाए। विशेष रूप से, योजनाबद्ध और अनयोजित विकास के बीच के क्षेत्रों में जोखिमपूर्ण, प्रगट्भवय, और अनावश्यक गाड़ी चलाने के व्यवहारों की अधिक दरें होती हैं। उल्टी घटी, पूरी योजनाबद्ध क्षेत्रों में ड्राइवर यातायात नियमों का अधिक पालन करने के प्रवृत्त होते हैं, हालांकि अनौपचारिक उल्लंघनों के साथ-साथ।

शोध ने भोपाल शहर में ड्राइवर के व्यवहार का व्यापक आकलन करने के लिए सर्वेक्षण और सांख्यिकीय विश्लेषण का एक बहुपक्षीय दृष्टिकोण अपनाया। सर्वेक्षण ने जनसांख्यिकीय कारकों के बारे में प्राप्तियां प्रदान की, जैसे कि आयु, लिंग, वैवाहिक स्थिति, शिक्षा, और ड्राइविंग अनुभव। सांख्यिकीय विश्लेषण का उपयोग महत्वपूर्ण संबंधों की पहचान के लिए किया गया, जैसे कि लिंग और वैवाहिक स्थिति के साथ महत्वपूर्ण ड्राइविंग व्यवहारों के बीच, और ड्राइविंग अनुभव के साथ प्रगटभवय ड्राइविंग की प्रवृत्तियों के बीच। ये फिंडिंग्स ड्राइवर के व्यवहार की जटिलता को दर्शाते हैं जिसे व्यक्तिगत गुणस्तर और पर्यावरणीय कारकों द्वारा प्रभावित किया जाता है, जिससे सड़क सुरक्षा को बढ़ावा देने के लिए सूक्ष्म रणनीतियाँ आवश्यक होती हैं।

शोध महत्वपूर्ण आवश्यकता को प्रमुखता देता है कि उन्हें भोपाल के मोटरचालकों के बीच खतरनाक ड्राइविंग अभ्यासों को कम करने और सुरक्षित व्यवहारों को बढ़ावा देने के लिए लक्षित हस्तक्षेपों की आवश्यकता है। शहरी रूप, जनसांख्यिकीय विशेषताएँ, और ड्राइविंग व्यवहार के बीच का जटिल संबंध समझकर, नीति निर्माता उन्हें ऐसे हस्तक्षेप तैयार कर सकते हैं जो शहर के विभिन्न क्षेत्रों में मौजूद विशेष जोखिम कारकों पर प्रभावी हों। यातायात प्रबंधन रणनीतियों, शैक्षिक प्रचारणा, और प्रवर्तन उपायों को कारगर बनाने का काम महत्वपूर्ण सिद्ध होता है, जिससे यातायात हादसों को कम किया जा सके और पूरे

शहर में एक सुरक्षित ड्राइविंग संस्कृति को बढ़ावा मिल सके। अंततः, शोध रोड सुरक्षा के प्रति एक समग्र दृष्टिकोण की प्रशंसा करता है जो शहरी योजना के विचारों को व्यवहारिक अंतर्दृष्टि के साथ एकजुट करता है, ताकि यातायात प्रबंधन और सार्वजनिक सुरक्षा परिणामों में स्थायी सुधार हो सके।

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Abbreviations

RTA Road traffic accidents
WHO World Health Organization
WHA World Health Assembly
DBQ Driver Behavior Questionnaire
PCA Principal component analysis
SPSS Statistical Package for Social Sciences
GOB Goal-oriented behavior
ADAS Advanced Driver Assistance Systems
EEG Electroencephalogram
ADS Aggressive Driving Scale
GPS Global Positioning System
NDD Naturalistic driving data
KMO Kaiser-Meyer-Olkin

CHAPTER 1: INTRODUCTION AND CONTEXTUAL BACKGROUND

1.1 Introduction

Road Traffic Accidents (RTAs) are a big problem all over the world. They hurt a lot of people, mess up cities, and make it hard for people to get around. In the future, more and more people will live in cities, which will make the problem even worse. Even though people have been studying and trying to fix road accidents for a long time, they're still happening a lot.

There are a bunch of things that cause road accidents, and they're not always simple. Sometimes it's because of how people drive. They might be distracted, tired, or just not paying attention. Other times, it's because of the roads themselves. Maybe they don't have enough signs or they're too narrow. And sometimes, it's because of the rules and laws that are supposed to keep people safe. Maybe they're not strict enough, or people don't follow them like they should.

One of the big things needed to think about is how many people are going to be living in cities in the future. Right now, about half of the world's population lives in cities, but by 2050, it's going to be more like 70% (WHO). That's a lot of people, and it's going to put a lot of pressure on our roads and transportation systems. If we don't do something to make our roads safer now, it's only going to get worse as more people move to cities.

1.2 Historical Context and Recognition of RTAs

The issue of RTAs has been a concern for decades, stretching back to the middle of the 20th century. Efforts to understand why they happen and how to prevent them began during this time. In 1962, the World Health Organization (WHO) released a report that delved into the various reasons behind RTAs.

Following the WHO report, in 1974, the World Health Assembly (WHA) took an official stance on RTAs. They recognized these accidents as a significant threat to public health on a global scale. This recognition was an important step in bringing attention to the seriousness of the issue and the urgent need for action. Despite these early efforts to address the problem, road accidents continue to

have devastating consequences, claiming millions of lives and causing injuries worldwide every year. The persistence of this issue highlights the complexity of the challenges involved in reducing RTAs and their impact.

Over the years, numerous factors have been identified as contributing to the occurrence of road accidents. These include human behaviors such as distracted driving, speeding, and driving under the influence of alcohol or drugs. Additionally, factors like inadequate road infrastructure, poor vehicle maintenance, and ineffective enforcement of traffic laws also play significant roles in the prevalence of RTAs.

One of the key challenges in addressing road accidents is the multifaceted nature of their causes. There is no single solution that can effectively eliminate all accidents. Instead, a comprehensive approach is needed, addressing various aspects such as driver behavior, road design, vehicle safety standards, and enforcement of traffic regulations.

Furthermore, the impact of road accidents extends beyond the immediate loss of life and injuries. These accidents also impose significant economic costs, including medical expenses, property damage, and lost productivity. Moreover, they can have long-term social and psychological effects on individuals and communities affected by them.

1.3 Global Impact and Epidemiology of RTAs:

RTAs have wide-ranging consequences, affecting public health, urban development, and economic productivity. Globally, approximately 1.2 million lives are lost annually due to RTAs, with an additional 50 million people sustaining injuries (global toll of road traffic accidents). These incidents result in substantial social and economic costs, including medical expenses, lost productivity, and psychological trauma. Moreover, vulnerable road users such as pedestrians, cyclists, and motorcyclists are disproportionately affected by RTAs, underscoring the need for targeted interventions to protect these groups.

The aftermath of RTAs extends beyond immediate casualties to impact various facets of society. Medical costs associated with treating injuries can burden individuals and families, while the loss of income due to injuries can exacerbate financial strain. Furthermore, disruptions to transportation networks caused by accidents can hinder economic productivity by impeding the flow of goods and

services. Vulnerable road users face heightened risks on the road due to their exposure to traffic and lack of protective barriers.

1.4 Understanding Driver Behavior:

Driving behavior encompasses a complex blend of cognitive, emotional, and behavioral elements that profoundly influence road safety. Research indicates that a significant majority, 94%, of road crashes result from driver behavior, underscoring the critical need to explore the motivations behind these actions. From minor oversights like failing to check blind spots to more severe issues such as speeding and aggressive driving, each behavior contributes to the frequency and severity of accidents (WHO). Distractions, whether from smartphones or external stimuli, divert attention from the road, increasing the likelihood of errors. Fatigue also impairs reaction times, heightening the risk of accidents. Moreover, aggressive driving not only endangers the driver but also jeopardizes the safety of others on the road. Personal factors such as age, experience, and gender further shape driving behaviors, with younger drivers often taking more risks due to their inexperience, and men exhibiting higher levels of aggression compared to women.

Understanding and studying driver behavior are paramount due to its profound impact on road safety, efficiency, and environmental sustainability. Globally, road traffic accidents claim approximately 1.35 million lives annually, according to the World Health Organization (WHO). In the United States alone, 38,824 traffic fatalities were reported in 2019 by the National Highway Traffic Safety Administration (NHTSA). Distracted driving plays a significant role in these statistics, contributing to about 8 deaths and over 1,000 injuries daily in the U.S., as reported by the CDC. Speeding, another prevalent behavior, was a factor in 26% of all traffic fatalities in 2019, according to NHTSA data. These behaviors not only pose risks to human lives but also impact environmental sustainability, with transportation accounting for approximately 28% of greenhouse gas emissions in the U.S. (EPA).

Addressing these behaviors through informed insights is crucial for developing effective policies, improving infrastructure, and advancing technologies aimed at

creating safer and more sustainable transportation systems globally. By delving into the complexities of driver behavior, we can strive towards reducing accidents, saving lives, and minimizing the environmental footprint of transportation networks.

1.5 Chapterization:

Chapter 1: INTRODUCTION AND CONTEXTUAL BACKGROUND

This chapter organizes the content into logical sections based on the themes and information provided, ensuring a structured approach to comprehensively understand the issue of road traffic accidents. It covers the evolution of awareness and policy responses, as well as the epidemiology, consequences, and understanding of driver behavior.

Chapter 2: LITERATURE REVIEW

In this chapter, case studies and research papers were reviewed on the selected theme. This review will further contribute to shaping the research aims, objectives, methodology, and methods of analysis.

Chapter 3: RESEARCH DESIGN

This chapter serves as a roadmap for investigating how drivers' behavior affects traffic. It begins by delineating the study's overarching aim, specific objectives, and methodology. Subsequently, the chapter explores the research's scope, potential limitations, and expected outcomes.

Chapter 4: STUDY AREA

This section details the characteristics and challenges of Bhopal, highlighting specific areas like Arera Colony, Jahangirabad, and Subhash Nagar, focusing on their distinct spatial dynamics and their influence on driver behavior and traffic patterns, emphasizing the comprehensive data collection necessary to analyze these factors effectively.

Chapter 5: Data Collection and Analysis

This chapter encapsulates the essential components of the study, including data collection methodologies, demographic analysis, and findings of driver behavior as assessed by the Driver Behavior Questionnaire (DBQ).

Chapter 6: Data Collection and Analysis

This chapter discuss the findings and highlights distinct driving behavior across urban locales: Subhash Nagar shows dangerous driving tendencies, Jahangirabad exhibits moderate inclinations, and Arera Colony displays frequent violations. Demographic factors like gender and marital status influence driving behavior more than age. Tailored traffic management and educational campaigns are crucial for promoting road safety in varied urban environments.

CHAPTER 2: LITERATURE REVIEW

Literature reviews were chosen to understand the behavior of drivers under various conditions and traffic characteristics, examining their relationship to different local environments such as intersections, low-volume freeways, post-congestion behavior, and gap acceptance. These reviews provide a comprehensive examination of existing studies and findings related to driver behavior in specific traffic scenarios. They analyze how drivers react and adapt to different road conditions, traffic densities, and infrastructure layouts. For instance, at intersections, studies may explore factors influencing driver decision-making, such as signal timing, visibility, and presence of pedestrians or cyclists. On low-volume freeways, researchers might investigate driver speed variations, lane-changing behaviors, and adherence to speed limits. Post-congestion behavior studies could focus on how drivers adjust their driving habits after encountering traffic jams or delays, including changes in speed, lane usage, and risk-taking behaviors. Gap acceptance studies delve into the psychology behind drivers' decisions to merge into traffic flow, considering factors like vehicle speed differentials, gap size perception, and driver confidence levels. By synthesizing findings from these diverse areas, literature reviews contribute to a deeper understanding of driver behavior across different local environments, informing strategies for improving traffic management, safety measures, and urban planning initiatives.

2.1 Studies of Driver Behaviors and Traffic Flow Characteristics at Roadway Intersections. Qiang Yang (2012).

Intersections and driveway access points are crucial components of road networks, impacting both efficiency and safety. Understanding driver behavior and traffic flow at these locations is intricate but essential for effective design and management. To address these challenges and provide guidance to engineers, a series of studies were undertaken.

In a study conducted by Amer, A., Rakha, H., El-Shawarby, I., 2010 in China, researchers examined the effects of countdown timers on driver behavior. They discovered that the presence of these timers could lead to behaviors such as

running yellow lights and late entries into intersections, highlighting the need for careful consideration of timer implementation.

Another study by Awadallah, F., 2009, proposed a phase gradient method for studying driver behavior and traffic characteristics at signalized intersections. This method was applied in a case study on red-light cameras in Knoxville, TN. By analysing the data collected, researchers gained insights into the effectiveness of red-light cameras in improving intersection safety and reducing violations.

Legal issues and arguments surrounding the use of red-light cameras for profit generation were explored in a separate study. This investigation delved into various engineering measures, particularly those related to traffic signal settings that could be employed to catch red-light runners and increase revenue from camera systems. The study emphasized the importance of ethical considerations in the implementation of such measures.

Additionally, an experiment was conducted by Dixon, K.K., Hibbard, J.L., Nyman, H., 2000 to simulate right-turn issues impacting safety and operational efficiency at intersections and driveway access points. By studying geometric parameters such as angle-of-turn and tangent, researchers assessed their influence on driver behavior and traffic flow characteristics. This research provided valuable insights into optimizing intersection design to mitigate potential risks associated with right-turn movements.

Collectively, these studies contribute to a better understanding of driver behavior and traffic dynamics at intersections and driveway access points. By uncovering the impacts of various factors such as countdown timers, red-light cameras, and geometric parameters, engineers can make informed decisions to enhance the safety and efficiency of road networks. Moreover, insights from these studies can inform the development of policies and practices aimed at improving traffic management and reducing accidents at critical points along roadways.

2.2 Analysis of the Driver's Behavior Characteristics in Low-Volume Freeway Interchange. Ronghua Wang, Jiangbi Hu (2016).

This paper investigates the significance of understanding driver behavior characteristics in designing freeway interchange facilities to enhance traffic safety. The study, conducted on Qingyin Expressway, selected four interchanges

with relatively low traffic volume, spanning from location 1 to location 2. Twelve qualified drivers, comprising six-car test drivers and six truck test drivers, participated in the experiment, adhering to a designated driving program.

Data collection involved the use of GPS and eye-tracking instruments to record parameters such as running speed, real-time tracking, and fixation points, among others. The analysis included employing box-plot graphs and Student's t-test to scrutinize the drivers' fixation on exit guide signs across the 12 datasets. Additionally, speed-distance curves were plotted for 11 effective datasets to evaluate driver behavior in diverging and merging areas.

Drivers typically recognize exit direction signs within an advanced distance of 170m–180m. The diverging influence area extends up to 1000m upstream of the diverging point, while the merging influence area spans 350m downstream of the merge point. It is recommended to place a NO OVERTAKING sign approximately 350m upstream of the diverging point.

These findings offer valuable guidance for the design and management of freeway interchange facilities, aiming to enhance traffic safety. Understanding when drivers typically recognize exit direction signs, the extent of influence areas in diverging and merging sections, and the optimal placement of signage such as the NO OVERTAKING sign are crucial considerations for designers and managers.

In conclusion, this study underscores the importance of incorporating driver behavior characteristics into freeway interchange design. By doing so, designers and managers can make informed decisions to create more effective and safer interchange facilities, ultimately contributing to improved traffic safety on expressways.

2.3 Methods for Analysis of Naturalistic Driving Data in Driver Behavior Research. JONAS BÄRGMAN (2016).

In recent years, there has been a notable shift in traffic safety research, especially within the automotive industry. Instead of solely focusing on reducing injuries after a crash occurs, the emphasis has moved toward preventing crashes altogether or lessening their impact. This shift encompasses various pre-crash safety measures, including the development of intelligent safety systems, the improvement of road infrastructure, the promotion of safer driving behaviors, and

the implementation of new policies. Central to the effectiveness of these measures is a deep understanding of driver behavior.

Understanding how drivers behave on the road is crucial for developing and evaluating pre-crash safety measures. Naturalistic driving data (NDD) has emerged as a valuable tool in this regard, providing insights into the causes of crashes and aiding in the assessment of safety interventions. However, the complexity of NDD presents challenges that require innovative methods to fully utilize its potential.

This thesis, along with its accompanying papers, aims to address several gaps in current knowledge by introducing novel approaches to analyzing NDD across various aspects of pre-crash safety measure development.

One such approach is the introduction of the "chunking" method, which helps identify and correct common biases when analysing everyday driving data. Additionally, a new method based on expert assessment of crash causation offers a unique perspective on understanding why crashes happen by analysing NDD alongside video footage.

Moreover, the thesis highlights the importance of using counterfactual simulations to improve product and prototype development. It emphasizes the need to choose appropriate models of driver behavior, as this can significantly impact the effectiveness of safety interventions and vehicle design.

The study also explores how specific driver behaviors, such as distractions or interactions with the vehicle, affect safety on the road. By combining analyses of where drivers are looking and what the vehicle is doing before a crash, researchers gain deeper insights into the factors contributing to crash risk.

