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College of Engineering

Department of Mechanical Engineering

A Strategic Framework for Managing a Sustainable Transition to Smart Mobility for Future Smart Cities in KSA

A Thesis Submitted in Partial Fulfilment of the Requirements for the Doctorate Degree in Engineering Management

Submitted by
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20190147

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University of Bahrain
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A Strategic Framework for Managing a Sustainable Transition to Smart Mobility for Future Smart Cities in KSA

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Defense Committee's Approval Page

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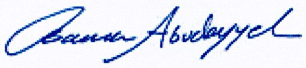
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Abstract

The urban population of Saudi Arabia is growing with few available modes of transportation. In turn, its cities are relying substantially on the cars. Saudi Arabia is intending to invest in alternative mobility options to cater ever growing transportation needs. Despite efforts being made by government towards smart mobility as an alternative mode, there are no comprehensive studies carried out in KSA for proposing framework design to integrate smart mobility into current transportation system. This study aims to develop a comprehensive framework identifying smart mobility solutions, their challenges and all the major KSA initiatives and stakeholders toward smart mobility. After a comprehensive literature review, detailed research of government plans, initiatives and programs were selected to identify government's future plans and their selected smart solutions for achieving the goal of smart mobility based network. Questionnaire survey for common users (User survey) and mobility experts (Supplier survey) was used for the feedback towards smart mobility solutions.

It was found that public transport along with the autonomous vehicles and shared mobility are among the preferred smart solutions from the important government funded initiative programs. Some of the important findings from the research methodology show that the governance failures such as lack of integration between institutes, outdated polices and challenges of developmental costs cause complications and inefficiency of the smart mobility paradigm, especially at the implementation level. Interestingly, majority of the responders also said they would prefer cars for their personal trips due to car dependency for many years. Most unprepared organization for the smart mobility comes out to be private logistic companies. The multiple criteria decision analysis (MCDA) model was also created based on the inferred criteria from the choices of expert and common users. The result of the analysis cites safety as one of the most important aspects of smart mobility. Mobility experts also suggested to start with the Pilot projects for the smart mobility solutions before wide scale implementation. Lastly comprehensive framework was developed using study results for achieving transition towards smart mobility solutions with better understanding and clarity. The framework was further validated by key decision maker in transportation from government and private sector.

الملخص

يتزايد عدد سكان المدن الحضرية في المملكة العربية السعودية مع وجود عدد قليل من وسائل النقل المتاحة بالمدن. وفي المقابل، تعتمد مدنها بشكل كبير على السيارات. تعتزم المملكة العربية السعودية الاستثمار في خيارات التنقل البديلة لتلبية احتياجات النقل المتزايدة باستمرار. وعلى الرغم من الجهود التي تبذلها الحكومة نحو التنقل الذكي كوسيلة بديلة، لا توجد دراسات شاملة أجريت في المملكة العربية السعودية لاقتراح تصميم إطار لدمج التنقل الذكي في نظام النقل الحالي. تهدف هذه الدراسة إلى تطوير إطار عمل شامل لتحديد حلول التنقل الذكي وتحدياتها وجميع المبادرات الرئيسية في المملكة العربية السعودية وأصحاب المصلحة تجاه التنقل الذكي. وبعد مراجعة شاملة للدراسات السابقة، تم اختيار بحث مفصل للخطط والمبادرات والبرامج الحكومية لتحديد الخطط المستقبلية للحكومة والحلول الذكية المختارة لتحقيق هدف الشبكة القائمة على التنقل الذكي. تم استخدام استبيان للمستخدمين العاديين (استبيان المستخدم) وخبراء التنقل (استبيان الموردين) لابداء المرئيات على حلول التنقل الذكية.

وجد أن وسائل النقل العام إلى جانب المركبات ذاتية القيادة والتنقل المشترك من بين الحلول الذكية المفضلة من برامج المبادرات الهامة الممولة من الحكومة. حيث تظهر بعض النتائج المهمة من منهجية البحث أن إخفاقات الحوكمة مثل عدم التكامل بين المؤسسات والسياسات القديمة وتحديات تكاليف التطوير تسبب تعقيدات وعدم كفاءة نموذج التنقل الذكي، خاصة على مستوى التنفيذ. ومن المثير للاهتمام أن غالبية المشاركين بالاستبيان قالوا أيضًا إنهم يفضلون السيارات لرحلاتهم الشخصية وذلك بسبب الاعتماد على السيارة لسنوات عديدة. وتأتي معظم المؤسسات غير المستعدة للتنقل الذكي لتكون شركات لوجستية خاصة. تم أيضًا إنشاء نموذج تحليل القرار المتعدد المعايير (MCDA) وبناءً على المعايير المستخلصة من اختيارات الخبراء والمستخدمين العاديين. وتشير نتيجة التحليل إلى السلامة المرورية أحد أهم جوانب التنقل الذكي. حيث اقترح خبراء التنقل أيضًا البدء بالمشاريع التجريبية لحلول التنقل الذكية قبل التنفيذ على نطاق واسع. أخيرًا تم تطوير إطار عمل شامل باستخدام نتائج الدراسة لتحقيق الانتقال نحو حلول التنقل الذكي بفهم ووضوح أفضل. وتم مراجعة الإطار من قبل متخصصين من صناع القرار من الجهات الحكومية والقطاع الخاص.

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List of Content

Defense Committee's Approval Page ..... A

Abstract ..... B

الملخص C

Acknowledgement Letter ..... D

List of Content ..... E

List of Figures ..... H

List of Tables ..... J

Abbreviation ..... K

Chapter One: Introduction to the Study 1

1.1 Introduction 2

1.2 Research Problem 5

1.3 Research Goal and objectives 6

1.4 Research methodology 6

Chapter Two: Literature review 10

2.1 Benefits from literature review 21

2.2 Research Gaps 22

2.3 Executive Summary 24

Chapter Three:Smart Mobility Ecosystem and Associated Challenges 27

3.1 Elements of Smart Mobility Ecosystem 30

3.1.1 Intelligent Transportation system (ITS) 30

3.1.2 Shared Mobility for Urban Area 39
3.2 Potential Challenges for the Design Ecosystem 41
3.2.1 ITS – IoT 41
3.2.2 ITS – Autonomous Vehicles 44
3.2.3 Challenges for Shared Mobility in Urban Area 45
3.2.4 Public Transport 50
3.3 Identifying Stakeholders 52
Chapter Four:Methodology and Procedures 53
4.1 Framework Design Methodology 54
4.2 Critical Review 56
4.2.1 National Spatial Strategy (NSS) 57
4.2.2 National Transport and Logistics Strategy (NTLS)/Model 59
4.2.3 Integration between Transport Planning And Management and Multi Dimensions Of Urban Planning Of Saudi Arabia (ITUP) 61
4.3 Questionnaire Survey 62
4.3.1 Development of Online Questionnaire Survey 63
4.3.2 Data Collection through Online Questionnaire Survey 64
4.3.3 Research Questions 65
4.4 Multiple Criteria Weight Selection 67
Chapter Five:Results and Discussion 70
5.1 Results and Discussion – Critical Review 71
5.1.1 Analysis of Key Findings from the Research Methodology 81

5.1.2 Ranking Based On Priority in Government Programs.....82
5.1.3 Projects and Initiatives under Government Programs 82
5.2 Results and Discussion – Questionnaire Survey.....85
5.3 Results and Discussion – Multiple criteria analysis.....118
5.4 Roadmap and Framework Towards Smart Mobility.....121
5.5 Validation of the Developed Framework.....123
5.5.1 Results of Validation Questionnaire.....124
Chapter Six: Conclusions and Recommendations 127
6.1 Conclusions and Contributions 128
6.2 Recommendations and Future.....130
6.3 Future Study.....132
References.....133
Appendix.....142

List of Figures

Figure 3.1: Smart Mobility Ecosystem 29
Figure 3.2: Variable Message Sign 34
Figure 3.3: Dynamic Posted Speed Sign.....35
Figure 3.4: Test Bed Traffic Control Center at University of Utah.....37
Figure 3.5: Summarized challenges for each smart mobility element..41
Figure 4.1: Selection of Criteria and modes for framework design.....56
Figure 4.2: Spatial Frame of Saudi Arabia for 2030 57
Figure 4.3: NSS 2030 Framework of moving forward 58
Figure 4.4: Chapters of NSS Policies.....59
Figure 4.5: Five main tech themes under NTLS Model.....59
Figure 4.6: Four Key identifiers by ITUP 61
Figure 4.7: Structure of Online Questionnaire Survey.....64
Figure 4.8: Hierarchy Model for smart mobility variables 68
Figure 5.1: NSS Main Key Points.....73
Figure 5.2: NTLS Main Key Points 76
Figure 5.3: ITUP Main Key Points 79
Figure 5.4: Ranking based on priority and frequency.....82
Figure 5.5: Working sectors of the participants 88
Figure 5.6: Opinion survey regarding the existing Transport system...89
Figure 5.7: Opinion survey regarding the existing Transport system...91
Figure 5.8: Choice of common users for alternative mobility solution 93
Figure 5.9: Ranking based on the choice of participants 93
Figure 5.10: Ranking of mobility solutions by common user.....94
Figure 5.11: Participants preference of traveling within city.....95
Figure 5.12: Working sectors of the participants 100