In summary, these new methods contribute to advancing our understanding of pre-crash safety measures by harnessing the potential of NDD. By leveraging this data, researchers can better comprehend driver behavior and the causes of crashes, ultimately leading to more effective safety interventions. This progress is vital for achieving the goal of zero crashes, a cornerstone of Sweden's Vision Zero initiative, and ensuring safer roads for all.

2.4 A Survey on Modelling of Driver Behavior for Tier II City of India. Parag M. Dhoble, Bhalchandra khode (2016).

Driving behavior is closely linked to traffic and is a significant factor in ensuring human safety on the roads. In today's fast-paced life, everyone is in a rush to reach their destinations, be it the office, college, or elsewhere. However, driving behaviors can vary depending on different conditions and situations.

Human factors that influence driving behavior include Excitement Sensation Seeking, Impulsiveness, Extraversion, and Driving Anger. Additionally, vehicle characteristics such as Braking and Deceleration capabilities, Low-speed and High-speed turning characteristics, Acceleration, Size, and Weight also play a role in driving behavior.

Unfortunately, in their haste to reach their destinations quickly, people often resort to driving at high speeds and disregard traffic rules. This reckless behavior frequently leads to road accidents and jeopardizes the safety of everyone on the road.

Data for this study was collected from a selected site located 15 meters from Hingna RBI Square in Nagpur. Video graphic methods were employed for data collection during both peak and off-peak hours. Important parameters such as rule violations and spot speed determination were considered in this project.

Driver behavior is a major contributing factor to road accidents. To address this issue effectively, it is essential to develop evaluation and prediction models for driving behavior. By understanding and predicting how drivers behave on the road, we can take proactive measures to prevent accidents and ensure safer roads for everyone.

2.5 Gap acceptance behavior of drivers at uncontrolled T-intersections under mixed traffic conditions. Manish Dutta, Mokaddes Ali Ahmed (2017).

This study focused on intersections where there are no traffic signals, known as uncontrolled intersections, which are more prone to accidents because drivers have to navigate without explicit instructions. In countries like India, drivers often fail to yield to oncoming traffic at these intersections, leading to an increase in collisions. The study aimed to understand and model the behavior of drivers at uncontrolled T-intersections, particularly focusing on their tendency towards aggressive behavior. Specifically, it examined how drivers on minor streets

decide when to enter the intersection, considering factors like the duration of available gaps and the drivers' aggressiveness.

Three intersections in the northeast region of India were chosen as case studies to gather data on driver behavior. Initial analysis revealed that aggressive driving behavior was not solely attributed to long waits at stop lines but rather stemmed from a general disregard for traffic regulations.

To understand and predict driver behavior, the study developed binary logit models for vehicles turning right from minor roads. These models considered various factors influencing gap acceptance behavior, including the duration of available gaps, the time it took for the road to clear, and the drivers' level of aggression. By analyzing these factors, the study aimed to estimate critical gaps, which represent the minimum gap size required for a driver to safely turn onto the busier road. The study found that considering clearing time and driver aggression led to more accurate estimates of critical gaps. By incorporating these factors into the models, researchers could better predict when drivers would choose to enter the intersection, thus improving the understanding of gap acceptance behavior. Additionally, the study compared critical gap estimates obtained from the developed models with those derived from existing methods based solely on clearing behavior. The results demonstrated that considering factors like clearing time and driver aggression resulted in more realistic estimates of critical gaps, highlighting the importance of accounting for these variables in intersection operational analysis and capacity estimates.

Overall, the study aimed to contribute to the improvement of intersection safety by providing insights into driver behavior at uncontrolled intersections. By understanding the factors influencing gap acceptance behavior and accurately estimating critical gaps, transportation planners and engineers can develop strategies to enhance intersection design and reduce the likelihood of accidents.

2.6 Driver Behavior as Road Safety Indicator– A Case Study of Gorakhpur, Uttar Pradesh, India. Ashutosh Gupta, A. K. Mishra (2020).

Driving serves as a means to reach destinations promptly and safely, but disruptions to this purpose can trigger emotional responses that influence behavior. This study delves into the driving habits of individuals in Gorakhpur

district, Uttar Pradesh, India, using the Driver Behavior Questionnaire to explore their connection with road accidents.

Surveying 391 drivers, the study uncovered that 12.4% are prone to making errors while driving, and 8.9% exhibit critical driving behaviors. These behaviors pose significant risks to other road users, highlighting the potential consequences of deviations from safe driving practices. Notably, the study observed correlations between these behaviors and gender.

While the percentages of drivers engaging in aggressive or ordinary violations were relatively low, the study underscores the paramount importance of road safety. It emphasizes that even small percentages of individuals displaying risky driving behaviors can have serious implications, particularly considering the frequency with which they utilize roads for various purposes, including work and social obligations.

The findings shed light on the complex interplay between driving behavior and road safety, emphasizing the need for ongoing efforts to promote responsible driving practices. By understanding the factors influencing driving behavior and their implications for road safety, policymakers and stakeholders can implement targeted interventions to mitigate risks and enhance overall road safety.

In summary, the study provides valuable insights into the prevalence of different driving behaviors among individuals in Gorakhpur district, Uttar Pradesh, India, and their association with road accidents. It underscores the imperative of prioritizing road safety initiatives to address risky driving behaviors and create safer environments for all road users.

2.7 Influence of traffic congestion on driver behavior in post-congestion driving. Guofa Li, Waijain Lai (2020).

Traffic congestion often leads to more aggressive driving behavior, which increases the risk of accidents. While past studies have mainly looked at how people drive during congestion, there's a gap in understanding how congestion affects driving behavior on roads right after the congestion clears. To fill this gap, this study looked at how traffic congestion influences driver behavior on post-congestion roads.

In this study, twenty-five participants took part in a driving simulation. They completed two trials: one after experiencing congestion and the other in non-

congested conditions. Researchers measured various aspects of driver behavior, including driving performance, eye movements, and brain activity using EEG readings. They then compared these measures between the two conditions. From their analysis, the researchers identified ten significant features that characterized drivers' behavior. They used these features to group drivers into different response patterns using a method called hierarchical clustering.

The results showed that after experiencing congestion, drivers tended to display more aggressive behavior compared to when driving in non-congested conditions. They also focused more on the road ahead but less on their dashboard. Moreover, there was a decrease in brain activity in the temporal region associated with cognitive processing.

The clustering analysis revealed distinct response patterns among drivers. Some exhibited more aggressive behavior and less awareness while driving in post-congestion situations.

Overall, the study highlighted that traffic congestion negatively affects driver behavior on roads following congestion. The findings suggest that there's a need for targeted interventions to address the challenges posed by aggressive driving in post-congestion scenarios.

By understanding how congestion impacts driving behavior beyond just the congested period, policymakers and educators can develop strategies to promote safer driving practices and reduce the risks associated with post-congestion driving. This could involve initiatives such as enhanced driving safety education programs aimed at addressing the specific challenges posed by post-congestion driving situations.

2.8 Analysis of factors influencing aggressive driver behavior and crash involvement. Anusha Avadikottu, Nagendra R Velaga (2021).

This study aimed to investigate the relationship between aggressive driving behavior and the likelihood of being involved in road crashes, a topic that has been relatively understudied despite its importance in road safety.

Using data from 405 Indian drivers, the study examined various factors contributing to aggressive driving behavior. Self-reported measures were used to assess driving aggression, while generalized linear models were employed to analyze the influence of independent variables such as age, gender, personality

traits (e.g., driving anger, physical aggression, hostility), and driving violations (e.g., excessive speeding, risky overtaking) on both aggressive driving behavior and crash probabilities.

Through the application of the K-means clustering technique, drivers were categorized into three groups based on their scores on the Aggressive Driving Scale (ADS): aggressive, normal, and cautious. The analysis revealed a significant correlation between gender and aggressive driving, with male drivers being 2.57 times more likely to engage in aggressive behavior compared to females. Furthermore, older drivers displayed lower tendencies for aggressive driving, with a 26% reduction observed for each year increase in age. Drivers who frequently engaged in behaviors such as excessive speeding and risky overtaking were almost three times more likely to exhibit aggressive driving tendencies. Personality traits also played a crucial role, with aggressive drivers exhibiting higher levels of certain traits associated with aggression.

Regarding crash involvement, the study found that aggressive drivers were 2.79 times more likely to be involved in road crashes compared to cautious drivers. Moreover, marital status and occupation were significant factors influencing crash probabilities, with married drivers exhibiting lower crash involvement probabilities, while professional drivers were at a higher risk of crashes.

The study highlights the importance of considering various factors such as age, gender, personality traits, and driving violations in understanding aggressive driving behavior and its implications for road safety. By identifying specific risk factors associated with aggressive driving, policymakers and safety advocates can develop targeted interventions aimed at mitigating the risks posed by aggressive drivers. Additionally, the findings emphasize the potential role of in-vehicle Advanced Driver Assistance Systems (ADAS) in enhancing safety by identifying and addressing aggressive driving behavior among different driver groups.

Findings from literature review

The literature review identified various variables influencing drivers, including age, gender, marital status, education level, and driving experience. Parameters such as critical driving, aggressive behavior, dangerous actions, and errors were recognized as significant aspects for assessing driver behavior. To evaluate these factors, the Driver Behavior Questionnaire was chosen as the instrument of measurement. Additionally, Principal Component Analysis was adopted over hierarchical clustering for data analysis to extract meaningful insights from the collected data. By examining these variables and parameters, the research aims to gain a comprehensive understanding of driver behavior and its underlying determinants, ultimately contributing to the development of effective strategies for promoting road safety and enhancing transportation systems.

Driver characteristics – Gender, Age, Marital Status, Education, Driving Experience.

Parameters – Errors of drovers, Propensity for aggression, Dangerous driving and Critical driving behavior.

Questions asked in DBQ-

1. Failed to notice a pedestrian crossing when turning into a side street from a main road.
2. Misjudged the road surface, through which your braking path is longer than you expected.
3. Almost go off the road because you ride too fast when turning a corner.
4. Underestimate the speed of an oncoming vehicle when overtaking.
5. Brake too quickly on a slippery road and/or steer the wrong way into a skid.
6. I lose track of where I am going.
7. I yell at the driver/drivers who make me nervous.
8. I have trouble staying in the correct lane. I drift into other lanes.
9. I forget to make appropriate adjustments in speed.
10. I maintain a large distance between myself and the driver in front of me.
11. I make gestures at the driver/drivers who made me nervous.
12. I try to put distance between myself and other cars.
13. I honk my horn at the driver who made me nervous.

14. I try to find ways to let other drivers know that they are making me nervous.
15. have difficulty merging into traffic.
16. Felt frustrated by other road users.
17. Felt angry and aggressive towards another road user.
18. Indicated your hostility towards another road user by whatever means you could.
19. Gave chase when angered by another rider or road user.
20. Physically attacked another vehicle or rider or road user.
21. I lose my temper while driving.
22. I always consider the actions of other drivers to be inappropriate or stupid.
23. I flash my headlamps when I get annoyed by other drivers.
24. I make rude gestures e.g. giving fingers, yelling curse words toward drivers who annoy me.
25. I verbally insult drivers who annoy me.
26. I illegally pass a car/truck that is going too slowly.
27. When I get stuck in a traffic jam, I get very irritated.
28. Passengers in my vehicle tell me to calm down.
29. I get irritated when a vehicle in front of me slows down for no reason.
30. I will drive in the shoulder lane or median to get around a traffic jam.
31. I will drive when I am in drunken condition.
32. I feel that most traffic rules could be considered as suggestions or advice.

CHAPTER 3: RESEARCH DESIGN

The primary aim of the study was to delve into the intricate relationship between driver behavior and its influencing factors. To accomplish this, various relevant research papers were selected centered on driver behavior and its association with traffic patterns. The findings from the research served as the foundation for defining the study's objectives, specifying data requirements, and determining the appropriate analysis methods.

From the research, it is underscored that drivers' behavior is closely tied to various personal attributes such as age, gender, marital status, education level, and driving experience. These factors play a significant role in shaping how individuals behave behind the wheel. To effectively evaluate driver behavior, the study identified several key parameters based on prior research. These parameters included lapses, errors in driving, instances of dangerous driving, aggressive behavior, and reckless driving. By examining these parameters, it is aimed to gain a comprehensive understanding of the diverse range of behaviors exhibited by drivers.

Aim and Objectives for the research

3.1 Aim

Identify the factors that influence Driver's behavior and its effects on traffic flow and safety.

Understanding the factors that shape how people drive and how they affect traffic flow and safety is vital for creating successful plans and actions to encourage safe driving behaviors, ease traffic jams, and enhance road safety.

3.2 Objective

- Baseline study of land use and Road network in the study area.
- To identify and understand the reasons and factors that influence or have the potential to influence the Driver's behavior in the study area.
- To compare the Driver's behavioral change and its potential effects on traffic flow and safety in different selected areas.

3.3 Scope

The scope of the study is to understand how the drivers of different groups behave within the group and concerning different city forms.

3.4 Limitation

The study is limited to the ward level which is the sub-part of the city and focused on the private mode of vehicle which is cars and bikes, it is because studying the whole city will require more time and manpower for collecting samples.

3.5 Utility

Study findings can be used to understand the cause of driver behavioral change concerning city form which will help to mitigate its effects on traffic flow and congestion for working towards fostering a culture of safe driving.

3.6 Expected Outcome

The research findings offer valuable insights to policymakers and traffic personnel, highlighting the specific areas in need of targeted interventions. These insights differentiate between planned areas, unplanned areas, and transitional zones, guiding decision-makers on appropriate strategies and actions for each context.

For data collection, the self-reported data obtained through a driver behavior questionnaire (bilingual) was opted. This approach allows to gather insights directly from the drivers themselves, providing valuable firsthand perspectives on their behaviors and attitudes while driving.

In terms of data analysis, a combination of analytical techniques was adopted. Descriptive statistics were utilized to summarize and describe the characteristics of the respondent drivers. Additionally, factor analysis using principal component analysis (PCA) with varimax rotation was conducted to identify underlying factors influencing driver behavior. This method helped to uncover any underlying patterns or relationships within the data.

Furthermore, frequency analysis and Chi-Square test using the Statistical Package for the Social Sciences (SPSS) version 26 was carried out to explore the prevalence of specific behaviors among the respondent drivers.

The structure of DBQ and the Flowchart of methodology are shown in Figure 1 and Figure 2 respectively. The DBQ shown in Appendix 1.

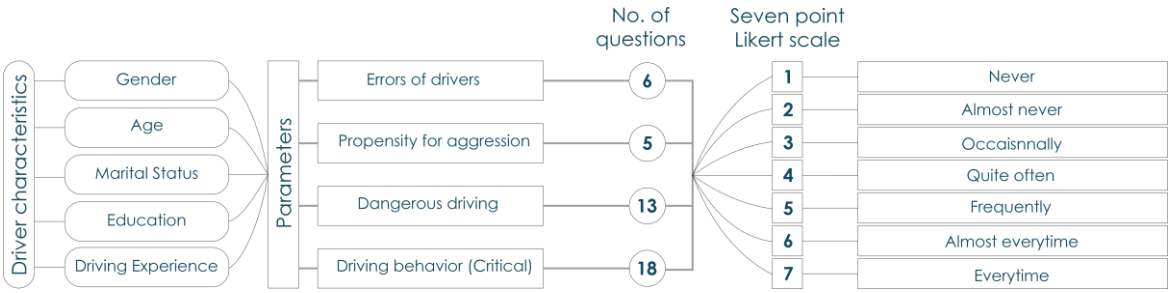


Figure 1: Structure of Drivers Behavior Questionnaire (DBQ)

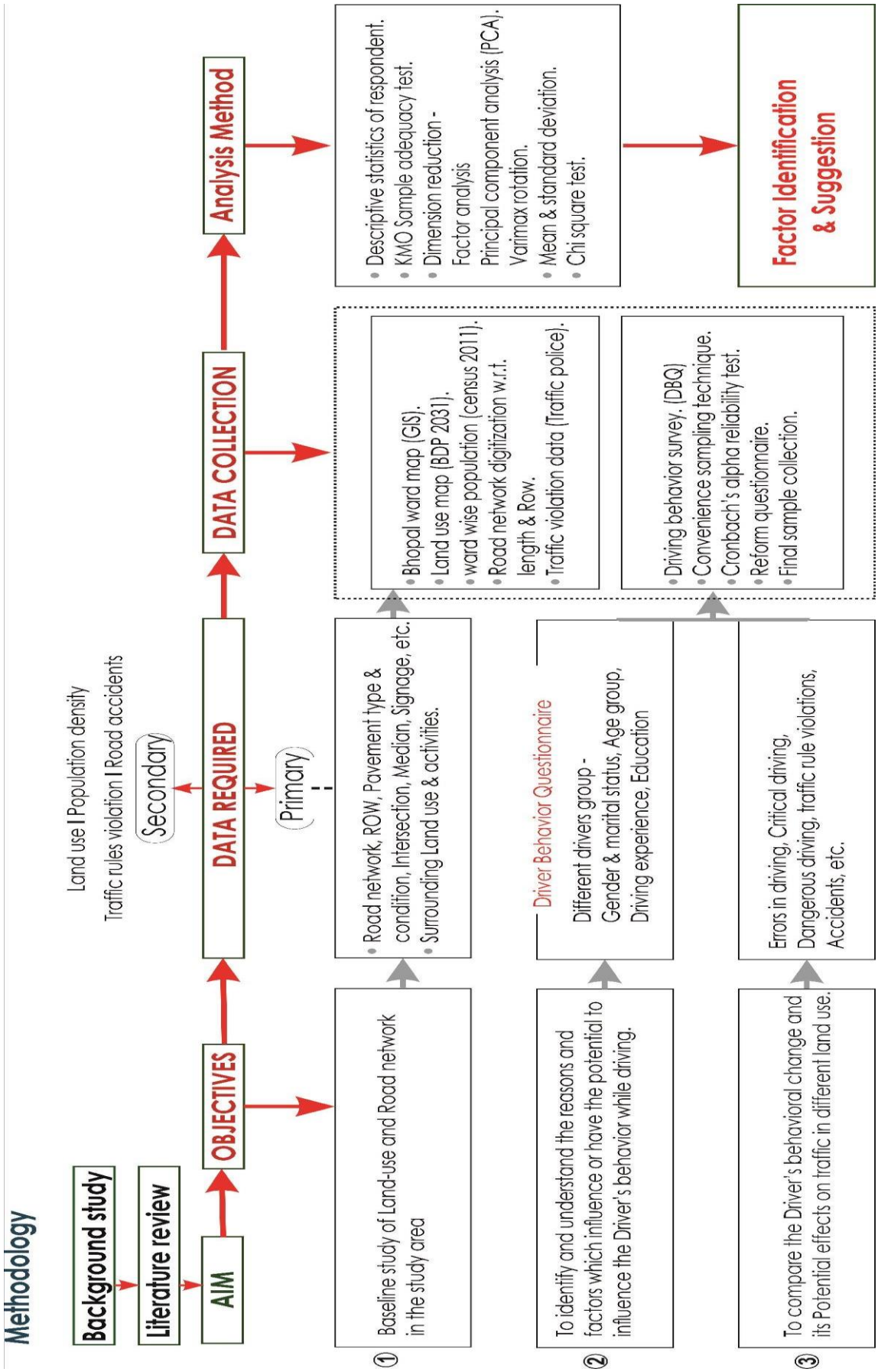
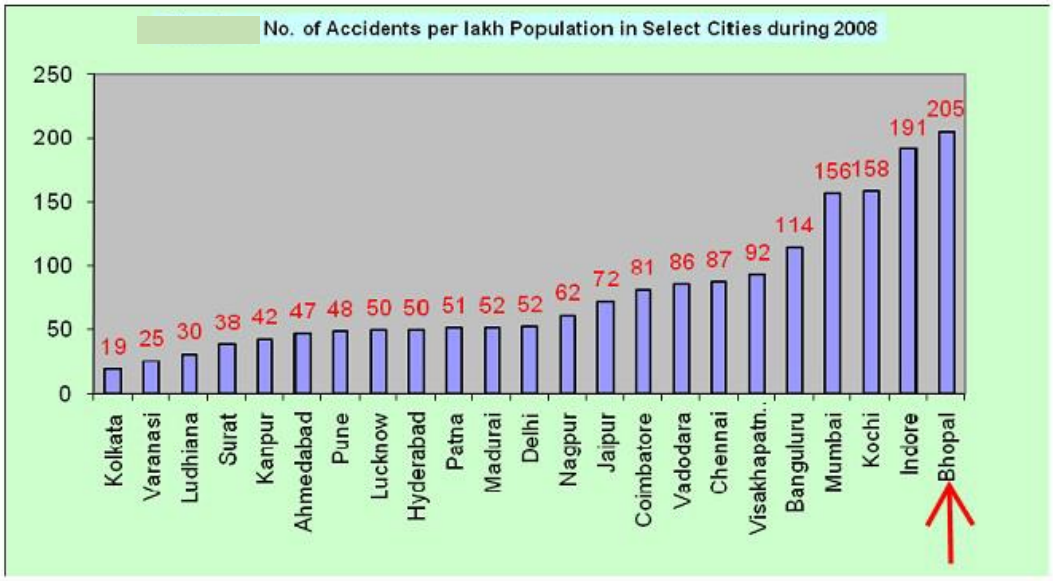


Figure 2: Methodology flow chart

CHAPTER 4: STUDY AREA

4.1 Study Area (Bhopal)

Deaths due to road accidents in Bhopal touched a new high in 2022. About 198 deaths due to road accidents were reported last year. The Karond Square area of Bhopal emerged as the top black spot, which saw 45 road accidents followed by ISBT Road, where 29 road accidents took place. The death tally due to road accidents in the bygone year surpassed the figures of 2021 and registered a 36 percent increase. In 2021, Bhopal city registered 126 road accident deaths. The figure rose to 198 in 2022. From the report "Road Safety Audit of Accident Prone Locations in Bhopal City" Bhopal was on the top os selected cities in accidents with number 205 per lakh in 2008.



Source: Road Safety Audit of Accident Prone Locations in Bhopal City

Bhopal is the capital city of the Indian state of Madhya Pradesh with a total area of 413 sq.km, a population of 1798218, and a population density of 3900 people per sq.km. Bhopal is a vibrant blend of rich history, cultural diversity, and modern development. Nestled in the heart of India, Bhopal is renowned for its scenic beauty, historical landmarks, and architectural marvels.

Originally founded by the Parmara king Bhoja in the 11th century, Bhopal has evolved into a bustling metropolis while retaining its traditional charm. Bhopal is famous for its majestic lakes, earning it the moniker "City of Lakes." The Upper Lake (Bada Talab) and Lower Lake (Chhota Talab) are iconic symbols of the.

Bhopal's cultural landscape is enriched by its vibrant festivals, traditional cuisine, and performing arts. The city celebrates festivals like Eid, Diwali, and Navratri with great fervour, showcasing its diverse cultural heritage.

In essence, Bhopal encapsulates the essence of India's rich past and promising future, making it a captivating destination for tourists and a thriving home for its residents.

The study zones in Bhopal, specifically Arera Colony, Jahangirabad, and Subhash Nagar, have been selected due to their distinctive spatial characteristics, each presenting unique challenges and opportunities. Arera Colony, a relatively modern development, contrasts sharply with Jahangirabad, one of the city's oldest neighbourhoods, while Subhash Nagar serves as an intermediary, showcasing elements of both planned and organic settlements. This study aims to delve into the land use patterns and driver behavior across these areas, considering factors such as road infrastructure, population density, and road width.

Arera Colony stands out as a meticulously planned area, characterized by wider roads, well-defined intersections with traffic signals, and ample road markings. These features contribute to efficient traffic flow and enhanced road safety. With a total area of 2.44 square kilometers and a population of 19,282, Arera Colony boasts a population density of 7905.1 people per square kilometer. Its road network spans 44.41 kilometers, with 9.93% of roads having a Right of Way (ROW) exceeding 18 meters, 14.19% falling between 12 to 18 meters, and the majority, 74.89%, ranging between 6 to 12 meters. Notably, there are no roads with a ROW less than 6 meters in Arera Colony.

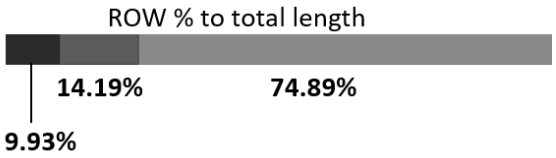
In stark contrast, Jahangirabad, spanning 0.49 square kilometers with a population of 25,485, exhibits the characteristics of an older, densely populated urban settlement. The area's historical significance is reflected in its narrow roads and high population density of 51667.81 people per square kilometer. Jahangirabad's road network covers 10.67 kilometers, with only 5.81% of roads having a ROW exceeding 18 meters, 17.24% falling between 12 to 18 meters, and the majority, 63.91%, having a ROW of less than 6 meters.

Subhash Nagar, occupying an area of 0.52 square kilometers with a population of 19,506, serves as an intermediary zone between Arera Colony and Jahangirabad. This area displays a blend of planned and organic development, with a population density of 36841 people per square kilometer. Subhash Nagar's road network spans 10.72 kilometers, with 6.52% of roads having an ROW exceeding 18 meters, 72.66% falling between 6 to 12 meters, and 20.8% having an ROW of less than 6 meters. Notably, there are no roads in Subhash Nagar with an ROW between 12 to 18 meters.

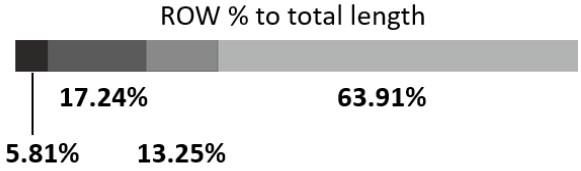
The differences in spatial dynamics among these areas significantly impact driver behavior and traffic patterns. Arera Colony's well-planned infrastructure facilitates smoother traffic flow and reduces congestion compared to the cramped and narrow roads of Jahangirabad. Subhash Nagar, serving as a transition zone, experiences a mix of traffic behaviors influenced by its proximity to both Arera Colony and Jahangirabad.

Analyzing driver behavior across these areas provides valuable insights into the effectiveness of urban planning, road design, and traffic management strategies. Factors such as road width, population density, and the presence of traffic signals and road markings influence driver decision-making, vehicle speeds, and overall road safety.

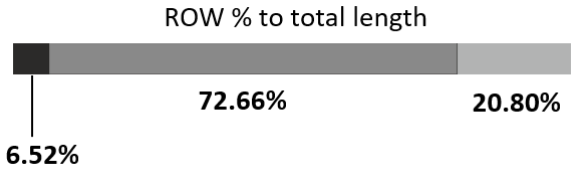
Understanding these dynamics is crucial for urban planners, policymakers, and transportation engineers to develop targeted interventions aimed at improving road safety, enhancing traffic flow, and creating more liveable urban environments. By identifying key challenges and opportunities within each area, informed decisions can be made to optimize infrastructure investments and promote sustainable urban development.



Graph 1: Arera Colony



Graph 2: Jahangirabad



Graph 3: Shubhash nagar

Percentage distribution of road length according to Right of Way

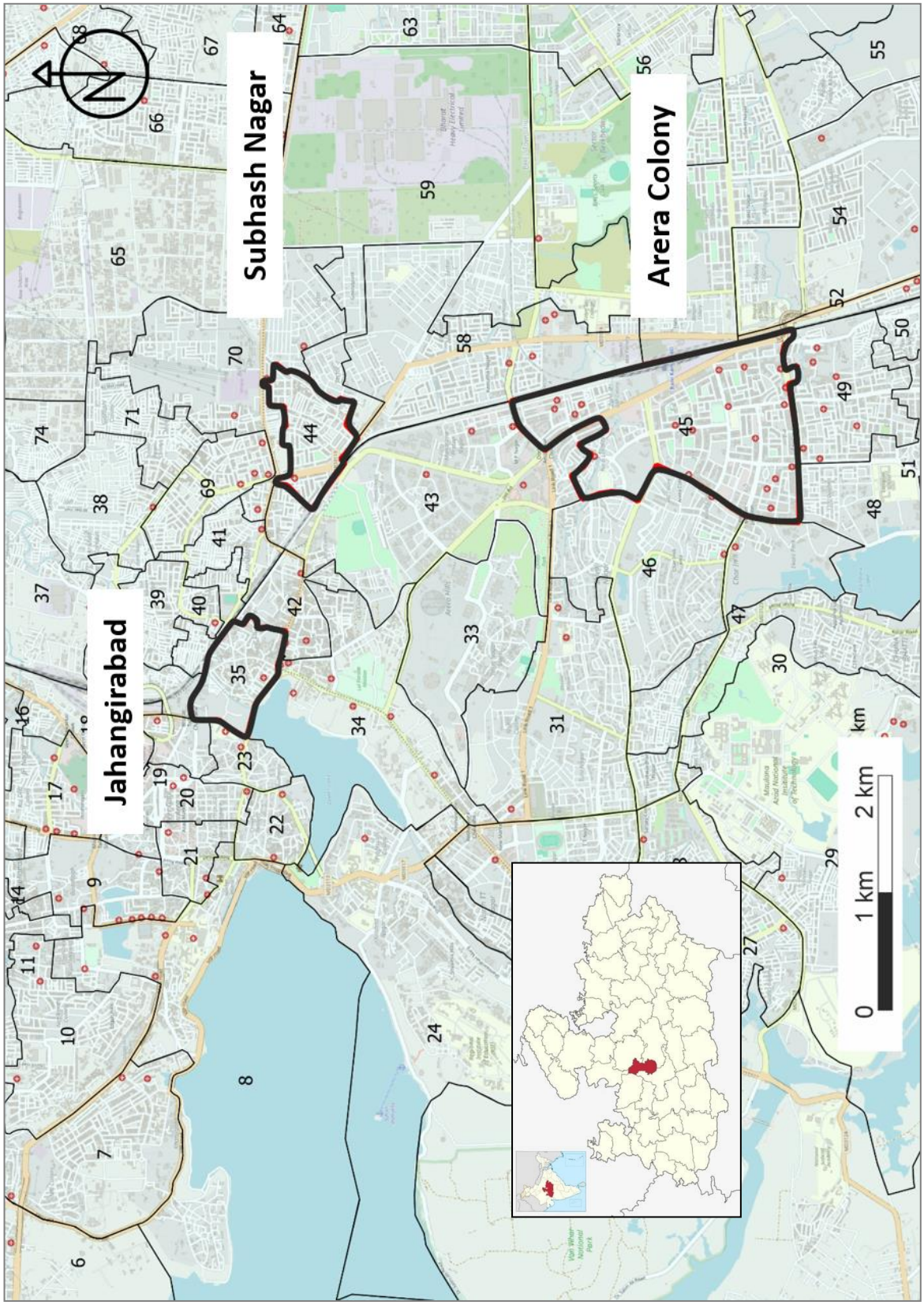


Figure 3: Key map of Study area

Area Colony

Arera Colony is a well-known residential area located in Bhopal. It is one of the oldest and most prominent colonies in Bhopal, known for its planned layout and serene surroundings.

Arera Colony is situated in the southern part of Bhopal, bordered by areas such as Shahpura, E-7 and E-8, and Habibganj Railway Station. It is centrally located and well-connected to other parts of the city.

Arera Colony is primarily a residential area, known for its spacious bungalows, independent houses, and apartment complexes. The colony is home to a diverse mix of residents, including government officials, professionals, businessmen, and families.

The colony boasts a well-planned layout with wide roads, green spaces, and organized sectors. It is divided into various sectors, each offering amenities such as parks, markets, schools, and healthcare facilities within easy reach.

While predominantly residential, Arera Colony also features commercial centers and market areas, catering to the daily needs of residents. These markets offer a range of shops, supermarkets, restaurants, banks, and other essential services.

Arera Colony is home to several prestigious educational institutions, including schools and colleges, making it an ideal residential choice for families with children. These institutions offer quality education and are well-regarded within the city.

The colony is known for its lush greenery and well-maintained parks, providing residents with ample opportunities for recreation and relaxation. Many parks feature walking tracks, playgrounds, and seating areas, making them popular destinations for residents of all ages.

Arera Colony enjoys excellent connectivity to other parts of Bhopal via road networks. It is located close to major landmarks and transportation hubs, facilitating easy travel within the city and beyond.