Figure 5.13: Role of the expert's organization in smart mobility initiatives 101
Figure 5.14: Opinion survey - the existing Transport system 103
Figure 5.15: Choice of expert users for alternative mobility solution 105
Figure 5.16: Ranking of mobility solutions by expert users 105
Figure 5.17: Ranking of mobility solutions by expert users 107
Figure 5.18: Participants preference of traveling within city 109
Figure 5.19: Mobility solution projects offered or planned by stakeholders' organizations 111
Figure 5.20: Comparison between public and private sector – Future projects 112
Figure 5.21: Challenges associated with the smart mobility solution. 113
Figure 5.22: Comparison between public&private sector-Challenges 114
Figure 5.23: Readiness of mobility suppliers 115
Figure 5.24: Effect of Covid-19 on the progress of smart mobility projects 117
Figure 5.25: Effect of Covid-19 on the progress of smart mobility projects 118
Figure 5.26 Smart Mobility Roadmap 121
Figure 5.27 Smart Mobility Executed Framework 123

List of Tables

Table 3.1: Stakeholders associated with the elements of Smart Mobility Ecosystem 52
Table 4.1: Selected Criteria for AHP analysis. 67
Table 5.1: NSS Smart Solutions vs. Thesis Study Smart solutions 74
Table 5.2: NSS Smart Solutions vs. Thesis Study Smart solutions 77
Table 5.3: ITUP Smart Solutions vs. Thesis Study Smart solutions.....80
Table 5.4: Frequency of Smart mobility elements in different government plans/programs 81
Table 5.5: Demographic Frequency Table – User Survey Result.....87
Table 5.6: Need of Different alternative mobility solution 92
Table 5.7: Demographic Frequency Table – Supplier Survey Result...98
Table 5.8: Decision makers and their Organizations 102
Table 5.9: Decision makers and their Organizations 102
Table 5.10: Comparison of ranking between user & supplier survey.106
Table 5.11: Comparison of ranking between user & supplier survey.108
Table 5.12: Cross table analysis between traveling preference and decision makers 109
Table 5.13: Opinions for Alternative mobility solutions helping congestion and safety 110
Table 5.14: Decision makers and the contribution potential of their organizations 115
Table 5.15: Best placed organizations selected by expert users 116
Table 5.17: Ranking of variables based on weightage.....120

Abbreviation

(AHP) Analytic hierarchy process

(AVs) Autonomous Vehicles

(CTAC) Combined Traffic Assignment and Control

(KSA) Kingdom of Saudi Arabia

(KPIs) Key performance indicators

(ICT) Information and communication technology

(IoT) Internet of things

(ITUP) Integration between transport planning & management & multi-dimensions urban planning of KSA

(ITS) Intelligent Transportation system

(MOI) Ministry of Interior

(MOT) Ministry of Transport

(NTLS) National Transport and Logistics services strategy

(NSS) National Spatial Strategy

(PuT) Public transport

(SDA) Sharqia Development Authority

(SC) Smart City

(SM) Smart mobility

(STC) Saudi Telecom Company

(TGA) Transport General Authority

(TMSs) Traffic management systems

Chapter One

Introduction to the Study

1.0 Introduction

1.1 Research Problem

1.2 Research Goal and Objectives

1.3 Research Methodology

Chapter One: Introduction to the Study

1.1 Introduction

According to United Nation, the population in urban cities is expected to amount to 66% of the world population by 2050 (Surdonja, Giuffre, & Deluka-Tibljas, 2020). Urban cities worldwide are pushing for the transformation of existing urban centers to the smart cities through the adoption of smart city concepts and technologies (Lim, Kim, & Maglio, 2018). The smart city concept is not yet well defined globally. A smart city is a well-functioning city built on technology and citizens' awareness of different aspects, such as people, governance, mobility, economy, and the environment (Tarek & Nasreldin, 2023). Using innovation and technology, smart cities solve urban issues such as land use, public services, infrastructure, environmental pollution, and mobility challenges in urban areas (Hajduk, 2016). According to Caragliu, et al (2009), information and communication technology (ICT) infrastructure along with traditional transportation and human capital are the keys to smart cities. Thus within the context of smart cities, the use of ICTs in urban transportation has played a prominent role in promoting smart mobility. Digital revolution and the transport sector have converged to form the concept of smart mobility (Sourbati & Behrendt, 2021). Smart mobility is multi-faceted and has recently piqued the interest of local authorities and several other stakeholders who are involved in city planning and development (Tomaszewska & Florea 2018; Lim, Kim, & Maglio, 2018). In this regard, Porru, et al (2020) suggest that smart mobility can improve sustainability, minimize carbon solutions, improve quality of life, and reduce traffic and parking challenges. Smart mobility includes connected and

autonomous vehicles, public transport, mass transit, biking, walking, and shared mobility (Noy & Givoni, 2018). The literature indicates that smart mobility is well recognized as an important component of the transformation of urban areas into smart cities.

Global urbanization is expected to increase the number of vehicles by 2030 to more than two billion, driving the recent development of smart mobility. (Sommer, Dargay & Gately, 2007). According to the World population prospect report in 2022, the population of Saudi Arabia in the year 2000 was 20,663,840 and since then the population had reached 35,340,680 in the year 2021 (United Nations, 2022). The decentralization of jobs increases mobility and ownership of vehicles (Aldalbahi & Walker, 2015). Hence, there is an increase in urban development. Therefore, most national and local government authorities and city planners are keen to adopt information and communication technologies (ICT) solutions for the effective management of the public affairs (Guevarra & Cheein, 2020). Saudi Arabian urban cities present unique challenges when considering the desire for including Saudi Vision 2030 and addressing the needs and impacts of transitioning into smart mobility concepts and modes. Kingdom of Saudi Arabia (KSA) population is heavily dependent on private vehicles as the primary transportation mode in urban cities. In addition, various government authorities will have to combine their parts of the mobility service in one integrated platform. By implementing smart mobility policies and initiatives, that have been successfully implemented elsewhere, Saudi Arabia can achieve its vision of a smart society (Alanazi, 2023).

The advent of information technology and the Internet has rapidly transformed societies and led to urbanization. This population shift has

resulted in multiple problems and issues in urban areas, such as energy consumption, traffic, waste treatment, and pollution (Benevolo, Dameri, & D'Auria, 2016). The increased congestion in cities has also affected people's mobility. As a result, smart mobility has become increasingly popular, especially in the transport and planning fields. This approach seeks to restructure conventional mobility, which has become a problem due to the resultant rapid congestions and its focus on traffic and roads rather than people (Papa & Lauwers, 2015). In this regard, smart mobility employs information communication technology (ICT) to enhance access to transport services (Docherty, Marsden, & Anable, 2018). As a result, more countries have begun plans to shift to smart mobility in urban settings.

Smart mobility research is growing, but few studies have explored how it can address associated key challenges. Smart mobility requires supportive policies, regulations, and governance structures to maximize its benefits while addressing key challenges and issues (Butler et al., 2020). The smart mobility transition is a long and intricate process that requires in-depth planning and partnerships between governments, public, and private stakeholders (Benevolo et al., 2016). Similarly, the integration of smart mobility innovations as a solution to associated key challenges is often treated as separate entities with only a few comprehensive attempts to conceptualize how they can contribute to or alleviate these issues. (Golbabaei et al., 2016). According to Munhoz et al. (2020), the government has to be proactive and invest in smart and sustainable transport solutions. On the other hand, private partners, such as technology companies, need to create the necessary systems that will support the shift. Intelligent and dynamic decision-making approaches are also essential as smart mobility issues often change in real-

time. Likewise, the government's policy-making bodies are necessary to ensure adequate laws that protect people's information.

A critical component of the present research is its contribution to the ongoing research on managing the transition to smart mobility in order to achieve the transformation towards the future smart city in Saudi Arabia, or any other car-dependent country. By reviewing the literature in a systematic manner, this study seeks to answer the frequently asked research questions for applying smart mobility such as, what are the main attributes and dimensions of smart urban mobility, which stakeholders and tools are involved in each phase of smart mobility and which challenges, and opportunities occur when they try to apply smart mobility (Simonofski et al., 2023; Tarek & Nasreldin, 2023; Butler et al., 2020; Francini et al., 2021).

1.2 Research Problem

Saudi Arabia's urban cities are growing and developing fast due to the fact that people are moving from rural areas to urban cities for jobs, education, and health care etc. The population of urban cities are growing with limited transportation options. Saudi government and decision makers are investing in smart mobility such as Riyadh metro, public transport, autonomous vehicles, and shared and sustainable mobility options. Such projects involve many stakeholders thus imposing key issues and challenges to manage and achieve desire future direction. Literature shows that generally, smart mobility projects lack standardized metrics and methodologies for assessing, prioritizing, financing, implementing, managing and replicating them. Moreover, there is no framework found in the present literature, which can facilitate the transition to smart mobility options for a city, taking into account infrastructure and behavioral changes. Therefore, the research question for

this present study is how to create an optimum framework for shifting to smart mobility, in order to manage a sustainable transition to smart mobility in Saudi's urban cities.

1.3 Research Goal and Objectives

The main goal of this PhD thesis is to develop an optimum strategic framework for managing a sustainable transition to smart mobility for the ultimate transformation to the future smart city. The framework will address the needs of all major KSA initiatives and stakeholders. To achieve the goal of the thesis, the following objectives will be accomplished:

1. Analyze and identify the challenges of the current urban infrastructure and available mobility modes in Saudi Urban cities
2. Analyze and identify smart mobility requirements for smart cities
3. Analyze the challenges associated with all stakeholders, including governance (local and national), city planners, transportation service providers (public and private), mobility system users (behavior and culture)
4. Develop an optimum framework that is informed by the needs of all stakeholders to manage a sustainable transition to smart mobility for future smart urban cities, with special focus on Saudi Arabia.