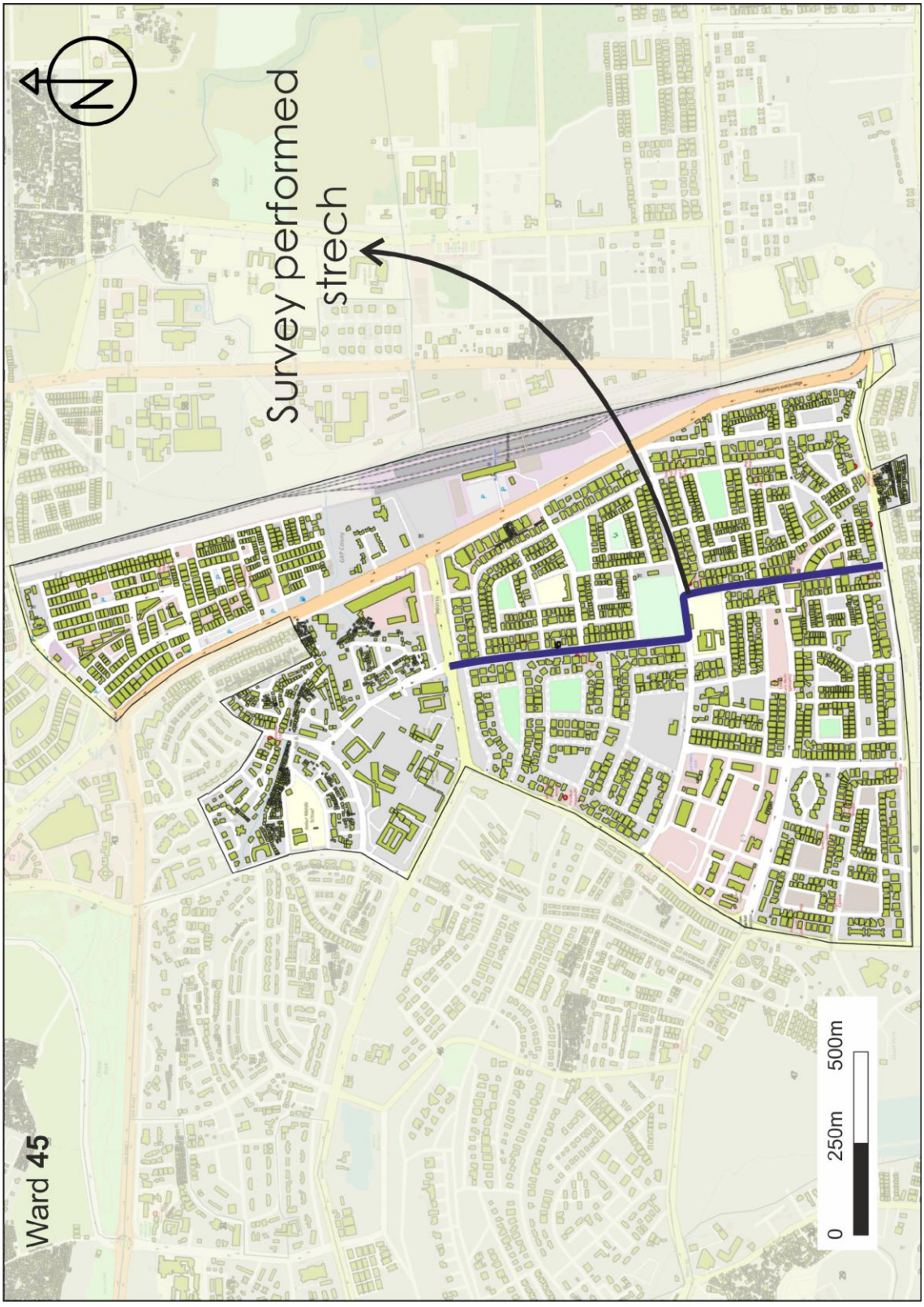


Figure 4: Arera Colony

Figure 5: Streets in Arera colony

Jahangirabad

Jahangirabad has a rich historical legacy and derives its name from Jahangir, the Mughal emperor. The locality has witnessed various historical events and has cultural significance.

Jahangirabad is centrally located in Bhopal, making it easily accessible from different parts of the city. It is situated near prominent areas such as Ibrahimpura, Idgah Hills, and Peer Gate.

Jahangirabad is primarily a residential area, characterized by a mix of residential properties, including independent houses, apartments, and bungalows. It is home to a diverse population, including families, professionals, and students.

While predominantly residential, Jahangirabad also features commercial establishments, markets, and shopping complexes. Residents have access to various amenities such as grocery stores, restaurants, banks, and healthcare facilities within the locality.

Jahangirabad is dotted with cultural landmarks, historical sites, and religious places of worship. These include mosques, temples, and shrines, which hold significance for the local community and attract visitors.

The locality enjoys good connectivity to other parts of Bhopal via road networks. Public transportation facilities such as buses and auto-rickshaws are readily available, providing residents with convenient travel options within the city.

Figure 6: Jahangirabad

Figure 7: Steerts of Jahangirabad

Subhash Nagar

Subhash Nagar is situated in the western part of Bhopal, bordered by areas such as Arera Colony, Nehru Nagar, and Shakti Nagar. It is centrally located, with easy access to other parts of the city.

Subhash Nagar is primarily a residential locality, known for its peaceful surroundings and family-friendly environment. The area is home to a mix of independent houses, apartments, and bungalows, catering to residents of various income levels.

The locality boasts well-developed infrastructure, including wide roads, street lighting, and access to basic amenities such as water supply, electricity, and sanitation services. Many residential complexes also offer additional amenities such as parks, community centers, and security facilities.

The locality enjoys good connectivity to other parts of Bhopal via road networks. Public transportation facilities such as buses and auto-rickshaws are readily available, providing convenient travel options for residents.

Subhash Nagar has two distinct areas: old and new. The old section features unplanned layouts, characterized by small plots, narrow roads, and dense building arrangements. In contrast, the new area boasts planned development, offering larger plots, wider roads, and lower building density. Old Subhash Nagar's haphazard setup contrasts starkly with the organized infrastructure of the new Subhash Nagar. This dichotomy reflects differing urban planning approaches, with the old area's cramped conditions standing in contrast to the spaciousness and orderliness of the new sector.

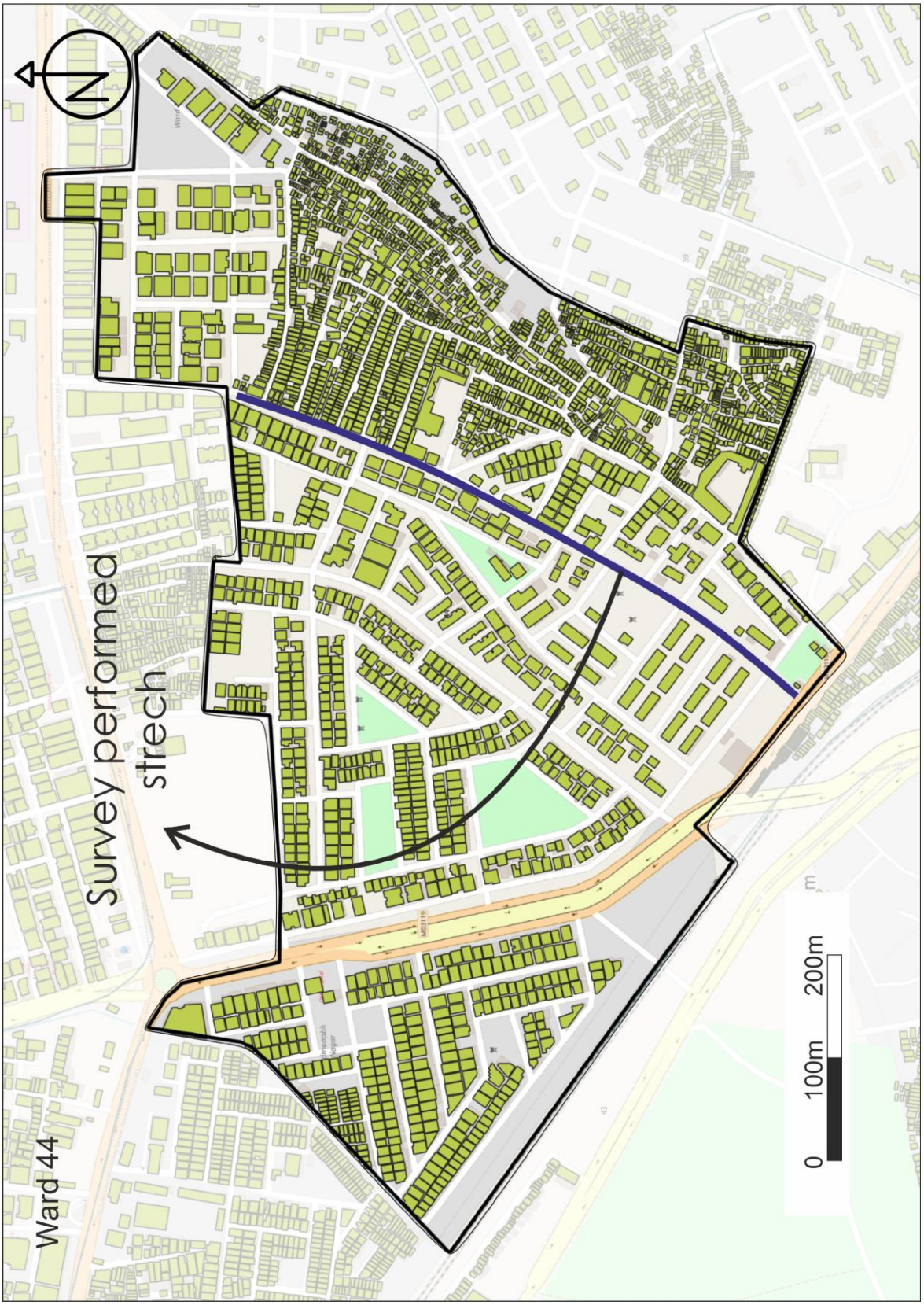


Figure 8: Subhash Nagar

Figure 9 Streets of Subhash Nagar

4.2 Data Required

To meet the study's goals and objectives, it's crucial to grasp drivers' behavior. This entails collecting data directly from drivers through a series of questions. Additionally, data from the traffic police control room, such as traffic rule violations and accident records, is essential. Furthermore, information about the road network, density, local environment, right-of-way (ROW), and other related factors is necessary for analysis. Gathering this comprehensive dataset will provide insights into various aspects influencing driving behavior and traffic patterns, facilitating a thorough understanding of the study area's dynamics.

Chapter 5: DATA COLLECTION and ANALYSIS

5.1 Data collection

Data collection for the study involved employing a self-reported data method, wherein drivers were asked to provide information about their behavior through a structured questionnaire. This questionnaire aimed to capture various characteristics of drivers and parameters of their behavior using a seven-point Likert scale. The Likert scale ranged from 1 to 7, with 1 representing "never" and 7 representing "every time." This scale allowed participants to indicate the frequency of their behaviors along a spectrum, including "almost never," "occasionally," "quite often," "frequently," and "almost every time."

The questionnaire, known as the Driver Behavior Questionnaire (DBQ), consisted of 42 items that assessed aberrant driver behaviors. These behaviors encompassed a range of actions and tendencies displayed by drivers on the road. Participants were required to indicate how often they engaged in each behavior, providing valuable insights into their driving habits and tendencies.

To ensure a representative sample, the questionnaire was distributed to motorists using the intercept survey method. This method involved intercepting drivers at selected locations within the study area and inviting them to participate in the survey. The selected locations were strategically chosen to capture a diverse cross-section of drivers traversing different road segments.

The intercept survey method utilized a roadside handout approach, by stationing at specific survey sites and approaching passing motorists. Drivers who agreed to participate were handed the questionnaire and provided with instructions on how to complete it. This approach allowed for direct engagement with drivers and facilitated the collection of data in real-time.

In total, data were collected from 60 drivers across three selected areas within the study area. These areas were chosen based on their representation of different traffic conditions, road types, and environmental factors. By collecting data from multiple locations, the study aimed to capture the variability in driver behavior across different contexts and road environments.

The questionnaire distribution process involved careful planning and coordination to ensure to collection of data from all variables like Age, Gender, marital status, educational status, and driving experience. Data was collected at predetermined

survey sites during peak traffic hours to maximize participant engagement. Additionally, efforts were made to minimize any biases or influences that could affect participants' responses, such as providing clear instructions and maintaining anonymity.

Upon completion of the survey, the collected data were compiled and analyzed to identify patterns and trends in driver behavior. Statistical techniques were employed to analyze the Likert-scale responses and derive meaningful insights from the data. The findings obtained from the questionnaire provided valuable information for understanding the factors influencing driver behavior and informing strategies for promoting road safety and efficiency.

Overall, the data collection process utilizing the self-reported questionnaire method yielded a rich dataset that contributed to the comprehensive analysis of driver behavior within the study area.

Driver's behavior questionnaire is mentioned in Appendix 1.

5.2 Data Analysis

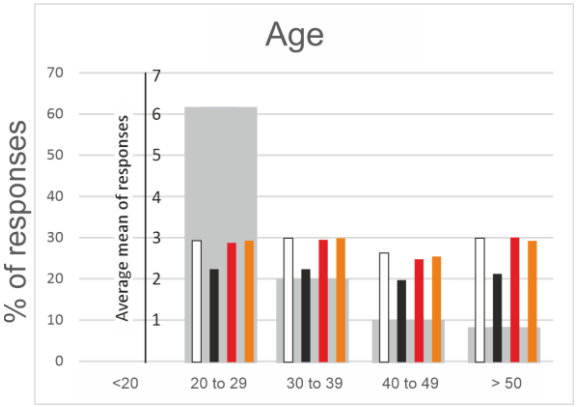
Drivers were sorted into five categories based on their characteristics: gender (male and female), marital status (married and unmarried), age (divided into five groups), education level (below high school and above high school), and driving experience (grouped into four categories).

According to the data, the distribution of respondents based on these characteristics is as follows:

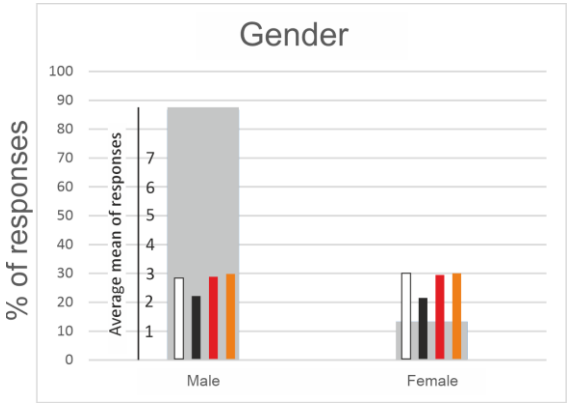
- 86.7% were male, while 13.3% were female.
- 51.7% were married, and 48.3% were unmarried.
- 48 % men and 75 % women were married.
- 88.3% had education above high school, whereas 11.7% had education below high school.
- In terms of age, none were less than 20 years old, 61.7% fell between 20 to 29 years, 20% were between 30 to 39 years, 10% ranged from 40 to 49 years, and 20% were above 50 years old.
- Concerning driving experience, 1.7% had less than 2 years, 23.3% had 2 to 5 years, 36.7% had 5 to 10 years, and 38.3% had more than 10 years of experience.

These percentages delineate the demographic composition of the surveyed drivers across various categories. The graphical representation of this distribution, depicted in graphs 4 to 8, offers a visual snapshot of the diversity within the driver sample. It aids in comprehending the makeup of the respondents in terms of gender, marital status, educational background, age, and driving experience.

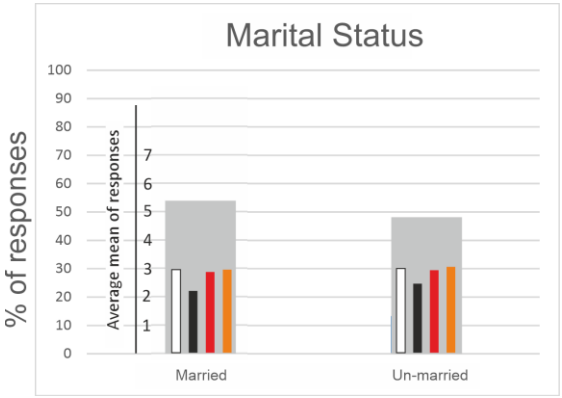
The categorization of drivers based on these characteristics allows for a nuanced analysis of behavior patterns and tendencies within different demographic groups. For instance, comparing the driving behaviors of male and female drivers or assessing how age and driving experience influence behavior can yield valuable insights into road safety and traffic management strategies. The average mean of each response under each parameter is shown in graphs 4 to 8.



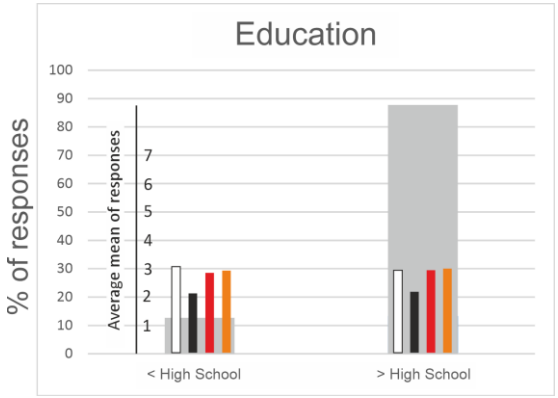
Graph 4: % of responses by age



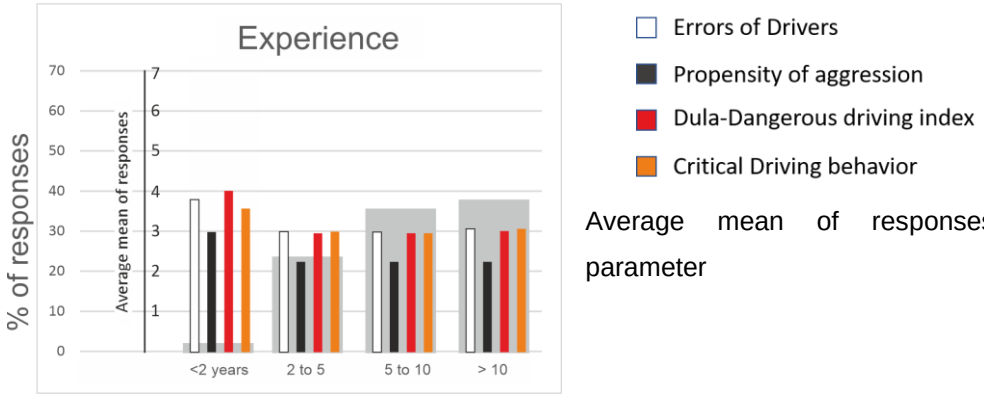
Graph 5: % of responses by Gender



Graph 6: % of responses by marital status



Graph 7: % of responses education



Average mean of responses under each parameter

Graph 8: % of responses by experience

On average, female drivers exhibit the highest level of errors in driving and critical driving behavior, with a mean value of 3, followed closely by male drivers displaying critical driving behavior at 2.9. Among drivers aged over 50, dangerous driving tendencies are most pronounced, averaging at 3, whereas those aged 40 to 49 show the lowest at 2.7. Drivers with less than 2 years of experience tend to display more critical behavior, with an average mean of 4. Similarly, drivers with education below high school level are more prone to errors in driving, scoring an average of 3.05, while those with education beyond high school are more inclined to engage in critical driving, scoring 2.97 on average. Furthermore, unmarried drivers are more likely to exhibit critical behavior, with a mean of 3.01, whereas married drivers tend to make more errors, with an average mean of 2.98.