1.4 Research Methodology

This research was fundamentally based on creating a strategic framework for managing a sustainable transition to smart mobility in Saudi's future smart cities. A smart mobility strategic framework would be a diagram describing the elements relevant for a smart mobility strategy (Simonofski et al., 2023;

Tarek & Nasreldin, 2023; Butler et al., 2020; Francini et al., 2021; Haller et al., 2018). The term strategic defines the core idea of the framework to interpret key challenges associated for the transition from existing mobility options to smart mobility option. By doing so, it is possible to identify important stakeholders, challenges, and opportunities for each step of transition. Thus, local governments are able to gain a better understanding of how smart mobility projects are conceptualized and can consider them thoroughly. The research problem was addressed by identifying the current mobility modes and infrastructure in the country as well as the needs for the transition into smart mobility through a comprehensive literature search.

This present research initiated by using a qualitative research method with an inductive approach using literature review related to smart cities, smart mobility, their ecosystems, elements, stakeholders, and challenges. The study began by collecting data through qualitative research and once a substantial amount of data was collected, the process for selective criteria and variables in the data was carried out. This process helped to develop a theory that could explain identified patterns and processes involved in smart mobility ecosystem, thus justifying inductive approach using qualitative method.

Once the criteria/variables were identified, a survey questionnaire was created to solicit feedback from the experts and common users to evaluate the identified set of criteria thus reversing the research approach at this point of methodology from inductive to deductive. The collected data was analyzed using statistical tools. Pearson's chi square correlation tests were also used to find dependency between the variables. The results from the survey questionnaire helped to evaluate the current mobility modes and to get opinion for the future smart mobility options. All these analyzed data was later used

for the development of framework design for smart mobility transition in Saudi Arabia.

On top of questionnaire survey, key variables of smart mobility were also compared by focus group for preferred choice model. For that purpose, results were drawn from quantitative analysis using analytical method of Analytic Hierarchy Process (AHP). Further validation of these results was conducted by another expert panel.

Six major phases were carried out to design and develop the framework based on focus group meetings, literature review and questionnaires to select the best smart mobility elements and their parameters. The phases are as follows:

1. First phase was dedicated to extensive literature review of recent publications and initiatives on smart mobility and smart cities to identify all mobility related challenges worldwide.
2. Second phase was focused on investigating Saudi Arabia challenges in mobility, urbanization, future Saudi smart cities, and sustainability of mobility solution.
3. Third phase focused in the challenges of the data needs and a set of cultural and behavioral change initiatives that was used as the basis for all the data collection efforts of phase 4.
4. Fourth phase focused on the data collection from all stakeholders including end users, government organizations, transportation manufacturers and service providers, IT developers and city planners through online questionnaires. This collected data would assist this present thesis for ranking the smart mobility solutions. Once the selected smart mobility modes were ranked based on

both research and questionnaire analysis. As a result of these rankings, stakeholders will be able to understand preferred choices and their respective variables/parameters.

5. Fifth phase, the collected data was analyzed through statistical tools and the strategic framework to manage a sustainable transition for smart mobility in the future urban Saudi cities that was developed along with timeline and measure of success. Based on the survey questionnaire developed in phase four, the multiple criteria decision analysis (MCDA) model is also created based on the inferred criteria from the choices of expert and common users. AHP analysis was carried out by pairwise comparison matrix for the preferred modes and their inferred criteria.
6. At the final phase of this research, the strategic developed framework and its key elements were validated by panel of decision maker experts through questionnaires of focused group. The expert focus group from government and private sector include vice ministries, chief executive officers and deputy ministers etc…

Chapter Two

Literature review

2.1 Benefits from Literature Review

2.2 Research Gaps

2.3 Executive Summary

Chapter Two: Literature Review

This present research study used a modified systematic literature review based on the study of Xiao and Watson, 2019. For the purpose of incorporating the final articles into the literature review, three steps were followed; planning, conducting and reporting.

Planning the analysis involved identification of key words/phrases for the research topic. In this case, some of the research key/phrases words included: Smart city, smart mobility, challenges and issues pertaining smart mobility, stakeholders involved in applying smart mobility, framework for smart mobility application, etc. These key words and sentences helped in answering the research problem by identifying relevant research efforts, and extracting and analyzing qualitative data.

This phase involved searching titles of literature to identify relevant articles. In this case, identified key words were used for the Google Scholar literature database search. The second step in this phase was the screening of the identified articles for inclusion, following the inclusion criteria using their abstracts. Only articles with information on Smart mobility in the context of smart cities were included. Reports such as government published white paper, policies and documents from other reputable international agencies were also considered.

Finally, results were presented in terms of literature distribution. There were 71 articles/studies found from reliable sources relevant to theory of smart mobility and its framework design. Out of 71, 47 literature resources were from Peer reviewed journal while 8 references were taken from the conferences and 13 references were comprised of reports such as United

Nations report on world urbanization, etc. There was one reference from the thesis publication as well.

Urban performances depend on communication and social systems apart from transport infrastructures. In the article entitled "Smart cities in Europe," Caragliu et al. (2009) focus on the factors that contribute to urban performance, including the hard infrastructure and the quality and availability of social and communication infrastructures. Furthermore, the study uses the 'smart city' concept, which is highly considered as a strategic instrument in enhancing urban growth and development. The authors use theoretical frameworks that emphasize the need for communication and information techniques based on their contribution in creating competitive urban profiles over the last two decades. However, the researchers recognize the elusive definition of the 'smart city' concept and intend to shed light using physical, social, and human capital factors. Subsequently, the source collects and presents EU27's geographical data and evidence to support the proposed operational and focused definition of the said concept. It also relies on graphical and statistical analytical approaches as the major scientific tools to execute the study. The authors use both qualitative and quantitative (non-numerical and numerical data) to analyze the modest urban data set to discern the contributing and determining aspects in smart cities' progress and performance. The article finds that urban wealth depends greatly on education level, ICTs usages in public institutions, accessibility of multimodal systems, and urban environment. It uses the findings to recommend the need for new strategic agendas to help European cities accomplish sustainable urban growth and development. Therefore, the source presents the smart cities' concepts and

related results that are indispensable in addressing different social and transport concerns.

Smart mobility depends highly on the nature, type, and effectiveness of systems and models used to enhance transformation at city levels. Letaifa (2015) performed the study titled "How to Strategize Smart Cities: Revealing the SMART Model." It aims at clarifying the dynamics of designing and applying strategic approaches in constructing smart cities. The author focuses on closing the existing gap emanating from the lack of the methodologies and sequences that urban cities follow in transforming cities' services in the previously executed studies. The source uses the qualitative research method to propose an implementation framework in smart cities based on case studies and literature reviews. This research approach is characterized by the usage of non-numerical analytical data. The author collects and utilizes information concerning large cities of Stockholm, London, and Montreal from both secondary and primary sources. Retrospective and real-time data are used to parse leadership strategic pathways employed in the said cities to depict the overall development pathways for other urban areas globally. However, the article lacks specified scientific methods despite having research and secondary research approaches. Nonetheless, the on-site observations and the subsequent interpretation of the collected data provide useful findings. The study results show that both private and public stakeholders in the three cities under study collaborate to change the urban resources and address challenges. The findings also associated city transformation with certain institutional, cultural, and social determinants. However, deficiencies in the political class, lack of financial and social diversity, and absence of clear future visions are

visible drawbacks. Thus, this article has indispensable literature and findings that can help in developing cities and fasten the transformation processes.

Many threats and opportunities associated with renovating cities and places exist, which can be related to the smart mobility context. Papa and Lauwers (2015) explore the existing risks and chances in the article titled "Smart Mobility: Opportunities or Threat to Innovate Places and Cities." The source criticizes the smart mobility strategy by arguing that the subsequent process of transforming places and cities is complex. The authors assert that proponents of the paradigm emphasize the simplicity acquired through smart mobility techniques. However, the material focuses on many other existing aspects and components of the concept that makes it sophisticated. This material does not offer radical critiques to the smart mobility concept; instead, it seeks to expose the lacking connection between the framework and other indispensable mobility governance and planning concepts. The article uses existing secondary resources as the major research tools and employs a qualitative methodology characterized by the usage of non-numerical analytical data. However, it lacks a scientific analytical approach, mainly because it does not use numerical data. The authors find that the major governance threat is the lack of citizen commitments in the participatory and interactive stages because only potential users of the mobility paradigm are involved. It also concludes that the involved stakeholders have opportunities to reciprocate the scenarios by forming collaborative and coordinative implementation environments. Therefore, the smarty mobility paradigm can be complicated and ineffective due to governance failures at the implementation level.

Smart mobility and smart city concepts are important in helping reduce urban-related challenges by improving service delivery in diverse perspectives. Benevolo et al. (2016) authored the article entitled "Smart Mobility in Smart City: Action Taxonomy, ICT Intensity, and Public Benefits" to explore the two topics. This source presents the two concepts that are the predominantly used winning approaches in addressing urban issues, mainly; energy consumption, traffic, waste treatment, and pollution. It aims at exploring the large smart city concept and its primary components, including the smart mobility framework. It also investigates ICT impact and contributions towards improving people's quality of life by developing public value. The authors use a qualitative scientific research approach, which is characterized by the usage of non-numerical analytical data. The data used are collected from existing secondary resources using a secondary research approach. However, it lacks a specific scientific-analytical tool despite finding reliable results. The qualitative details suggest that the smart city concept is a long-term vision and sophisticated phenomenon that involves improving people's quality of life and reducing urban problems. Furthermore, the writers find mobility to be the most important aspect of the smart city paradigm, especially in metropolitan areas. The principal rationale is that it has different economic and environmental factors that require people's efforts and technological application. Accordingly, ICT usage in both forward and backward directions contribute significantly to enhancing mobility and creating smart cities. Therefore, technology is a major determinant of whether urban areas can be transformed into smart cities.