Table 1 displays the driver's reactions, presenting percentages for each scale alongside the mode of all questions. The mode represents the most frequent response across all questions. In this case, the overall mode is 3, indicating that respondents tended to exhibit aberrant behavior occasionally. This suggests that while drivers may generally adhere to safe practices, they occasionally engage in behaviors that deviate from standard norms. Understanding these patterns is crucial for identifying areas where interventions may be needed to promote safer driving.

Table 1 Distribution of responses

S.NO.	Question
	Errors of drivers
1	मेन रोड से मुड़ते वक़्त पैदल यात्री को नोटिस नही कर पाते
2	रोड की सतह को सही से ना परख पाने की वजह से ब्रेक लगाने पर अनुमान से जादा दूरी तय कर जाते हैं
3	गाड़ी तेज चलाने की वजह से गाड़ी रोड से बाहर हो जाती है
4	ओवरटेक करते समय आने वाले वाहन की गति को कम आंकते है
5	फिसलन भरी सड़क पर बहुत तेजी से ब्रेक लगाना और/या स्किड में गलत दिशा में गाड़ी चलाना।
6	ट्रैफिक सिग्नल पर हरि बत्ती के आखिरी 1 से 2 सेकंड या पीली बत्ती पर तय नही कर पाते की सिग्नल क्रॉस करे या नही
	Propensity for aggression
7	आपने गुस्से में कितनी बार दूसरे ड्राइवर का पीछा किया है?
8	क्या आपने कभी किसी अन्य वाहन या ड्राइवर पर शारीरिक हमला किया है?
9	आप सड़क पर अन्य ड्राइवरों के प्रति कितनी बार नकारात्मक भावनाओं (निराशा, क्रोध, आदि) का अनुभव करते हैं?
10	आप कितनी बार ऐसे व्यवहार में संलग्न होते हैं जिन्हें अन्य ड्राइवरों के प्रति आक्रामक या शत्रुतापूर्ण माना जा सकता है (जैसे, चिल्लाना, अशिष्ट इशारे करना)
11	आप कितनी बार मौखिक अपमान, चिल्लाहट या असभ्य इशारों के माध्यम से अन्य ड्राइवरों के प्रति अपनी झुंझलाहट या घबराहट व्यक्त करते हैं
	Dula Dangerous driving index
12	गाड़ी चलाते समय आप कितनी बार अपना आपा खो देते हैं?
13	आप कितनी बार बहुत धीमी गति से जा रही किसी कार/ट्रक को गलत तरीके से ओवरटेक कर जाते हैं?
14	ट्रैफिक में फंसने पर आप कितनी बार चिढ़ जाते हैं?
15	गाड़ी चलाते समय यात्री आपको कितनी बार शांत रहने के लिए कहते हैं?
16	जब आपके सामने कोई वाहन बिना किसी कारण से धीमा हो जाता है तो क्या आप चिढ़ जाते हैं?
17	ट्रैफ़िक से बचने के लिए आप कितनी बार शोल्डर लेन या मीडियन में गाड़ी चलाते हैं?
18	आप कितनी बार नशे में गाड़ी चलाते हैं?
19	आप कितनी बार ट्रैफिक नियमों का उल्लंघन करते हैं.
20	आप कितनी बार महसूस करते हैं कि सड़क किनारे के संकेत महत्वपूर्ण हैं?
21	आप कितनी बार गलत दिशा में गाड़ी चलाते हैं?
22	सिग्नल पर दूसरी गाड़ी को रेड लाइट मे सिग्नल क्रॉस करते देख कर आप भी सिग्नल क्रॉस करते है
23	ट्रैफिक जाम से निकलने के बाद आप गाड़ी के दिये हुए गति सीमा से अधिक तेज चलते है
24	दूसरे चालक को नियम का पालन ना करते देख कर आप भी नियम का पालन नही करते है

S.NO.	1	2	3	4	5	6	7	
	कभी नहीं	लगभग नहीं	कभी-कभी	अक्सर	बार-बार	लगभग बार-बार	हर बार	Mode
1	6.7	35.0	40.0	5.0	5.0	8.3	0.0	3
2	10.0	35.0	40.0	11.7	0.0	3.3	0.0	3
3	26.7	21.7	28.3	13.3	5.0	5.0	0.0	3
4	13.3	40.0	21.7	13.3	6.7	5.0	0.0	2
5	16.7	31.7	25.0	18.3	3.3	5.0	0.0	2
6	6.7	18.3	16.7	15.0	16.7	13.3	13.3	2
7	33.3	35.0	18.3	5.0	5.0	3.3	0.0	2
8	70.0	28.3	1.7	0.0	0.0	0.0	0.0	1
9	3.3	25.0	38.3	23.3	5.0	5.0	0.0	3
10	20.0	46.7	25.0	8.3	0.0	0.0	0.0	2
11	11.7	60.0	23.3	5.0	0.0	0.0	0.0	2
12	40.0	33.3	15.0	6.7	1.7	3.3	0.0	1
13	16.7	21.7	33.3	10.0	10.0	5.0	3.3	3
14	1.7	10.0	21.7	23.3	21.7	13.3	8.3	4
15	40.0	38.3	10.0	5.0	3.3	1.7	1.7	1
16	8.3	25.0	16.7	11.7	20.0	11.7	6.7	2
17	11.7	21.7	33.3	18.3	10.0	3.3	1.7	3
18	66.7	23.3	5.0	3.3	1.7	0	0	1
19	35.0	35.0	23.3	3.3	3.3	0	0	1
20	0	1.7	1.7	13.3	11.7	18.3	53.3	7
21	20.0	53.3	21.7	5.0	0	0	0	2
22	23.3	30.0	18.3	10.0	11.7	6.7	0	2
23	15.0	33.3	28.3	20.0	3.3	0	0	2
24	18.3	31.7	18.3	6.7	18.3	3.3	3.3	2

	Driving behavior (Critical)
25	आपको कितनी बार सही लेन में रहने और दूसरी लेन में चले जाने में परेशानी होती है?
26	आप कितनी बार गति पर नियंत्रण बनाना भूल जाते हैं?
27	आप कितनी बार अपने सामने वाले ड्राइवर से आवश्यकता से अधिक दूरी बनाए रखते हैं?
28	क्या आप सामने वाली कार के इतने करीब गाड़ी चलाते हैं कि आपात्कालीन स्थिति में रुकना मुश्किल हो जाए।
29	आप कितनी बार हॉर्न बजाकर अपने और दूसरी कारों के बीच दूरी बनाने की कोशिश करते हैं?
30	आप कितनी बार अन्य ड्राइवरों को यह बताने के तरीके खोजने की कोशिश करते हैं कि वे आपको परेशान कर रहे हैं?
31	आपको कितनी बार ट्रैफ़िक में शामिल होने में कठिनाई होती है?
32	क्या आप गाड़ी चलाते समय अपने फ़ोन का उपयोग करते हैं?
33	जब दूसरा ड्राइवर आपसे आगे निकल रहा हो तो क्या आप गति बढ़ा देते हैं?
34	किसी ऐसे व्यक्ति से आगे निकलने का प्रयास करें जिस पर आपने ध्यान नहीं दिया हो कि वह दाईं ओर जाने का संकेत दे रहा है
35	बाहर निकलने, लेन बदलने आदि से पहले अपने रियरव्यू मिरर की जांच करने में विफल रहें।
36	मुख्य सड़क पर बायीं ओर मुड़ने के लिए कतार में, आप यातायात की मुख्य धारा पर इतना ध्यान देते हैं कि आप लगभग सामने वाली कार से टकरा जाते हैं
37	ट्रैफिक सिग्नल पे क्याआप किसी दूसरे गाड़ी को पीछे छोड़ने के नियत से गाड़ी तेज चलते है
38	किसी जंक्शन को यह जानते हुए पार करें कि ट्रैफिक लाइटें पहले ही आपके विरुद्ध हो चुकी हैं
39	क्या आप बाएँ संकेत करते समय दाएँ मुड़ते हैं?
40	आप कितनी बार ट्रैफिक पुलिस से बचते हैं?
41	ट्रैफिक जाम मे आप इधर उधर से निकालने की कोसिस करते है
42	ट्रैफिक जाम मे दूसरी गाड़ी आपके सामने से इधर उधर से निकले की कोसिस करती है

S.NO.	1	2	3	4	5	6	7	
	कभी नहीं	लगभग नहीं	कभी-कभी	अक्सर	बार-बार	लगभग बार-बार	हर बार	Mode
25	18.3	20.0	33.3	16.7	5.0	3.3	3.3	3
26	25.0	35.0	20.0	8.3	3.3	3.3	5.0	2
27	0	8.3	26.7	23.3	20.0	15.0	6.7	3
28	20.0	46.7	25.0	1.7	1.7	5.0	0.0	2
29	6.7	15.0	25.0	20.0	15.0	15.0	3.3	3
30	10.0	13.3	36.7	15.0	16.7	1.7	6.7	3
31	5.0	23.3	25.0	25.0	8.3	8.3	5.0	3
32	33.3	36.7	20.0	3.3	6.7	0	0	2
33	25.0	40.0	23.3	5.0	6.7	0	0	2
34	20.0	40.0	31.7	1.7	3.3	0.0	1.7	2
35	40.0	21.7	21.7	8.3	6.7	0.0	1.7	1
36	21.7	56.7	13.3	3.3	1.7	3.3	0	2
37	30.0	41.7	13.3	8.3	1.7	5.0	0	2
38	33.3	23.3	18.3	10.0	6.7	5.0	3.3	1
39	61.7	26.7	3.3	1.7	3.3	3.3	0.0	1
40	5.0	18.3	33.3	20.0	10.0	8.3	5.0	3
41	3.3	11.7	31.7	21.7	20.0	8.3	3.3	3
42	0	0	10.0	10.0	23.3	25.0	31.7	7

practices.

5.3 Reliability test of the questionnaire

Cronbach's alpha coefficient is a statistical measure used to assess the internal consistency or reliability of a set of survey items. It helps determine whether the items in a survey consistently measure the same underlying characteristic. The coefficient quantifies the level of agreement among the items on a standardized scale ranging from 0 to 1. Higher values indicate stronger agreement between the items, suggesting greater reliability.

In this case, a reliability test was conducted using Cronbach's alpha coefficient, resulting in a value of 0.804. According to Fraenkel and Wallen (1996), a commonly accepted range for Cronbach's alpha is between 0.70 and 0.99, indicating good internal consistency. The behavior scale demonstrated satisfactory internal consistency within this range. However, the propensity for aggression exhibited a lower alpha value of 0.708, suggesting a slightly weaker consistency.

Despite this, the Cronbach multiplier value obtained aligns with those reported in other literature, indicating that the reliability of the survey items is consistent with established standards. This suggests that while there may be some variability in the propensity for aggression, overall, the survey items reliably measure the intended constructs.

5.4 Factor analysis

Factor analysis is a statistical technique used to reveal hidden patterns or structures within a dataset, particularly when dealing with a large number of variables. It aims to identify underlying dimensions or factors that explain the correlations among these variables. These factors represent unobservable variables that cannot be directly measured but are inferred from the observed data.

The primary objective of factor analysis is to simplify the dataset by identifying a smaller set of underlying factors that capture the essential information contained in the original variables. This simplification aids in interpreting the data and enables further analysis.

Factor analysis operates under the assumption that observed variables are linear combinations of the underlying factors plus some error or unique variance. The relationships between observed variables and underlying factors are expressed through a factor loading matrix, which indicates the strength and direction of the association between each variable and each factor. This matrix helps in understanding how the variables contribute to each factor and how the factors are related to one another. Overall, factor analysis provides valuable insights into the underlying structure of complex datasets, facilitating a deeper understanding of the relationships between variables.

5.5 Principal Component Analysis

Principal Component Analysis (PCA) serves as a pivotal statistical technique within the realm of data analysis, offering a methodical approach to streamline complex datasets while facilitating their visualization. At its core, PCA endeavors to distill intricate data into a more manageable form, thereby reducing the dimensionality of the dataset while retaining the essence of its original information. This process not only aids in simplifying the data but also unveils underlying patterns and structures that may otherwise remain obscured amidst the complexity.

In the context of the study, the drivers' behavior was explored, utilizing PCA as their analytical compass. Initially, a comprehensive dataset comprising 42 distinct behavioral indicators was subjected to PCA using the SPSS software, accompanied by varimax rotation to enhance interpretability. Varimax rotation is a common technique employed in factor analysis, including PCA, to achieve simpler and more interpretable factor structures by maximizing the variance of the squared loadings within each factor.

Upon conducting the initial PCA, 14 factors emerged, collectively elucidating a substantial portion of the dataset's variance, amounting to approximately 79.78%. Despite this notable achievement, an evaluation of the Kaiser-Meyer-Olkin (KMO) measure yielded a value of 0.375, indicating a suboptimal adequacy for factor analysis. The KMO measure serves as a diagnostic tool in factor analysis, assessing the suitability of the data for this analytical technique. Ideally, a KMO value exceeding 0.7 is considered indicative of adequate sample adequacy for

factor analysis, signifying that the correlations among variables are sufficiently high to warrant their inclusion in the analysis. However, the obtained KMO value falling short of this threshold underscored the need for further refinement and validation of the analytical approach.

In response to the KMO assessment and to enhance the robustness of the analysis, the dataset was refined by selecting 16 key behavioral indicators based on their respective contributions to the variance observed in the initial PCA. This iterative process aimed to prioritize the most influential variables while mitigating the effects of noise and redundancy inherent in the original dataset. Subsequently, PCA was once again employed utilizing the refined set of 16 variables, intending to unravel the underlying behavioral dimensions with greater clarity and fidelity.

The outcome of the refined PCA revealed the emergence of four distinct factors, each encapsulating unique facets of drivers' behavior. Notably, the KMO measure for this refined analysis demonstrated a marked improvement, attaining a value of 0.719, indicative of its enhanced suitability for factor analysis. The graphical representation of the analysis, depicted through a scree plot, further corroborated the significance of the identified factors, with each factor exhibiting eigenvalues exceeding 1, thereby substantiating their relevance in explaining the variance within the dataset.

Delving deeper into the interpretation of the identified factors, Factor 1 was delineated as "**Critical Driving Behavior**," encapsulating behaviors characterized by prudence, attentiveness, and adherence to traffic regulations. Factor 2, denoted as "**Dangerous Driving Behavior**," encapsulated actions exhibiting recklessness, impulsivity, and a propensity for hazardous maneuvers. Factor 3, labeled "**Aggression**," pertained to behaviors typified by hostility, assertiveness, and confrontational tendencies in driving contexts. Finally, Factor 4 was attributed the appellation of "**Violations**," encompassing breaches of traffic laws, rules, and regulations.

To ascertain the internal consistency and reliability of the items comprising each factor, Cronbach's alpha tests were performed, a widely utilized measure of internal consistency reliability. The results of these tests revealed satisfactory levels of internal consistency for each factor, with Factor 1 demonstrating a Cronbach's alpha coefficient of 0.854 for its constituent six items, Factor 2

exhibiting a coefficient of 0.698 for its four items, Factor 3 yielding a coefficient of 0.707 for its four items, and Factor 4 registering a coefficient of 0.710 for its two items. These findings lend credence to the reliability and coherence of the identified factors, bolstering the validity of the analytical framework employed in elucidating drivers' behavior.

Transitioning from the realm of statistical analysis to the realm of practical implications, the results of a descriptive analysis of drivers' behavior, shed light on the prevailing behavioral tendencies across different geographic locales. Noteworthy insights gleaned from this analysis include the observation that dangerous driving behavior manifested most prominently in Subhash Nagar, as evidenced by an average mean rating of 3.39, followed closely by aggressive behavior and critical driving behavior, which garnered average mean ratings of 2.98 and 2.96, respectively. Conversely, the area designated as Area Colony exhibited the highest mean rating for violations, with an average mean score of 3.68, indicative of a propensity for non-compliance with traffic regulations and norms within this locale.