Understanding urban transformation and development requires profound insights regarding factors affecting smart mobility. Walker and Aldalbahi

(2016) executed research titled "Riyadh Transportation History and Developing Vision." The authors use Saudi Arabia's capital city (Riyadh) to explore the trading transportation and urban development agendas in the contemporary world. The article investigates the supportive reasons for car ownership and the subsequent effects on public transportation. It uses non-numerical data (qualitative research approach) and relies mostly on Riyadh historical development documents and other urban- and transport-related literature as research tools to execute the study. It also captures key contributing aspects in the city's transport network, such as demographic, governmental, and urban planning factors based on historical development patterns. The source lacks scientific instruments and does not use scientific methods to achieve its objectives. However, the authors find that Riyadh has favorable political and demographic conditions and urban planning abilities to construct a new public transport system characterized by highway lanes, bus movement networks, and a six-intern connecting metro. Nevertheless, Riyadh has to address the adverse impacts associated with historical splits in public transport modals. The city also suffers from competitive inabilities due to over-reliance on commuter movements and cars. Therefore, the article depicts the importance of public transport systems in urban transformations.

The impact of emerging techniques like the internet of things, sharing applications, and automated vehicles can transform mobility at individual and collective levels. The article titled "The Governance of Smart Mobility" assesses the contribution of advanced technology in the smart mobility concept (Docherty et al., 2018). The authors aim at exploring the predominantly accepted notion that technological combinations revolutionize mobility systems within the larger smart mobility paradigm. Although the

authors seem to agree with the perceived importance of the said techniques, they question the mechanism in which the approaches enhance mobility revolution and city transformation. The material uses four thematic cases and existing literature to complete the qualitative research because it uses non-numerical data. It finds that technological rapid changes in the modern world surpass trends in governance structures and systems. Lastly, failure by the involved stakeholders to counteract the identified issues affects the overall impact of advanced technologies. Therefore, advanced techniques are not enough, on their own, to enhance city transformation and development.

Transforming small cities requires certain dimensions and concepts depending on nature and implementation requirement of the smart mobility concept. Doheim et al.'s (2019) article titled "Smart City Vision and Practices Across the Kingdom of Saudi Arabia Review" examines smart mobility dimensions. It uses Saudi Arabia cities and their respective development progress to discern the impact of the said dimensions on urban transformation. However, it does not determine whether or not Saudi cities are transformed; instead, it aims at discerning whether the nation's vision depicts smart city dimensions and concepts. In this regard, the paper relies on smart cities existing quantitative and qualitative literature and Saudi historical information to answer research questions. Although the article does not use any scientific methods to analyze and discuss the acquired data, it reports that environment, intelligent city, and digital city are the major dimensions in the smart mobility concept. The material finds that Saudi Arabia strives to transform its cities into smart ones. It has a clear vision, willingness, and the required resources to achieve its aspirations. However, many other dimensions, such as smart economy, governance, mobility, people, environment, and living standards,

also contribute significantly to the paradigm. Thus, countries needed resources, willingness, and ability to implement the smart mobility concept to accomplish their visions.

Urban development and growth depend highly on key drivers of urban mobility intelligence because they help in enhancing transformation. Maldonado et al. (2020) use both qualitative and quantitative research methodologies to explore aspects associated with urban mobility intelligence. The qualitative part of the research involves numerical data collected from existing sources using secondary research methodology. Conversely, the qualitative part is manifested in the results segment, whereby primary numerical data collected through a survey was presented and analyzed. The research finds that technical and city governance are major factors affecting smart mobility intelligence. These solutions suggest that involved parties in urban transformation must possess decision-making skills to transform rural and urban areas. Overall, stakeholders in urban transformation must have technical and governance aptitudes to achieve smart mobility and city in the future.

Smart mobility resolutions can be used to transform and develop both rural and urban areas based on the strategic systems used by the involved stakeholders. Porru et al. (2020) authored the paper titled "Smart Mobility and Public Transport: Opportunities and Challenges in Rural and Urban Areas" to contribute to the continuing debate regarding urban transformation to smart cities. The article focuses on the dynamics of adapting creative strategies in the existing public transport systems. It narrows the focus to the demographic factors that determine urban progress and abilities to transform its services in the transport context. Moreover, the researchers investigate the usefulness of

internet of things techniques and their response to diverse mobility difficulties in rural areas. The material uses four thematic cases and existing literature to complete the qualitative research because it uses non-numerical data. It also uses the Interreg Central Europe Project (RUMOBII) to compare the applicability and usefulness of smart solutions in urban and rural contexts. Although it lacks a specific scientific tool, it manages to identify three major problems affecting both urban and rural mobility. These problems are; simplicities of programming and investment planning, lack of optimal route standardized metrics, and dynamic definition of mobility. The authors report that smart mobility solutions, such as technological infrastructures, monetary opportunities, population scattering, and social maturity, have significant impacts on rural and urban developments than other proposed resolutions. Thus, the research considers the need for smart mobility systems for both urban and rural areas desiring transformation.

The report published by Swiss Re Institute (2019), states that the urbanization, changing demographics and environmental awareness are pressurizing the existing mobility infrastructure to change. To tackle modern urban mobility issues, more sustainable means of moving goods and people should be considered. An Ecosystem is a system that includes and integrates different transportation modes and their users as well as the way they affect each other. With the introduction of new ways of mobility and the advances in technology, a robust connected and integrated network is needed which could be classified under smart mobility ecosystem. An example of the changes in the mobility ecosystem is the introduction of shared mobility for urban areas, for e.g., ride-sharing, and car-sharing. The deployment of Information and Communication Technologies (ICT) throughout the

transportation system is expected to significantly shape the current structures and operating models. Infrastructure, vehicles and end-user handsets are becoming increasingly intelligent and instrumented with sensors and broadband connectivity, which in turn enables a wide range of smart mobility services (Casey, T., & Valovirta, V., 2016). One of the recent reports by Accenture (2020) states that the whole mobility ecosystem will need to become more fluid. Its constituent parts will need to be connected both in the physical world (infrastructure itself) and in the digital world (data, platforms, APIs).

There is a consensus among researchers that it is imperative to take in to account the perceptions, opinions, and interests of the people or users in the implementation of new technological solutions in the development of smart cities. The research by Youssef et al. (2021) titled "Modeling the Modal Shift towards a More Sustainable Transport by Stated Preference in Riyadh, Saudi Arabia" is premised on this conceptualization in addressing concerns of the growing traffic congestion in Riyadh City. According to the researchers, the perceptions that emerge among the people concerning urban mobility modes have an impact on future transport planning and policymaking. The study focuses on the Riyadh Metro that was developed by the government of Saudi Arabia in developing sustainable public transportation. The researchers explore the perceptions that emerge among potential commuters regarding the Metro services and the factors that might compromise their propensity. The researchers also use the insights gathered from commuters to understand the tradeoffs that emerge when individuals experience a combination of mode characteristics. These are travel time, price, Metro fare, and walking time. The research used a sample from Riyadh, and data was collected using structured

interviews. A quantitative analysis was carried out using a discrete choice model that was based on binary logistic regression. The research established that the travel time, fuel cost, metro fare, and walking time, were statistically significant and an impact on the choice in the mode of travel. In this context, an increase in fuel prices by 10% would lead to a 5.3% increase in the use of the metro, leading to reduced dependency on cars. A reduction of the walking time by 5 minutes to the metro station would lead to a 22% increase in usage. The researchers also found that an increase in parking charges per hour would reduce car dependency, implying that people would use the metro as an alternative means of transport. Nevertheless, an increase in Metro fare by 10% would reduce its usage by 6.9%. Drawing from this research, the strategic measures taken in developing smart transportation should take to account the interests that emerge among the people. This highlights the need for increased public participation in such development projects to ensure their input in the decision-making.

2.1 Benefits from Literature Review

The previous researches used in this study will help significantly in achieving the main goals of the thesis in developing a strategic framework for managing a sustainable transition to smart mobility for the ultimate transformation to the future of Saudi's urban smart cities. Furthermore, this conducted literature review will identify the main definitions, dimensions, and patterns of smart urban mobility. Following this, a framework for identifying smart urban mobility is developed to address the needs of all major initiatives and stakeholders in KSA.

The major reason is that the data recommends analytical tools that can be used to analyze and identify the challenges of the current urban

infrastructure and available mobility modes in Saudi Urban cities. Moreover, these instruments can be used to assess smart mobility requirements for smart cities and the challenges associated with all stakeholders, including governance (local and national), city planners, transportation service providers (public and private), mobility system users (behavior and culture). These benefits will be achieved mainly due to the relevance of the methodologies used in the used sources in responding to this study's research questions. The major reason is that previous studies use both qualitative and quantitative research approaches, which are indispensable in answering study questions from both numerical and non-numerical perspectives. Therefore, previous researches offer details and analytical approaches that will help this study achieve its major objectives.

2.2 Research Gaps

Most of the studies reviewed in this research show that there is a need for more and recent empirical research addressing different aspects of smart cities and smart mobility. There is a high reliance on historical documents and research from other regions such as cities in Western countries. Although these insights are important for understanding the challenges faced, opportunities, and best practices in the development of smart cities and smart mobility, there is a need for this research to investigate and reflects on issues emerging in Saudi Arabia and the experiences of the Saudi's citizen and residents who will be users of the new technological developments.

Drawing from the research conducted by Caragliu et al. (2009), there is a lack of a consensus on definition of smart cities. This can be attributed to the notion that there are elusive definitions that lack to take to account important factors such as physical, social, and human capital. Although some

studies such as those of Maldonado et al. (2020) and Youssef et al. (2021) offer insights on such issues, this study will contribute to defining smart cities and mobility by incorporating how factors such as the level of education and adoption of information and communication technology impact on perceptions associated with smart mobility in Saudi Arabia.

Literature review also shows that very few studies are conducted regarding approach for smart city development in Saudi Arabia. Majority of the studies in Saudi Arabia are either targeting general smart city applications or smart city elements. In addition, research exists regarding the required smart mobility elements and their technical requirements in the context of smart cities. However, there is no systematic framework design addressing development of a transitional framework for smart mobility applications.

The research by Letaifa (2015) utilized retrospective and real-time data to draw insights about Stockholm, London, and Montreal, while studies by Aldalbahi and Walker (2016) and Doheim et al. (2019) focus on the Saudi Arabian context of smart developments based on historical accounts. This highlights the need for insights that utilize recent or real-time data to develop knowledge and recommendations that can be aligned with the necessary changes in the development projects. This research will involve the integration of such data with the perceptions that emerge among the potential commuters to develop an informative account that can contribute to satisfactory and constructive project management initiatives.

According to Doheim et al.'s (2019) research, Saudi Arabia strives to transform cities into smart cities. Although various studies have identified limitations that make it difficult for the country to achieve success on the transformation to smart cities, there is a lack of clear insights on whether there

have been effective mitigation measures and strategic approaches with the development of smart mobility, considering that the two concepts are intrinsically linked. The research by Maldonado et al. (2020) shows that leadership is inherent in decision-making, and the strategies are taken to address challenges in managing projects in the development of smart cities. Although the Saudi government has been committed to the development of smart mobility and cities, there is a lack of evidence that there has been effective leadership in these projects. This can be attributed to the findings by Doheim et al. (2019) that despite the availability of the necessary resources, the country strives to make transitions to smart cities. This research will also gather insights that reflect the actual roles of leaders in project management and their contribution to this transition and its sustainability.

All the above-mentioned gaps in literature can be attributed to the absence of an organized framework that can be used to steer the transition to smart mobility while taking in to account important factors, such as; public participation, leadership, data collection, etc. This study is a positive step in this direction which provides a working framework for the researchers and transportation officials around the world. The framework was applied and validated for Saudi Arabian cities which are going through their transition to smart mobility presently.

2.3 Executive Summary

- Transport systems are a major component that is used to determine whether rural and urban areas are transforming towards being smart cities.
- Smart mobility relies highly on the nature, type, and effectiveness of systems and models used to enhance transformation at city levels.

- Urban performances depend on communication and social systems apart from transport infrastructures.
- Smart mobility systems are needed for both urban and rural areas desiring transformation.
- Governance failures cause complications and inefficiency of the smarty mobility paradigm, especially at the implementation level.
- Many threats and opportunities associated with renovating cities and places exist, which makes it relevant to understand their impacts in a smart mobility context.
- There are many dimensions to the smart mobility concept, including smart economy, governance, mobility, people, environment, and living.
- The presence of emerging techniques, like the internet of things, sharing applications, and automated vehicles can transform mobility and individual and collective levels.
- Technology is a major determinant of whether urban areas can be transformed into smart cities.
- The progress, growth, and development of urban areas and cities is highly dependent on entrepreneurs' decision-making.
- Urban development and growth depend highly on key drivers of urban mobility intelligence because they help in enhancing transformation.
- Stakeholders in urban transformation must have technical and governance aptitudes to achieve smart mobility for their city in the future.
- Public participation in mobility development projects is important to ensure their input is part of the decision-making.

- All these key mobility components, technologies, and stakeholders needed to be integrated with each other under one platform/system i.e. Smart Mobility Ecosystem. In this ecosystem all key component would be fluid in nature and affect each other in various aspects to shape the mobility into efficient and sustainable entity.

Chapter Three

Smart Mobility Ecosystem and Associated Challenges

3.1 Elements of Smart Mobility Ecosystem

3.2 Potential Challenges for the Design Ecosystem

3.3 Identifying Stakeholders

Chapter Three: Smart Mobility Ecosystem and Associated Challenges

This chapter focuses on the challenges of the data needs and a set of cultural and behavioral change initiatives that would be used as the basis for all the data collection efforts of next phases. From the literature review of definitions, it is clear that there is no consensus on the requirements or attributes that characterize the smartness that cities strive to achieve. Therefore it is pertinent to define and identify the possible smart mobility ecosystem requirements inside KSA in order to follow the right direction to achieve the transition to smart mobility. There are different solutions and areas of interest within smart mobility (SM), however, the current congested transportation system in KSA is designed around infrastructure and vehicles: roads, bridges, and cars. Considering the fact that Saudi Arabia's vision 2030 points to a very different future model, one designed around individual mobility and sustainable mobility, it is of utmost importance to reimagine the transportation ecosystems.

Smart Mobility encompasses a variety of areas of interest, for example as per Smart Mobility World (2017) main areas of SM may include:

- Safer driving – ensuring safe and secure movements of the vehicles including interaction with other cars and mobility infrastructure.
- Efficient street lighting – providing controls and measures for better and efficient lighting systems using low energy solutions.
- Shared Mobility for Urban Areas – sharing transport systems for all the available modes of transportation systems. Encourage multimodal transportation for efficient and sustainable transport solutions

- Electric Mobility – providing a sustainable mobility solutions that are eco-friendly, low in fuel consumption and help saving the natural fuel reservoirs.
- Green Mobility – helps reducing climate related issues due to heavy reliance over hydrocarbon fuels in transportation sectors.
- Methods of payment – New payment procedures using ICT and other modern payment structures

This study will focus only on drivers, with an emphasis on Intelligent Transportation Systems, and Shared mobility for urban areas. SM ecosystem for this research study can be seen in the figure 3.1:

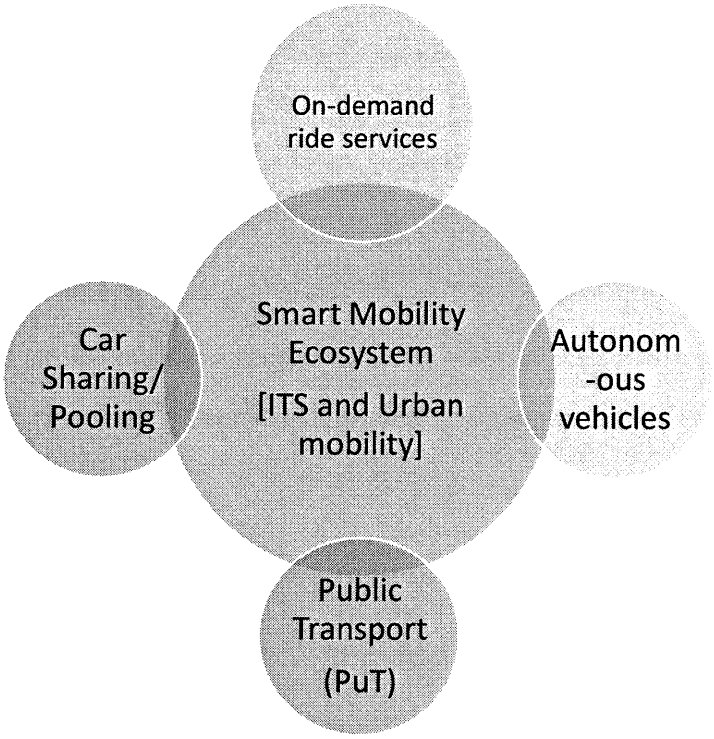


Figure 3.1: Smart Mobility Ecosystem

3.1 Elements of Smart Mobility Ecosystem

In this study research, smart mobility (SM) ecosystem moves around two major elements as mentioned before i.e. Intelligent Transportation Systems (ITS) and urban mobility. Following sections will elaborate each elements and their respective sub-elements for the way-forward

3.1.1 Intelligent Transportation System (ITS)

Intelligent transportation system has become an integral element in urban planning for the transition towards smart cities. The ITS has transformed the life style of the inhabitants in modern urban cities. Mobility is a central and key element for any person in today's urban city to move from one place to another for different daily trip purposes. Vanderschuren , (2003) reported that ITS can help achieving efficient mobility system using variable message signs offering real-time information about congestion, accidents, etc. These ITS solutions help reducing total travel time along with comfort and safety.