Descriptive analysis on drivers behavior

		Overall		Arera colony		Jahangirabad		Subhash nagar	
Factor 1 : Critical driving behavior		Mean	SD	Mean	SD	Mean	SD	Mean	SD
	Factor1	2.48		2.14		2.60		2.69	
5	फिसलन भरी सड़क पर बहुत तेजी से ब्रेक लगाना और/या स्किड में गलत दिशा में गाड़ी चलाना।	2.75	1.310	2.55	1.234	2.85	1.387	2.85	1.348
22	सिग्नल पर दूसरी गाड़ी को रेड लाइट मे सिग्नल क्रॉस करते देख कर आप भी सिग्नल क्रॉस करते है	2.77	1.544	2.40	1.501	2.75	1.482	3.15	1.631
26	आप कितनी बार गति पर नियंत्रण बनाना भूल जाते हैं?	2.60	1.597	1.80	1.005	2.85	1.814	3.15	1.599
28	क्या आप सामने वाली कार के इतने करीब गाड़ी चलाते हैं कि आपातकालीन स्थिति में रुकना मुश्किल हो जाए।	2.37	1.193	2.20	1.152	2.25	1.333	2.55	1.050
36	मुख्य सड़क पर बायीं ओर मुड़ने के लिए कतार में, आप यातायात की मुख्य धारा पर इतना ध्यान देते हैं कि आप लगभग सामने वाली कार से टकरा जाते हैं	2.17	1.076	2.05	0.510	2.4	1.392	2.05	1.146
37	ट्रैफिक सिग्नल पे क्याआप किसी दूसरे गाड़ी को पीछे छोड़ने के लिये से गाड़ी तेज चलते है	2.25	1.297	1.85	0.745	2.5	1.504	2.4	1.465
Factor 2 : Dangerous driving behavior									
	Factor2	2.64		2.13		2.60		3.39	
3	गाड़ी तेज चलाने की वजह से गाड़ी रोड से बाहर हो जाती है	2.63	1.402	2.20	1.056	2.75	1.293	2.95	1.731
23	ट्रैफिक जाम से निकलने के बाद आप गाड़ी के दिये हुए गति सीमा से अधिक तेज चलते हैं	2.63	1.073	2.05	0.945	2.5	0.827	3.35	1.040
25	आपको कितनी बार सही लेन में रहने और दूसरी लेन में चले जाने में परेशानी होती है?	2.93	1.471	2.55	1.191	2.45	0.686	3.8	1.908
38	किसी जंक्शन को यह जानते हुए पार करें कि ट्रैफिक लाइटें पहले ही आपके विरुद्ध हो चुकी हैं	2.37	1.193	1.70	1.031	2.7	1.261	3.45	2.114
Factor 3 : Aggresive driving behavior									
	Factor3	2.53		2.09		2.54		2.98	
11	आप कितनी बार मौखिक अपमान, चिल्लाहट या असभ्य इशारों के माध्यम से अन्य ड्राइवरों के प्रति अपनी झुंझलाहट या घबराहट व्यक्त करते हैं	2.22	0.715	1.95	0.605	2.2	0.523	2.5	0.889
15	गाड़ी चलाते समय यात्री आपको कितनी बार शांत रहने के लिए कहते हैं?	2.05	1.307	1.35	0.587	2	1.338	2.8	1.436
19	आप कितनी बार ट्रैफिक नियमों का उल्लंघन करते हैं.	2.05	1.016	1.60	0.754	2	0.973	2.55	1.099
41	ट्रैफिक जाम मे आप इधर उधर से निकालने की कोसिस करते है	3.82	1.384	3.45	1.191	3.95	1.432	4.05	1.504
Factor 4 : Violations									
	Factor4	3.28		3.68		2.98		3.18	
24	दूसरे चालक को नियम का पालन ना करते देख कर आप भी नियम का पालन नही करते है	3.00	1.638	3.20	2.042	2.6	1.465	3.15	1.387
40	आप कितनी बार ट्रैफिक पुलिस से बचते हैं?	3.55	1.478	4.15	2.059	3.35	0.988	3.2	1.105

Table 2 Descriptive analysis on driver's behavior

5.6 Chi-Square test

The Chi-Square test serves as a statistical cornerstone for assessing the relationship between categorical variables, enabling researchers to discern whether observed differences are statistically significant or merely the result of chance. In our study, we leveraged this test to elucidate the intricate interplay between drivers' characteristics and their behavior on the road.

The analysis unearthed compelling insights into how gender and marital status intertwine with driving behavior under critical and dangerous driving with the significance level ranging between 0.00 to 0.006 and 0.029 to 0.045 respectively. Specifically, we found that these demographic factors exhibit notable associations with aggressive and critical driving tendencies. Male drivers, in particular, displayed a higher propensity for engaging in dangerous driving practices compared to their female counterparts. This finding underscores the importance of gender considerations in understanding and addressing road safety issues.

Moreover, the examination revealed a less pronounced yet discernible relationship between education levels and driving behavior. While not as striking as gender or marital status, educational attainment still emerged as a factor worth considering when evaluating drivers' conduct on the road. This suggests that educational background may play a nuanced role in shaping driving habits, albeit to a lesser extent than gender or marital status.

Interestingly, the analysis unveiled a noteworthy correlation between driving experience and aggressive driving behavior. Drivers with 5 to 10 years of experience exhibited a heightened tendency towards engaging in aggressive driving maneuvers which is significant at the significance level between 0.00 to 0.001. This finding underscores the notion that driving experience, while often associated with enhanced skills and competence behind the wheel, may also influence drivers' behavioral inclinations, particularly towards more assertive or risk-taking behaviors.

Conversely, the investigation did not yield any significant correlation between age and driving behavior within our sample. While age is commonly cited as a determinant of driving behavior in existing literature, findings suggest that its impact may vary across different contexts or populations. Nonetheless, the absence of a significant relationship between age and driving behavior in the study does not negate the importance of age-related considerations in road safety initiatives. Rather, it underscores the need for nuanced and context-specific analyses to comprehensively understand the factors driving behaviors on the road. The chi-square matric box is given in Table 3.

Summary of Chi-square test of Driving Behavior and respondent's charactristics

		Factor 1						Factor 2				Factor 3				Factor 4	
		Items						Items				Items				Items	
		5	22	26	28	36	37	3	23	25	38	11	15	19	41	24	40
Gender	Pearson Chi-Square	24.291[a]	7.459[a]	16.937[a]	16.154[a]	23.348[a]	24.173[a]	5.079[a]	10.826[a]	3.724[a]	12.877[a]	2.342[a]	3.170[a]	7.253[a]	12.347[a]	2.059[a]	13.912[a]
	df	5	5	6	5	5	5	5	4	6	6	3	6	4	6	6	6
	Asymptotic Significance (2-sided)	0.000	0.189	0.010	0.006	0.000	0.000	0.406	0.029	0.714	0.045	0.505	0.787	0.123	0.055	0.914	0.031
	Phi	0.636	0.353	0.531	0.519	0.624	0.635	0.291	0.425	0.249	0.463	0.198	0.23	0.348	0.454	0.185	0.482
	Cramer's V																
Marital Status	Pearson Chi-Square	4.276[a]	14.397[a]	6.121[a]	12.807[a]	6.132[a]	10.594[a]	9.236[a]	9.581[a]	12.299[a]	10.247[a]	9.801[a]	9.821[a]	11.279[a]	15.917[a]	16.242[a]	4.315[a]
	df	5	5	6	5	5	5	5	4	6	6	3	6	4	6	6	6
	Asymptotic Significance (2-sided)	0.510	0.013	0.410	0.025	0.294	0.060	0.100	0.048	0.056	0.115	0.020	0.132	0.024	0.014	0.013	0.634
	Phi	0.267	0.49	0.319	0.462	0.32	0.42	0.392	0.4	0.453	0.413	0.404	0.405	0.434	0.515	0.52	0.268
	Cramer's V																
Education	Pearson Chi-Square	7.888[a]	19.115[a]	10.769[a]	8.076[a]	9.176[a]	14.203[a]	7.692[a]	27.522[a]	11.585[a]	20.789[a]	5.414[a]	21.261[a]	4.048[a]	36.233[a]	21.475[a]	30.427[a]
	df	15	15	18	15	15	15	15	12	18	18	9	18	12	18	18	18
	Asymptotic Significance (2-sided)	0.928	0.209	0.904	0.921	0.868	0.510	0.936	0.006	0.868	0.290	0.797	0.266	0.983	0.007	0.256	0.033
	Phi	0.209	0.326	0.245	0.212	0.226	0.281	0.207	0.391	0.254	0.34	0.173	0.344	0.15	0.449	0.345	0.411
	Cramer's V																
Age	Pearson Chi-Square	6.388[a]	10.122[a]	14.410[a]	12.552[a]	7.722[a]	11.646[a]	16.155[a]	18.338[a]	23.499[a]	20.292[a]	16.097[a]	16.786[a]	5.631[a]	24.276[a]	17.685[a]	27.307[a]
	df	15	15	18	15	15	15	15	12	18	18	9	18	12	18	18	18
	Asymptotic Significance (2-sided)	0.972	0.812	0.702	0.637	0.934	0.706	0.372	0.106	0.172	0.317	0.065	0.538	0.934	0.146	0.477	0.073
	Phi	0.188	0.237	0.283	0.264	0.207	0.254	0.3	0.319	0.361	0.336	0.299	0.305	0.177	0.367	0.313	0.389
	Cramer's V																
Experience	Pearson Chi-Square	14.523[a]	21.773[a]	36.432[a]	19.516[a]	38.509[a]	22.622[a]	33.482[a]	8.850[a]	19.670[a]	28.616[a]	32.427[a]	41.788[a]	39.263[a]	18.012[a]	22.079[a]	12.541[a]
	df	15	15	18	15	15	15	15	12	18	18	9	18	12	18	18	18
	Asymptotic Significance (2-sided)	0.486	0.114	0.006	0.191	0.001	0.093	0.004	0.716	0.352	0.053	0.000	0.001	0.000	0.455	0.228	0.818
	Phi	0.284	0.348	0.45	0.329	0.463	0.355	0.431	0.222	0.331	0.399	0.424	0.482	0.467	0.316	0.35	0.264
	Cramer's V																

Significant at a significance level 0.05 | Significant at a significance level 0.1

Table 3 Chi-square test summary

CHAPTER 6: CONCLUSION & RECOMMENDATIONS

The study's findings highlight distinct behavioral trends among drivers across different locales. Notably, the Transactional area of planned and unplanned city form (Subhash Nagar) stands out for its prevalent dangerous driving, aggressive behavior, and critical driving tendencies, indicating a heightened risk of road incidents in this area. In contrast, drivers in unplanned city form (Jahangirabad) exhibit a more moderate inclination towards such behaviors, suggesting a comparatively safer driving environment. Conversely, the Planned city form (Arera Colony) shows a concerning pattern of frequent violations, signaling a lax attitude towards adhering to traffic regulations in that locality.

Furthermore, the analysis underscores the significant impact of drivers' gender and marital status on critical driving behavior. It suggests that certain demographic factors play a pivotal role in shaping how individuals behave behind the wheel. Additionally, driving experience emerges as a significant determinant, particularly concerning aggressive driving tendencies. However, the study did not find any significant correlation between age and driving behavior, implying that age may not be as influential a factor in this context.

The study reveals distinct patterns of driving behavior across different urban areas. Subhash Nagar, acting as a transitional point between planned and unplanned zones, exhibits heightened levels of dangerous driving, aggressive behavior, and critical driving tendencies. In contrast, areas like Arera Colony and Jahangirabad demonstrate varying degrees of driving violations but may not exhibit the same level of aggressive or critical driving behaviors.

These findings underscore the need for tailored attention from traffic personnel and authorities in addressing driving behaviors in different city forms. Subhash Nagar, characterized by its transitional nature and higher risk profile, requires heightened focus and proactive measures to address prevalent driving behaviors. In contrast, while areas like Arera Colony and Jahangirabad may require attention, the nature of interventions may differ based on the specific driving behaviors observed.

To address driving behaviors such as critical and aggressive driving, education, and awareness programs are essential. Traffic personnel and authorities should conduct targeted campaigns to educate drivers about the risks and consequences of such behaviors. These programs can include workshops, seminars, and outreach initiatives aimed at raising awareness and promoting responsible driving practices. By enhancing drivers' understanding of the implications of their actions, these programs can help foster a culture of safety on the roads.

Strict enforcement of penalty rules is crucial for deterring dangerous driving behavior and violations. Authorities should ensure consistent and robust enforcement of traffic regulations, including penalties for offenses such as speeding, reckless driving, and traffic violations. By imposing consequences for non-compliance, authorities can send a clear message about the seriousness of traffic offenses and discourage motorists from engaging in risky behaviors.

Effective traffic management requires collaboration between various stakeholders, including government agencies, law enforcement, community organizations, and transportation authorities. Collaborative initiatives can involve joint efforts to implement education and awareness programs, improve infrastructure, and enhance enforcement measures. By working together, stakeholders can leverage their respective resources and expertise to address the multifaceted challenges of urban traffic management comprehensively.

Tailoring traffic management strategies to suit the unique characteristics of different urban areas is essential for promoting road safety and mitigating the risk of accidents. By understanding the driving behaviors prevalent in various city forms and implementing targeted interventions, traffic personnel, and authorities can create safer road environments and foster a culture of responsible driving among motorists. Through collaborative efforts, investment in infrastructure, and continuous evaluation, urban traffic management can be optimized to meet the evolving needs of modern cities and ensure the safety and well-being of all road users.

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Appendix 1: Questionnaire

DRIVER BEHAVIOUR QUESTIONNAIRE

Gender	Marital Status	Level of Education	Age	Driving Experience	Vehicle / CC	Locality of driving
Male ☐ Female ☐	Married ☐ Un Married ☐			Years		