As the roads are shared entities for both persons and vehicles therefore their relationship can be improved with the help of technologies like internet of things (IoT) and Internet of services (IoS). These technologies can integrate people and vehicles into road infrastructure for better management and control in the transport network. According to Walker (2015), integrating ITS with the road transport and different transportation modes will make existing mobility systems ecologically sustainable, efficient and safer. To get clearer objective under SM ecosystem, ITS is further divided in two sub-element categories as following:

i. Internet of things

ii. Autonomous Vehicles (AVs)

IoT – Internet of things

Modern urban cities have seen huge developments in the technologies in recent times, with ICT becoming an important tool in urban planning and management. ICT comprised of numerous technologies like Big Data, IoT, IOS, etc. These technologies have become key part in achieving transition towards modern and smart cities. Integration of all these ICTs isn't an easy task and pose challenges for the urban cities like gathering huge sets of data which is also called 'Big data" and analysis of these huge sets of data for achieving desired objectives. (Bagloee et al., 2016). With new urban planning tools available, a concept of Smart City (SC) has begun to engulf modern urban societies. Smart cities incorporate new technological concepts in making cities more connected and efficient than ever. As the concept is gaining attention globally, more and more cities are trying to implement these new SC initiatives.

Even though, use of IoT in smart cities is improving the services like education, health care and utilities but definition of IoT in this section are solely centered on transportation and mobility solutions.

Smart payment systems like smart cards are among the applications of IoT in public transport. These smart cards carry a lot of important information thus can be utilized by governmental authorities in different useful ways. For example, one of application could be possibility of behavioral analysis of the passengers using smart cards, Bagchi and White, (2005). However, they also found out that travel purposes are not recorded directly thus still requiring surveys to complement the results and the findings from the analysis of Smart cards. Agard et al. (2006) also discussed the issue related to accurate behavioral analysis, the study suggested combining smart card and data

mining would help getting more accurate behavioral analysis of the users. Similarly, Devillaine et al. (2012) tried to find out a method using smart cards for accurate estimation of locations, time and trip purposes using public transportation. The same study method was trialed in the cities of Santiago in Chile and Gatineau in Canada. From above case studies and literature, it could be said that unified smart cards across the country or city could be a huge step forward in achieving the goals and objective under smart city initiatives.

As the number of vehicles are increasing in majority of the global cities, these high numbers are the reasons of traffic congestions, traffic accidents and high traffic related emissions. The traffic management systems (TMSs) are one of the most important component of ITS and it is pivotal to solve the ever increasing congestions and traffic related problems. According to De Souza et al. (2017), TMS can be classified into three categories which includes:

i. Collecting information
ii. Method of processing information
iii. Actions and recommendation

Though TMS are helping traffic management and control but at the same time these system also pose threats to cyber security and safety. Djahel et al. (2015) carried out a study on the safety and security issues related to TMS and its respective technologies. The study suggested various security issue effecting drivers and transport infrastructure.

Another management technique is combined traffic assignment and control (CTAC). Farhan et al. (2010) mentioned that traffic simulation models using CTAC can show the behavior and interaction of the drivers with the used ITS technologies in the transport network. The concept of simulation models using CTAC methodology has been implemented by many researchers

in their studies across the worlds since 1990s. Numerous established solution algorithms and their formulations are available in the literature review related to combined traffic assignment and control. Although proven in research and practice worldwide, the use of the combined traffic assignment and control modeling framework is rare in Saudi Arabian traffic engineering practice. Generally in Saudi Arabia, the route choice, traffic signal control cycle program development and optimization processes are kept separate. But in that case the interactive relationship between the controls and driver is ignored. Van Zuylen and Taale, (2000) also suggested the same that CTAC use in models could depict the interaction between the driver and the controls.

In many cases the driver may also be able to get better route choice information via Variable Message Signs (VMS) or Dynamic Message Signs (DMS). In case of VMS or DMS, the drivers are informed of the ongoing incident or of the on-going traffic congestion level on certain busy routes in a selected area, and are often given travel time comparison of the congested route with the alternative routes. The comparison of travel time typically would provide timely choice to several drivers who may opt for the relatively less congested routes. Figure 2 shows an example of a VMS showing travel time comparison on selected routes for the driver's enroute.



Figure 3.2: Variable Message Sign (Mississippi department of transportation, 2021)

In addition to the travel time comparisons, the VMS could also be used to alert the drivers in advance of any incident or emergency so that they could make appropriate maneuvers accordingly, (Nygårdhs, 2011). In addition to the Variable message signs, the dynamic signage could help the drivers realize the temporary variations in the standard roadway conditions. Guidelines by Katz et al. (2012) states that dynamic posted speed sign could lower the posted speed in case of formation of black ice in extreme snowy conditions, or alternatively it could also lower the posted speed in case of foggy driving conditions which may not last for a long stretch of a time in a day. The dynamic sign would revert to the original posted speed as soon as the temporary roadway condition subsides. Figure 3.3 shows the dynamic posted speed sign which differentiates between the difference of posted speed limits for regular and truck traffic.



Figure 3.3: Dynamic Posted Speed Sign (Daniels and Focant, 2017)

In addition to the travel times, the enforcement side of the equation could also be improved by the deployment of advanced ITS. For instance, a higher non-compliance on posted speeds occurs right after the statically installed camera locations as compared to before the camera, where the drivers would generally slow down before the camera, and would non-comply as soon as they pass the camera knowing there is no way of capturing the non-compliance. Hence, the statically assigned posted speed enforcement cameras may help in lowering the speed to some extent, but all in all they do not contribute in lowering the non-compliance rates; in-fact the non-compliance occurs in higher proportions right after the camera locations, (Corbett and Simon, 1999). In such cases "Point to Point (P2P) systems could be introduced where the drivers could be penalized only if they drive a given section of a corridor in a relatively shorter time as compared to the one for the posted speed.

1. *Dedicated Fiber Optic Based High Speed Internet Connection to Traffic and ITS Infrastructure*

All the above mentioned advanced ITS feature deployment is impossible without the high-speed data driven connectivity of the ITS infrastructure in the region. To deploy advanced ITS features such as mentioned above, Orphanoudakis et al. (2009) reported that the ITS and traffic infrastructure should be connected well by deployment of fiber optic across the regional network. Given that the state owned Saudi Telecom Company (STC) has already expanded the "Fiber to the Home" (FTTH) on a large scale, dedicated fiber optic based high speed internet connectivity of traffic and advanced ITS infrastructure is reasonably possible now. If implemented, the region could see unimaginable benefits in terms of improvement in overall efficiency of the traffic system in the region.

2. *Test Bed Mobility Lab to Demonstrate Effectiveness of Live City-Wide Traffic Operation Centers or Traffic Control Centers*

With all the connectivity possible as discussed in above postulates, and access to live data, there will be an immense need of an arrangement where this data could not only be assessed but it could also be archived for future use. Without this arrangement, the data will be wasted, and the entire ITS deployment and arrangement will not be utilized to its full potential. Turner, (2005) recommended building a small scale traffic operation center rather than a large regional project at once due to the possibilities of complex anomalies or unknowns. It is therefore recommended that a small scaled mobility lab, good for a small to a medium sized study area, should be established. The lab will serve as the prototype for the regional traffic operation center or traffic control and mobility center where the data for the study area in consideration

will be hosted, analyzed, and assembled for all stakeholders' consumption. Figure 3.4 shows a test bed Traffic Control Center founded on the concept of Traffic Mobility Lab at the University of Utah, USA.

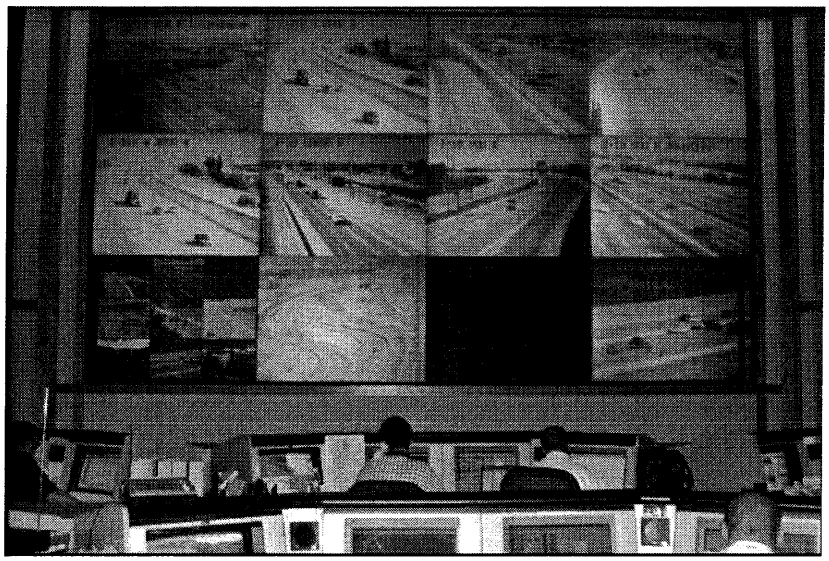


Figure 3.4: Test Bed Traffic Control Center at University of Utah, USA (Utah department of transportation, 2002)

ITS – Autonomous Vehicles (AV)

According to European Commission (2019), humans are responsible for the 90 percent of total accidents on the roadways. Thus the introduction of autonomous vehicles might give an opportunity for safer road travel with the help of automation technologies that could intervene whenever necessary to avoid traffic accidents, (Cui et al., 2019). Autonomous vehicles can help in reducing energy consumption by providing continuous flow of traffic and improvement in roadway capacities. The smooth continuous traffic flow could be possible by minimizing the successive distance between the vehicles. This consistent headway distance can be ensured with help of multiple sensors in

the AVs that control the gap between the vehicles based on recommended safety distance.

AVs have become an important enabler in the concept of smart cities by providing connected and integrated infrastructure for vehicles. AVs can be driverless cars, trucks or public transport buses which could play an important role in achieving goals of smart cities. Smart urban cities use cloud storage systems to predict and manage the flow on the roads. These information can further be linked to data analysis using artificial intelligence (AI) and thus can predict future demands and decisions based on real-time information and historical stored data sets. Typically, AVs used in-vehicle sensors like GPS to connect with the surrounding infrastructure for visualizing real and accurate information and thus making road smarter and safer. And this could be done using integration of these autonomous vehicles to connect with the network infrastructure and then consequently being controlled and managed under Traffic Management Systems.

It is also important to know that the level of automation, in AVs, can vary from 'no automation' to 'full automation'. Thorn et.al, (2018) classified vehicle automation in five different levels for National Highway Traffic Safety Administration (NHTSA):

- No Automation (Level 0): All the time, driver has complete control over the vehicle in terms of vehicle operations like braking, accelerating etc.
- Functional controlled automation (Level 1): Few specific functions can be fully automated like vehicle stability control.
- Automation with combined function (Level 2): In this level at least two main control features like adaptive cruise control combining with the lane configurations are automated.

- Partial self-driving automation (Level 3): In this level, the driver can have full command over majority of safety features but also depend the vehicle for any sudden changes in conditions.
- High Driving Automation (Level 4): Very few operational control to driver

3.1.2 Shared Mobility for Urban Area

A transportation system in the study SM ecosystem is comprised of three modes of alternative mobility solution such as:

i. Viechnicki et.al (2015) mentions Ridesharing as a resource of utilizing empty car seats .As in case of ridesharing no new vehicles are added in to the system therefore it helps reducing traffic congestion on the urban roads.

   Car sharing is a concept of ride sharing which allows companies and individuals to rent or share their cars to different individuals across the day. Same car being utilized by different individuals same day thus adding no new vehicles to the system.

ii. On-demand ride services companies like Careem and Uber allow common drivers to use their personal vehicles for providing transportation services. Traditional taxi services can integrate their systems with on demand ride services as well. A notable milestone was achieved in 2016 with an aggressive implementation of car sharing (Sourbati, 2020; Kim, 2015). The launch of Uber's product, Uberpool, has since been a great success in New York. The second notable milestone was the introduction of autonomous public transportation in 2019. The use of these vehicles designed by Optimus Ride, a self-

driving car company, has since taken New York by storm. Just like London, New York is still on course to achieve full smart mobility transition. The introduction of the zero emission vehicles (ZEVs) in 2021 is a testimony of the efforts implemented in the city (Slowik et al., 2019; Kurani et al., 2016).

iii. Public Transport, if integrated with infrastructure through IoT and technologies like mobile apps can make wonders in urban mobility. Currently there is no system which makes public transportation easy and convenient in Saudi Arabia. People face various problems while traveling within cities as they have to book private transportation which is expensive, compared to public transportation. So to provide the passengers a convenient way to travel, the public transportation network must be integrated to the SM ecosystem.

3.2 Potential Challenges for the Design Ecosystem

Potential challenges for the identified elements are discussed in this section. These challenges will give better understanding of the transition towards smart mobility. This section enumerates and discusses indispensable requirement based challenges for the successful deployment of smart mobility ecosystem. Table 1 shows the potential identified challenges associated with the design ecosystem. Each challenges mentioned in figure 3.5 are discussed briefly starting from section 2.1 to 2.3 in this chapter.

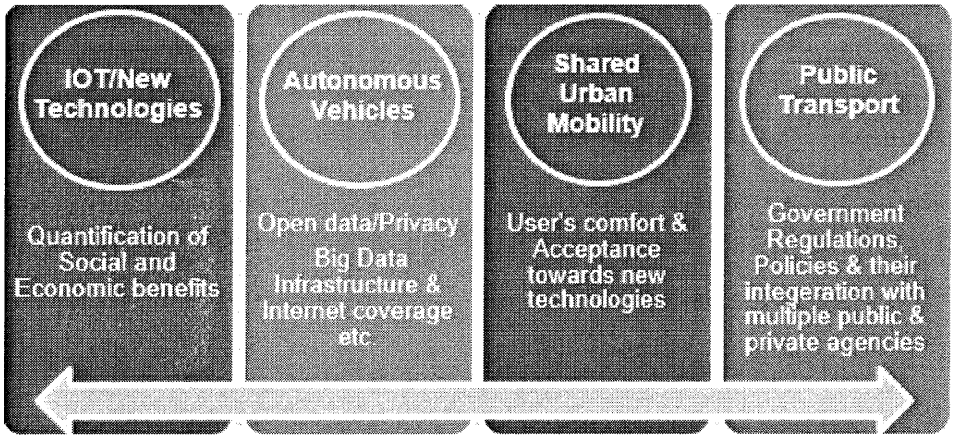


Figure 3.5: Summarized challenges for each smart mobility element

3.2.1 ITS – IoT

The Internet of Things is among the latest technologies to revolutionize the livability in the cities. IoT has been an integral part of the test beds and pilots that happened in different parts of the world with likes of US and UK among forefront, Debnath et al. (2014). Many of these IoT based smart city projects are in experimental phase therefore testing the potential of business viability of these technological solutions. Some of the probable challenges for the IT around the world may include followings, IEE SECON, (2016):

1. *Overcoming city vendor lock-in*

The lack of available guidelines and an established architecture for IoT based smart city solutions, makes it difficult for the stakeholder of the cities to commit with a single vendor. As the concept of smart cities are still emerging and under continuous development there are few available vendors in the market thus there is fear of potential vendor lock-in that can affect the procurement decisions, expansions and scaling of infrastructure. As a result, cities are often reluctant to carry out huge investments in such smart city projects.

2. *Meeting real citizen needs*

For sustainable development of the smart city projects involving IoT, it is important to consider the views of public, private and public technological companies. Griffiths and Sovacool, (2020) showed that smart cities like s Masdar (Abu Dhabi) and Songdo (South Korea) never achieved the desired objectives due to ignoring realistic needs of citizen and other stakeholders. There are possibilities when these IoT based services attracts the perspective of public authorities but aren't accepted by the citizens.

3. *Quantifying social and economic benefits*

It is difficult to estimate social and economic benefits in the IoT based smart cities. It is still largely unknown how these IoT based technologies impact the sustainability of the cities. The lack of available framework for capturing accurate socio-economic benefits is also among a major challenge. These challenges of inaccurate cost and benefit analysis cause a lot of trust deficits thus making investment decisions more difficult.

4. Sharing open data

Smart cities are generally developed around open data which are not considered sensitive. However, there are such datasets in the smart city frameworks which uses information like organizational data or personal data of the citizens. These information have large potential of security risk if data is breached therefore causing reluctance from the major business organizations and the citizen. Therefore, regulations must be created to increase confidence and trust in sharing information to these data architectures. Lack of regulations, integrated platform and ecosystem has therefore created a large void of non-implementation of the IoT.

5. How to Put an Operations Center into Action – Big Data

Recent studies have proven that the utilization of urban big data is crucial in the smart mobility transition (Barns, 2016; Lim et al., 2018). However, most car-dependent countries lack the framework for big data use, making it a challenge to transition their urban mobility to smart mobility. Traffic management center could be the answer to solve this challenge of Big Data and development of framework for the process. Schreiner (2016), in one of the international case studies of smart cities mentioned that the creation of operational center (Traffic Management System) is only possible with strong support and understanding of the stakeholders, which would provide a connected and technological platform contributing towards the infrastructure development and better livability of the citizens.

6. Inadequate Infrastructure

Poor infrastructure in the form of telecommunication, and power distribution tends to slow the development of smart mobility solutions related

to IoT. This kind of robust technology needs good regional coverage of fiber optics and associated infrastructure.

3.2.2 ITS – Autonomous Vehicles

Similar to other smart mobility elements, autonomous vehicles have also numerous challenges for implementation and integration into any current typical mobility system. Here are few challenges which Saudi Arabia could face during their transition towards smart mobility.

1. Low Acceptance

More often than not, the adoption of new technological solutions has encountered resistance from people who are attached to traditional or contemporary solutions. The concept of car dependence has been ingrained in the lifestyle of the residents of many cities for more than half a decade. People have been accustomed to a certain way of living in relation to their mobility. The advent of smart mobility aims to introduce several new technological solutions that will alter the lifestyle of people in car-dependent cities. Most of these cities are experiencing challenges transitioning to smart mobility because their residents are finding it hard to accept new technological solutions for mobility (Šurdonja et al., 2020). Therefore, car-dependent cities will have to examine the kind of behavioral change required to implement smart mobility solutions successfully.

Similar to other new technological solutions, acceptability of the users for AVs also poses a stern test to all stakeholders. Faqih (2011) showed that users are reluctant to use such technologies which are new and not tested before. Complete trust into technology and lack of excitement are among the decisive reasons for non-acceptability of AVs.

2. *Unequal Accessibility:*

Unequal accessibility to smart mobility resources and solutions is major challenge to smart mobility transition. Smart mobility transition needs to keep user demand in mind by considering accessibility during urban planning and the setting of new innovations Zhang et al. (2020). A large proportion of the people lacks the ability to get access to or use smart devices and solutions.

3. *System Security – Cyber/Physical*

As there are many challenges for the AV industry to put them into mainstream transportation systems. One of the critical challenge posed towards AV industry is the safety and security of Autonomous vehicles. As AVs use ICT and other cyber technologies therefore they are vulnerable towards breach of cyber security, information leakage, safety of the car controls, etc. (Yaqoob et al., 2019).