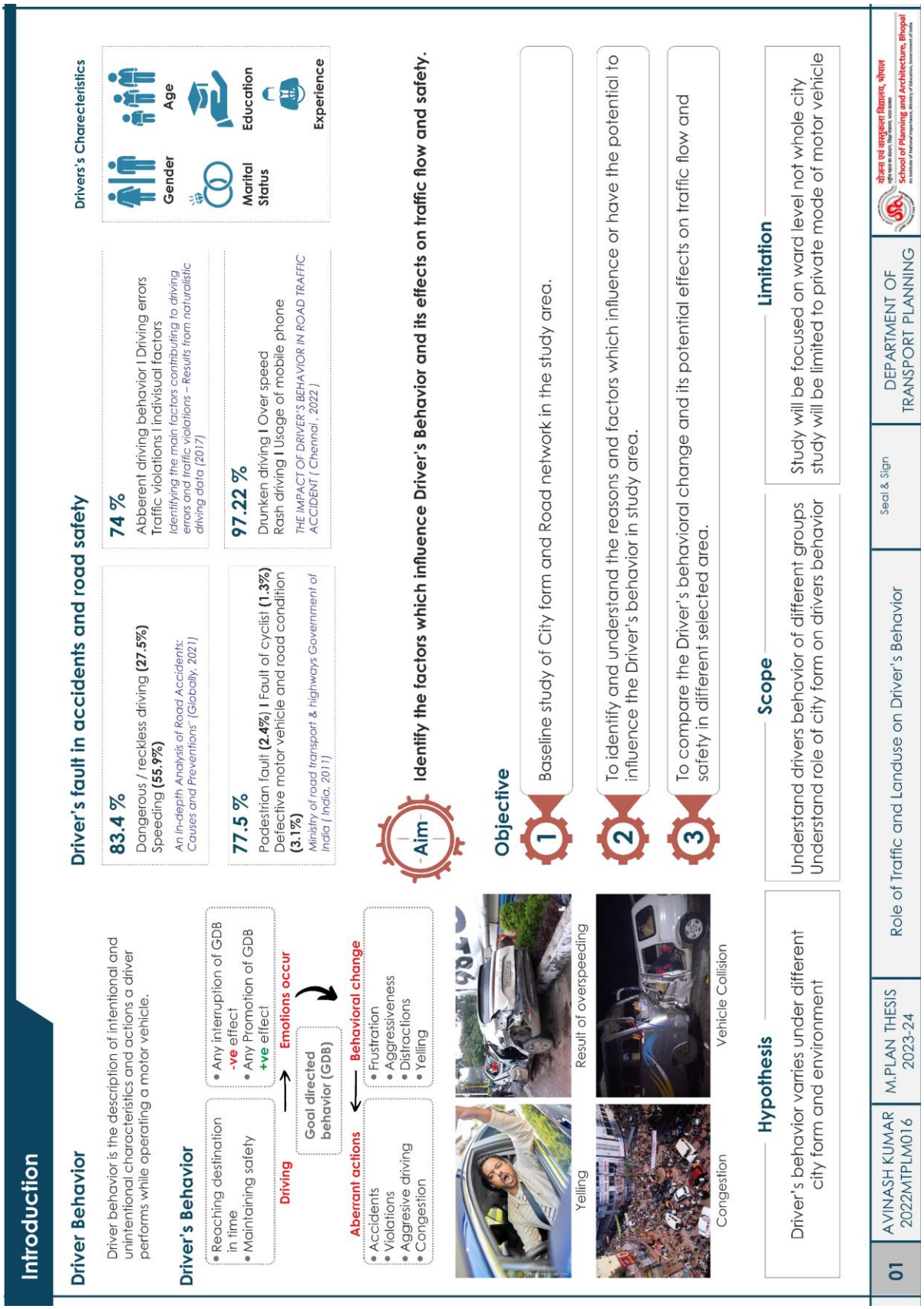
S.NO.	Question	1	2	3	4	5	6	7
1	मेन रोड से मुड़ते वक्त पैदल यात्री को नोटिस नही कर पाते							
2	रोड की सतह को सही से ना परख पाने की वजह से ब्रेक लगाने पर अनुमान से जादा दूरी तय कर जाते हैं							
3	गाड़ी तेज चलाने की वजह से गाड़ी रोड से बाहर हो जाती है							
4	ओवरटेक करते समय आने वाले वाहन की गति को कम आंकते है							
5	फिसलन भरी सड़क पर बहुत तेजी से ब्रेक लगाना और/या स्किड में गलत दिशा में गाड़ी चलाना।							
6	आपने गुस्से में कितनी बार दूसरे ड्राइवर का पीछा किया है?							
7	क्या आपने कभी किसी अन्य वाहन या ड्राइवर पर शारीरिक हमला किया है?							
8	गाड़ी चलाते समय आप कितनी बार अपना आपा खो देते हैं?							
9	आप कितनी बार बहुत धीमी गति से जा रही किसी कार/ट्रक को गलत तरीके से ओवरटेक कर जाते हैं?							
10	ट्रैफिक में फंसने पर आप कितनी बार चिढ़ जाते हैं?							
11	गाड़ी चलाते समय यात्री आपको कितनी बार शांत रहने के लिए कहते हैं?							
12	जब आपके सामने कोई वाहन बिना किसी कारण से धीमा हो जाता है तो क्या आप चिढ़ जाते हैं?							
13	ट्रैफ़िक से बचने के लिए आप कितनी बार शोल्डर लेन या मीडियन में गाड़ी चलाते हैं?							
14	आप कितनी बार नशे में गाड़ी चलाते हैं?							
15	आप कितनी बार ट्रैफिक नियमों का उल्लंघन करते हैं.							
16	आप कितनी बार महसूस करते हैं कि सड़क किनारे के संकेत महत्वपूर्ण हैं?							
17	आप कितनी बार गलत दिशा में गाड़ी चलाते हैं?							
18	आपको कितनी बार सही लेन में रहने और दूसरी लेन में चले जाने में परेशानी होती है?							
19	आप कितनी बार गति पर नियंत्रण बनाना भूल जाते हैं?							
20	आप कितनी बार अपने सामने वाले ड्राइवर से आवश्यकता से अधिक दूरी बनाए रखते हैं?							
21	क्या आप सामने वाली कार के इतने करीब गाड़ी चलाते हैं कि आपात्कालीन स्थिति में रुकना मुश्किल हो जाए।							
22	आप कितनी बार हॉर्न बजाकर अपने और दूसरी कारों के बीच दूरी बनाने की कोशिश करते हैं?							
23	आप कितनी बार अन्य ड्राइवरों को यह बताने के तरीके खोजने की कोशिश करते हैं कि वे आपको परेशान कर रहे हैं?							
24	आपको कितनी बार ट्रैफ़िक में शामिल होने में कठिनाई होती है?							
25	क्या आप गाड़ी चलाते समय अपने फ़ोन का उपयोग करते हैं?							
26	जब दूसरा ड्राइवर आपसे आगे निकल रहा हो तो क्या आप गति बढ़ा देते हैं?							
27	किसी ऐसे व्यक्ति से आगे निकलने का प्रयास करें जिस पर आपने ध्यान नहीं दिया हो कि वह दाईं ओर जाने का संकेत दे रहा है							
28	बाहर निकलने, लेन बदलने आदि से पहले अपने रियरव्यू मिरर की जांच करने में विफल रहें।							
29	मुख्य सड़क पर बायीं ओर मुड़ने के लिए कतार में, आप यातायात की मुख्य धारा पर इतना ध्यान देते हैं कि आप लगभग सामने वाली कार से टकरा जाते हैं							
30	ट्रैफिक सिग्नल पे क्याआप किसी दूसरे गाड़ी को पीछे छोड़ने के नियत से गाड़ी तेज चलते है							
31	किसी जंक्शन को यह जानते हुए पार करें कि ट्रैफिक लाइटें पहले ही आपके विरुद्ध हो चुकी हैं							
32	क्या आप बाएँ संकेत करते समय दाएँ मुड़ते हैं?							
33	आप कितनी बार ट्रैफिक पुलिस से बचते हैं?							

34	आप सड़क पर अन्य ड्राइवरों के प्रति कितनी बार नकारात्मक भावनाओं (निराशा, क्रोध, आदि) का अनुभव करते हैं?							
35	आप कितनी बार ऐसे व्यवहार में संलग्न होते हैं जिन्हें अन्य ड्राइवरों के प्रति आक्रामक या शत्रुतापूर्ण माना जा सकता है (जैसे, चिल्लाना, अशिष्ट इशारे करना)							
36	आप कितनी बार मौखिक अपमान, चिल्लाहट या असभ्य इशारों के माध्यम से अन्य ड्राइवरों के प्रति अपनी झुंझलाहट या घबराहट व्यक्त करते हैं							
37	ट्रैफिक जाम मे आप इधर उधर से निकालने की कोसिस करते है							
38	ट्रैफिक जाम मे दूसरी गाड़ी आपके सामने से इधर उधर से निकले की कोसिस करती है							
39	सिग्नल पर दूसरी गाड़ी को रेड लाइट मे सिग्नल क्रॉस करते देख कर आप भी सिग्नल क्रॉस करते है							
40	ट्रैफिक जाम से निकलने के बाद आप गाड़ी के दिये हुए गति सीमा से अधिक तेज चलते है							
41	दूसरे चालक को नियम का पालन ना करते देख कर आप भी नियम का पालन नही करते है							
42	ट्रैफिक सिग्नल पर हरि बती के आखिरी 1 से 2 सेकंड या पीली बती पर तय नही कर पाते की सिग्नल क्रॉस करे या नही							

Where, 1: बिलकुल भी नहीं, 2: कभी नहीं, 3: कभी-कभी, 4 अक्सर, 5: बार-बार, 6: लगभग हर बार, 7: हर बार

*Note: This Survey is intended to fulfill the academic purpose only

Appendix 2: Sheet 1



Appendix 3: Sheet 2

Literature Review

Title of the paper	Authors	Year	Takeaways
Studies of Driver behaviors and Traffic Flow Characteristics at Roadway Intersections	Qiang Yang	2012	• countdown timers study was performed in China about their influences on driver behavior. • It was found that the presence of countdown timers may encourage yellow running behavior and late entry into intersection. • Driver behavior and traffic characteristics are heavily associated with the local conditions like the culture.
Analysis of the Driver's Behavior Characteristics in Low Volume Freeway Interchange	Ronghua Wang, Jiangbi Hu	2016	This paper has examined the drivers' behavior characteristics when driving across expressway interchanges through field test and found: • drivers will recognize the exit direction guide in a certain advanced distance. • driver needs 10 s–15 s to achieve a stable traveling condition after merge point.
Methods for Analysis of Naturalistic Driving Data in Driver Behavior Research	JONAS BÄRGMAN	2016	• Driver Self Report Data – Interview & Questionnaire. • In-Depth crash investigation – Previous crash data analysis. • Driving Simulator Study – Data collected in highly controlled environment. • Naturalistic Driving Studies (NDS) - Data collected in without experimental environment.
A Survey on Modeling of Driver Behavior for Tier II City of India	Parag M. Dhoble, Bhalchandra khode	2016	• Drivers were classified in four age groups these age group are less than 16 year, 16-30 year, 30-50 year and above 50 years. • The teenagers' driver generally not follows the traffic rule and due to which rule violation occurs
Gap acceptance behavior of drivers at uncontrolled T-intersections under mixed traffic conditions	Manish Dutta, Mokaddes Ali Ahmed	2017	• The purpose of study was to model gap acceptance behavior of drivers and to find the critical gaps which are widely used in the intersection operational analysis and capacity estimates. • It was that drivers behave aggressively because of their lack of respect for traffic rules, rather than due to drivers losing his patience because of unavailability of a suitable gap.
Driver behavior as Road Safety Indicator– A Case Study of Gorakhpur, Uttar Pradesh, India	Ashutosh Gupta, A. K. Mishra	2020	• Study was aims to find the Driving behavior patterns of road users. • young male drivers have higher tendency to do ordinary errors and aggressive violations
Influence of traffic congestion on driver behavior in post-congestion driving	Guofa Li, Waijain Lai	2020	• Research examined the influence of traffic congestion on driver behavior on the post-congestion roads. • The results showed that driver behavior in post-congestion situations became more aggressive, more focused in the forward area but less focused in the dashboard area, the clustering results showed more aggressive and lack-of-aware response patterns while driving in post-congestion situations.
Analysis of factors influencing aggressive driver behavior and crash involvement	Anusha Avadikottu, Nagendra R Velaga	2021	• Research focused on quantifying the effect of aggressive driver behavior on crash probability. • Compared to female drivers, male drivers were 2.57 times more likely to engage in aggressive driving. • The results revealed that in addition to age and gender personality traits were significant predictors of driving aggression. • The driver's marital status was negatively correlated with the crash involvement and professional drivers were more likely to be involved in crashes than nonprofessional drivers.

Variable

Gender, Age, Marital status, Education, Driving experience

Parameters

Drivers Errors, Drivers aggression, Critical driving, Dangerous driving, Traffic rue violations

Method of assessing drivers behavior

Self reported data (Drivers behavior questionnaire)

Survey Questions

Analysis method

Factor analysis (principal component analysis)

Chi square test

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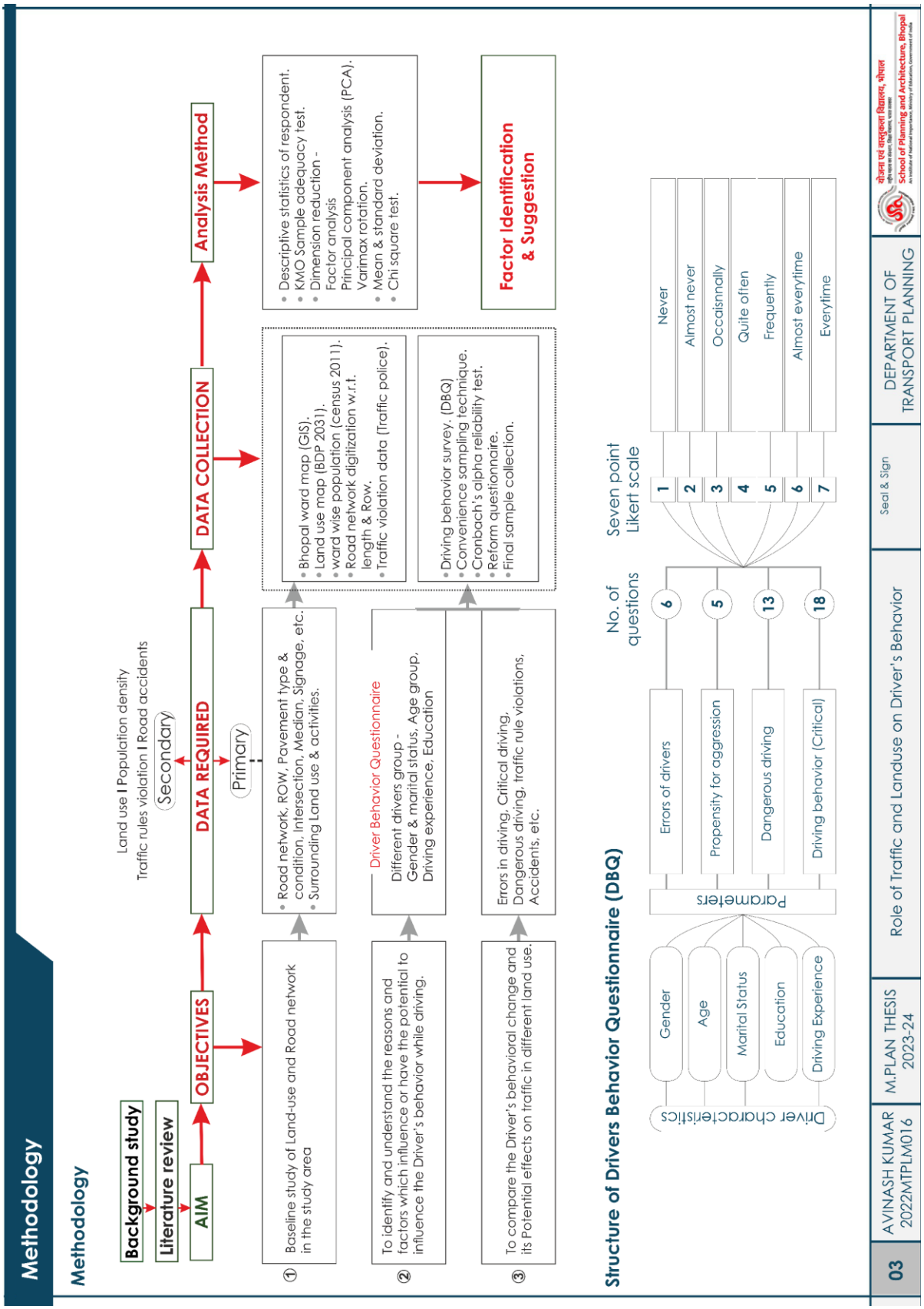
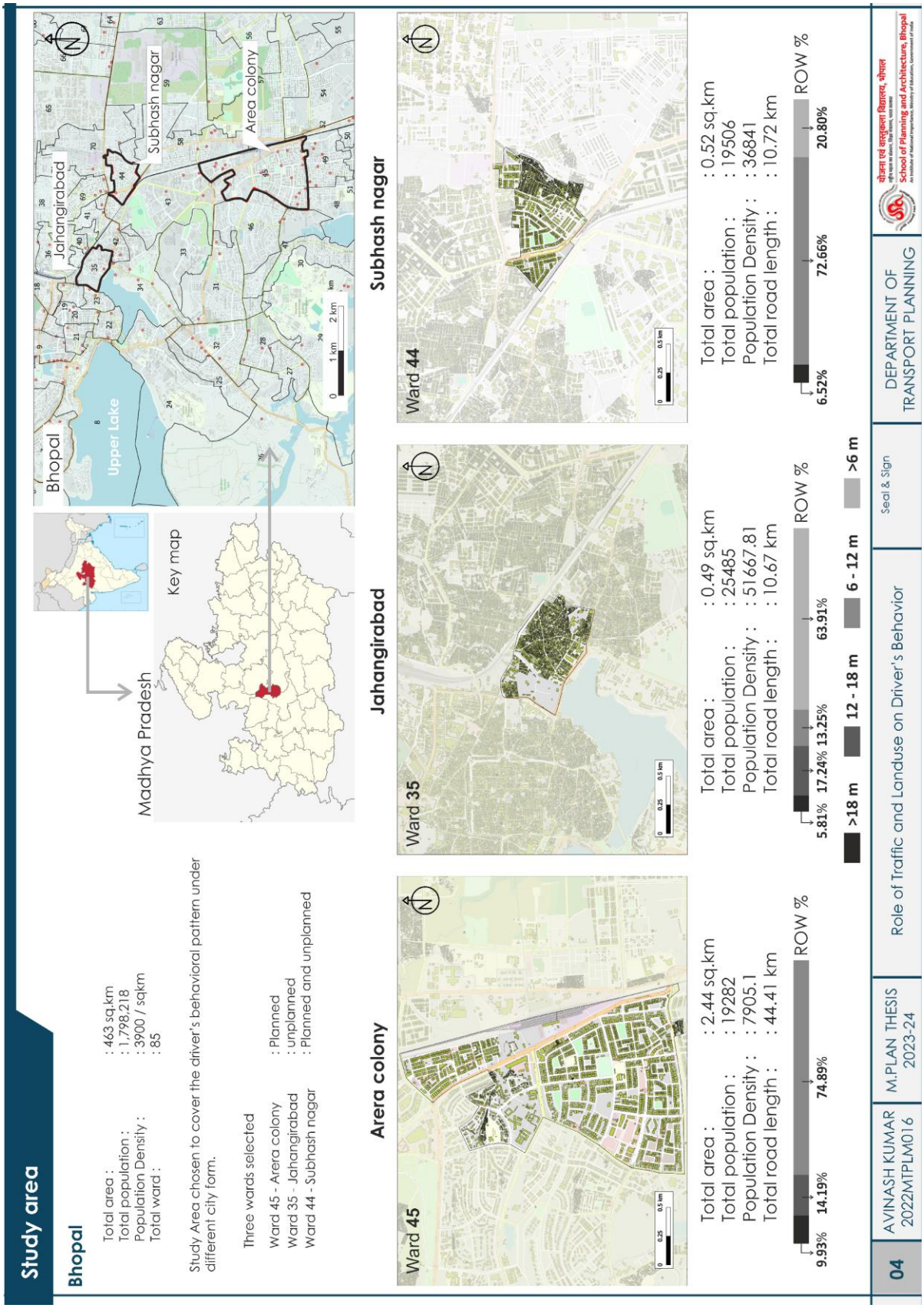
Appendix 4: Sheet 3

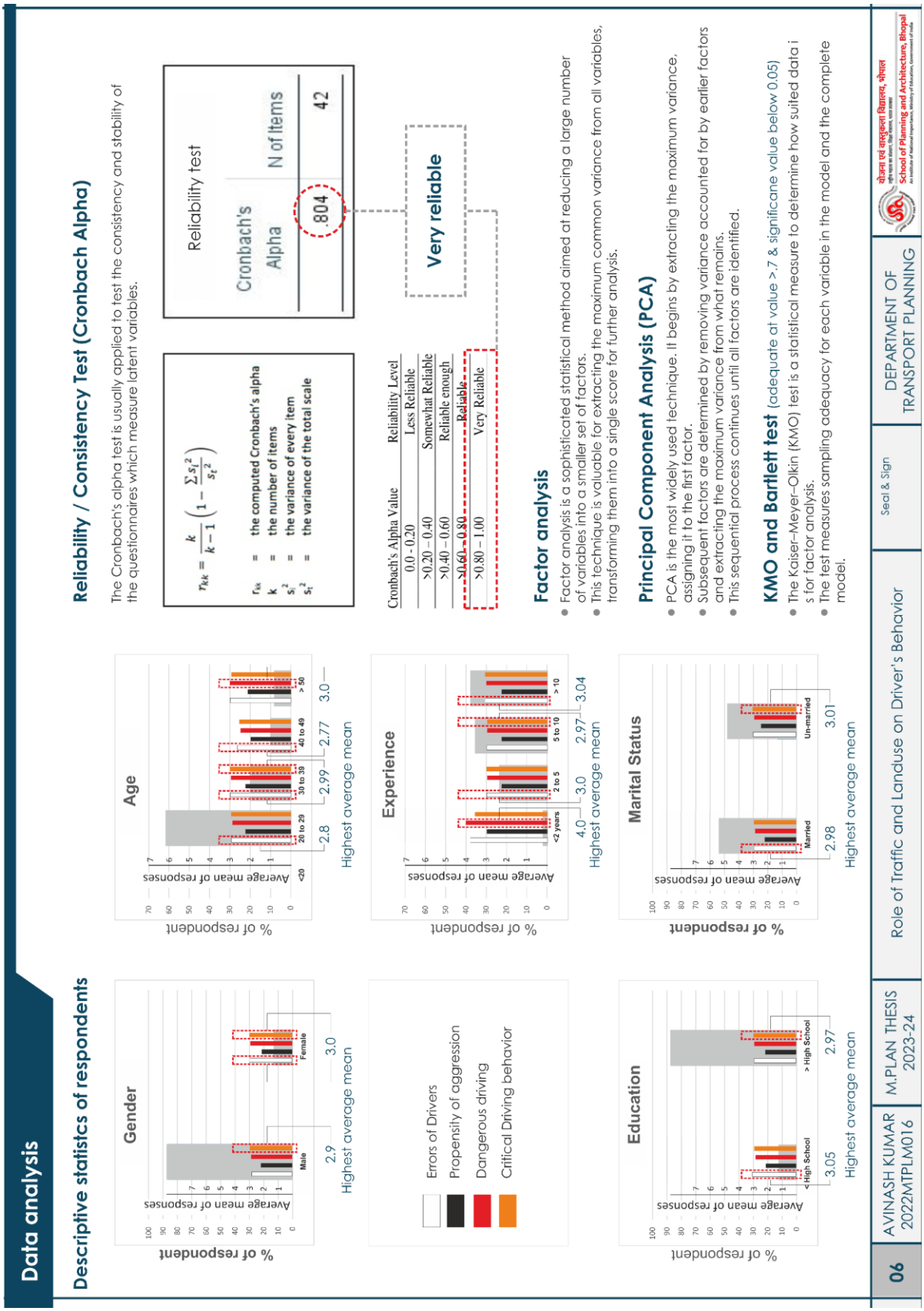


Appendix 5: Sheet 4

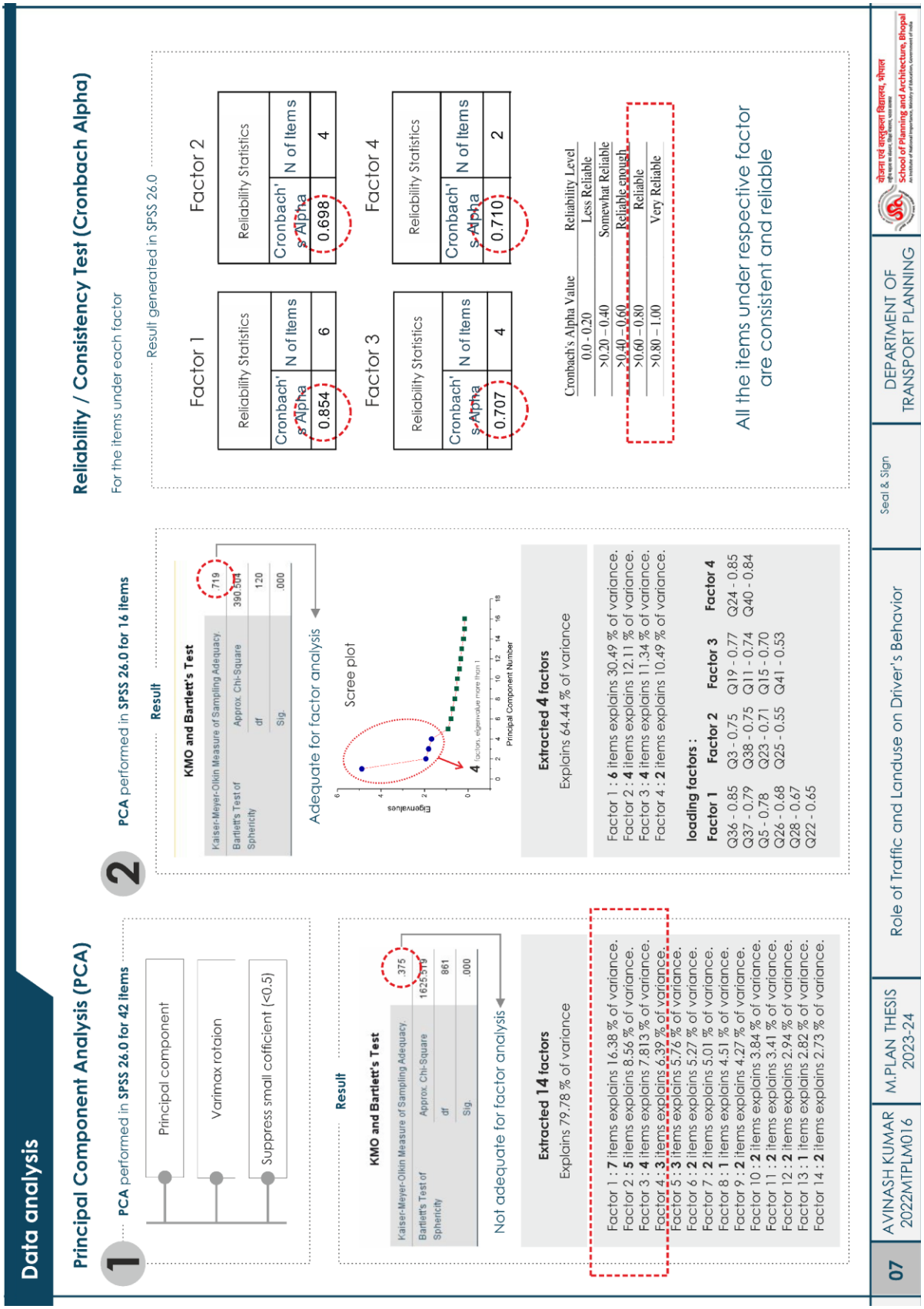


Appendix 6: Sheet 5

Appendix 7: Sheet 6



Appendix 8: Sheet 7



Appendix 9: Sheet 8

Data interpretation

Descriptive analysis on drivers behavior

Low tendency | Moderate tendency | High tendency

Factor 1 : Critical driving behavior

	Factor1	Overall Mean	Overall SD	Arera colony Mean	Arera colony SD	Jahangirabad Mean	Jahangirabad SD	Subhash nagar Mean	Subhash nagar SD
	Factor1	2.48		2.14		2.60		2.69	
5	फिसलन भरी सड़क पर बहुत तेजी से ब्रेक लगाना और/या स्किड में गलत दिशा में गाड़ी चलाना।	2.75	1.310	2.55	1.234	2.85	1.387	2.85	1.348
22	सिग्नल पर दूसरी गाड़ी को रेड लाइट मे सिग्नल क्रॉस करते देख कर आप भी सिग्नल क्रॉस करते है	2.77	1.544	2.40	1.501	2.75	1.482	3.15	1.631
26	आप कितनी बार गति पर नियंत्रण बनाना भूल जाते हैं?	2.60	1.597	1.80	1.005	2.85	1.814	3.15	1.599
28	क्या आप सामने वाली कार के इतने करीब गाड़ी चलाते हैं कि आपात्कालीन स्थिति में रुकना मुश्किल हो जाए।	2.37	1.193	2.20	1.152	2.25	1.333	2.55	1.050
36	मुख्य सड़क पर बायीं ओर मुड़ने के लिए कतार में, आप यातायात की मुख्य धारा पर इतना ध्यान देते हैं कि आप लगभग सामने वाली कार से टकरा जाते हैं	2.17	1.076	2.05	0.510	2.4	1.392	2.05	1.146
37	ट्रैफिक सिग्नल पे क्याआप किसी दूसरे गाड़ी को पीछे छोड़ने के नियत से गाड़ी तेज चलते है	2.25	1.297	1.85	0.745	2.5	1.504	2.4	1.465

Factor 2 : Dangerous driving behavior

	Factor2	Overall Mean	Overall SD	Arera colony Mean	Arera colony SD	Jahangirabad Mean	Jahangirabad SD	Subhash nagar Mean	Subhash nagar SD
	Factor2	2.64		2.13		2.60		3.39	
3	गाड़ी तेज चलाने की वजह से गाड़ी रोड से बाहर हो जाती है	2.63	1.402	2.20	1.056	2.75	1.293	2.95	1.731
23	ट्रैफिक जाम से निकलने के बाद आप गाड़ी के दियें हुए गति सीमा से अधिक तेज चलते है	2.63	1.073	2.05	0.945	2.5	0.827	3.35	1.040
25	आपको कितनी बार सही लेन में रहने और दूसरी लेन में चले जाने में परेशानी होती है?	2.93	1.471	2.55	1.191	2.45	0.686	3.8	1.908
38	किसी जंक्शन को यह जानते हुए पार करें कि ट्रैफिक लाइटें पहले ही आपके विरुद्ध हो चुकी हैं	2.37	1.193	1.70	1.031	2.7	1.261	3.45	2.114

Factor 3 : Aggresive driving behavior

	Factor3	Overall Mean	Overall SD	Arera colony Mean	Arera colony SD	Jahangirabad Mean	Jahangirabad SD	Subhash nagar Mean	Subhash nagar SD
	Factor3	2.53		2.09		2.54		2.98	
11	आप कितनी बार मौखिक अपमान, चिल्लाहट या असभ्य इशारों के माध्यम से अन्य ड्राइवरों के प्रति अपनी झुंझलाहट या घबराहट व्यक्त करते हैं	2.22	0.715	1.95	0.605	2.2	0.523	2.5	0.889
15	गाड़ी चलाते समय यात्री आपको कितनी बार शांत रहने के लिए कहते हैं?	2.05	1.307	1.35	0.587	2	1.338	2.8	1.436
19	आप कितनी बार ट्रैफिक नियमों का उल्लंघन करते हैं.	2.05	1.016	1.60	0.754	2	0.973	2.55	1.099
41	ट्रैफिक जाम मे आप इधर उधर से निकालने की कोसिस करते है	3.82	1.384	3.45	1.191	3.95	1.432	4.05	1.504

Factor 4 : Violations

	Factor4	Overall Mean	Overall SD	Arera colony Mean	Arera colony SD	Jahangirabad Mean	Jahangirabad SD	Subhash nagar Mean	Subhash nagar SD
	Factor4	3.28		3.68		2.98		3.18	
24	दूसरे चालक को नियम का पालन ना करते देख कर आप भी नियम का पालन नही करते है	3.00	1.636	3.20	2.042	2.6	1.465	3.15	1.387
40	आप कितनी बार ट्रैफिक पुलिस से बचते हैं?	3.55	1.478	4.15	2.059	3.35	0.988	3.2	1.105

Findings :

- Subhash nagar respondent has the high tendency towards aggressive, dangerous and critical driving behavior with the average mean 2.69, 3.39 and 2.98 respectively.
- Arera colony respondent has the high tendency towards violations with average mean 3.68.

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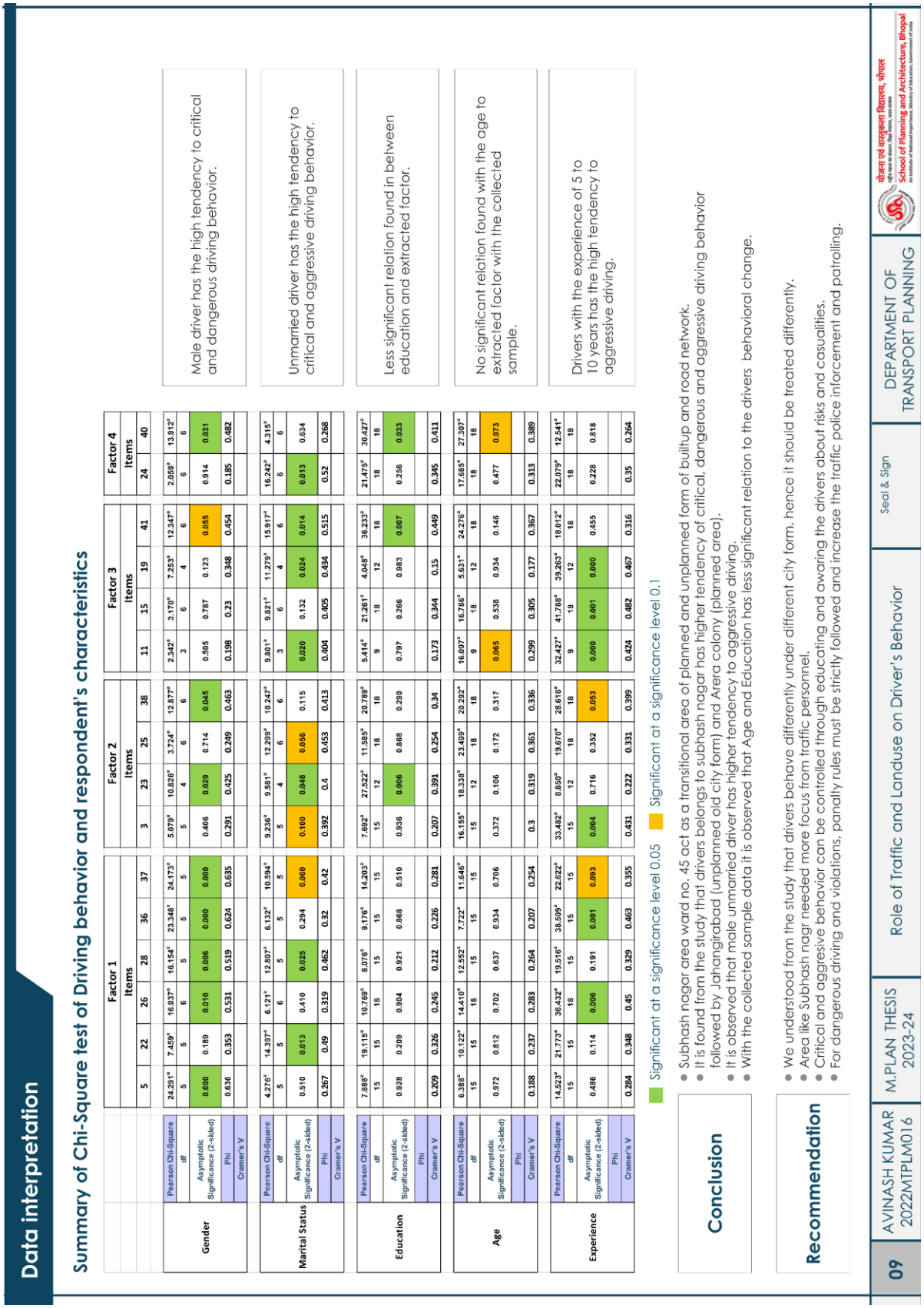
Appendix 10: Sheet 9



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