4. *Policy implications*

Incorporating AVs into major mainstream transportation system is among the major challenge for the government regulators. For making it happen, government must devise new polices and regulations to integrate AVs into urban mobility systems. It is also of utmost importance for government stakeholders to convince the users and drivers about the AV's capability to drive safely.

3.2.3 Challenges for Shared Mobility in Urban Area

The purpose of this section is to assess the challenges associated with shared urban mobility. With new modes and alternative mobility solutions are in demand all over the world it is also important to analyses the challenges

toward Ride sharing and car sharing services and their integration into existing mobility systems.

Ride-Sharing/Car Pooling

There are many advantages of higher ridesharing trips within any transportation system and these ride sharing companies are largely depending upon the views from both public and private stakeholders in the mobility sector. Though a well-planned ride-sharing system may help in saving cost and reducing travel times yet ridesharing hasn't achieved large success in many countries, Amey, (2010). The same study show that there are still not clear benefits against the challenges which are associated with the ride-sharing. So, therefore it would be really beneficial to see the possible challenges for implementing ride-sharing into urban mobility.

1. Mismatching

Ridesharing services may end up with a mismatch where either driver or passengers are not comfortable with each other. Even though these services use artificial intelligence and online review scores to develop a sophisticated matching framework yet there exists many imperfect matching and other inefficiencies in the algorithms.

2. Failed Pilot Tests Ridesharing

Many pilot tests across the world failed due to few common reasons which are as follows (Graziotin, 2013):

- Complicated rules and user interface
- Weak marketing effort
- Limited number of users

3. Low Acceptance from natives

The adoption of such trip sharing technological solutions would surely face resistance from people who are attached to traditional and local solutions. The concept of car dependence in Saudi Arabia has been ingrained in the lifestyle of the residents of many cities for decades. Also, it would be difficult to share a ride with unknown persons due to typical stranger anxiety. According to the US department of Labor, (2008) very low percentage is observed in case of ride sharing between the unknown passengers. Study stated that majority of the shared trips either happened among the family members, friends, neighbors and co-workers. Thus it is quite clear from the studies that fewer people tend to share their rides with strangers due to safety and comfort issues.

Car-Sharing

From the literature review, it is quite evident that car sharing technologies are facing numerous challenges to establish themselves into mainstream transportation system. Some of the identified major challenges may include:

1. Coordination for multiple agencies

One of the major challenge faced by the ride sharing services is the lack of coordination and operational control for the use of cars at various time-frames of the day. For example, more demand of vehicles during weekdays, while weekends may not be busy and thus cause no or fewer trips.

2. *Emergency maintenance/Insurances*

In case of emergency, the services providers and government stakeholders should have clear regulations and standard operating procedures

(SOPs) for the responsibility and action. Also there need clear regulations in terms of operation of vehicle and type of insurance needed in case of emergency and regular maintenances.

3. Failed Car sharing programs around the world

Programs like BMW's Drive now, Mercedes's Car2 go, Blueindy etc., all failed to show up the potential benefits industry was realizing for long. The probable reasons of the failures are due to stern competition, high operating costs and the lack of available framework and infrastructure for supporting new technologies.

On-demand ride services

These kind of ride services are getting popular in Saudi Arabia after more companies have come in to this service market. However, it is important to know the fact that these companies are just providing riding services like any other taxi services and there is virtually no platform available for sharing the same trip with different users. Following are few probable challenges related to on demand ride services:

1. Public policies and regulations

As ride sharing concept is still novice and dealing with the new improvements every other day. Therefore not many governments are comfortable in introducing these services into main streamline transport sector. However, nowadays new regulations and planning tools are implemented by various governments for integrating ride sharing companies into transport systems. Careem and uber are among the examples of successful operations in many different countries, where they are among the

major mode of transports. Some countries, like Singapore, are moving forward with unified regulations for both taxis and ridesharing services.

2. *Empty Vehicles running around*

It is very important to analysis, whether these ride sharing services really help the mobility systems in terms of congestion and travel comfort. Generally, more sharing vehicles on the road will reduce the personal trips through the cars in traffic but in case of empty vehicles or under-utilized vehicles , the answer could be no when it comes to direct impact on easing congestion. A study by San Francisco County Transportation Authority found that riding and taxi cars contribute as high as 30% of the total travel delay in the study area and over 50% in another selected area in the study.

3. *Model sustainability in terms of costs*

One of the major issues in the industry of ride sharing is the lack of sustainable model in terms of profits and costs. The competition among different taxi and ride sharing providers is very high. As a result, these services providers fight for each other's market share. The existing business structures in the industry is power and influenced based, which causes unbalance profitability in this sector. Financing is another major challenge to the smart mobility transition (Liao, 2020). Despite the undoubted benefits of smart mobility, questions are still being raised concerning its financial sustainability. Many countries are yet to figure out the cost implications of smart mobility in terms of capital investment and cost recovery mechanisms and the operation cost.

3.2.4 Public Transport

If any public transport is unintegrated to its mobility system then it doesn't meet the demand of the passengers, which can result in lower number of passengers. Here are few important considerations to see the impact of possible challenges in public transport sector:

1. Travel comfort

For example, passenger may need to buy more than one tickets to complete his/her trip though the public transport. This may cause unwanted discomfort of buying tickets more than once. Single ticket concept would attract more passengers.

2. Passenger information services

Passengers must be informed clearly about the tickets, frequency timetables available both inside stations and vehicles.

3. Delays

Without proper coordination and planning of Timetables and connections may cause unwanted delays and waiting time for the passengers. Multimodal trip planning must be ensured to avoid the connection related delays.

4. Environmental Impact

Although public transport is an eco-friendly transportation mode against the other modes available yet many public transport systems in the urban cities are using old buses or technologies which contribute negatively towards environment safety in terms of emissions and pollution. United Nations (UN) also stated that the transportation sector including private vehicles and public transport are major contributor towards greenhouse gas emissions.

5. Inadequate Infrastructure

Inadequate infrastructure threatens smart mobility transition in car-dependent countries. Existing Infrastructure are just inclined towards private vehicles and lack of public transport infrastructure in the form of rail and road network, tends to slow the development of smart mobility solutions. However, inadequate infrastructure has hindered the progress towards full smart mobility transition. Therefore, the rapidly growing urban centers in these countries need to improve their infrastructure to expand their implementation of smart mobility.

3.3 Identifying Stakeholders

Stakeholder identification is important for stakeholder analysis related to the study. Stakeholders are identified as those getting directly impacted due to SM ecosystems, those who may be indirectly affected or have an impact over the ecosystems. Following table 2 is showing all the potential stakeholders associated with the elements of SM ecosystem.

Table 3.1: Stakeholders associated with the elements of Smart Mobility Ecosystem

ELEMENTS OF ECOSYSTEM		STAKEHOLDERS
Intelligent Transportation System (ITS)	Internet of things	MOI, MOT, Municipalities, Cellular companies [STC, Mobily etc.], ITS Consultants [Siemens etc.], Car Manufacturers [Toyota etc.], Costumers/Users
	Autonomous Vehicles	
Urban Mobility	Car Sharing/Pooling	MOI, MOT, Uber/Careem etc., Car Manufacturers [Toyota etc.] , Costumers/Users
	On Demand Ride services	MOI, Uber/Careem, Ajra Taxi, Local taxi services, Costumers/Users
	Public Transport	MOI, MOT, Municipalities, SAPTCO etc., Costumers/Users

Chapter Four

Methodology and Procedures

4.1 Framework Design Methodology

4.2 Critical Review

4.3 Questionnaire Survey

4.4 Multiple Criteria Weight Selection

Chapter Four: Research Methodology and Data Collection Procedures

This chapter will focus on the methodology conceived from research questions for designing and developing the framework based on key elements, attributes and challenges identified through literature review, and questionnaires to select the best smart city elements and their parameters. This was done through different survey procedures to get their opinions and expectations related to the smart mobility options presented in the study.

4.1 Framework Design Methodology

Three steps were taken to design and develop the framework based on literature review, online questionnaire surveys and panel surveys to select the best smart mobility modes of transport and their parameters through the opinions of common users and mobility experts.

Step 1: This step initially used a qualitative research method with an inductive approach to develop key findings from the literature review. In this step, a comprehensive literature review and detailed research of the government's white paper related to smart mobility in KSA were conducted to identify all relevant criteria and processes involved in the smart mobility ecosystem. Once the criteria are identified, a survey questionnaire was created to solicit feedback from the experts and common users to evaluate the identified set of criteria. Following two approaches have been developed to assess the respondents' feedback, and to reflect the preferences of the participants as accurately as possible.

I. **Critical Review of Plans** – This methodology will focus upon the government's plans, challenges and targets towards the goal of achieving

smart mobility based network.

II. **Questionnaire Survey targeting all identified stakeholders** – Once the criteria/variables are identified, a survey questionnaire was then created to solicit feedback from the experts and common users. The identified set of criteria would be evaluated from the survey results, the research approach will reverse from inductive to deductive at this point of methodology.

After step 1, selected smart mobility modes were ranked based on both research and questionnaire analysis. These rankings would help stakeholders in understanding preferred choices and their respective variables/parameters.

Step 2: This step comprises the development of the multiple criteria decision analysis (MCDA) model based on inferred criteria for the preferred choices (smart mobility modes) of both experts and users from the survey questionnaire developed in Step 1. AHP analysis was carried out by pairwise comparison matrix for the preferred modes and their inferred criteria. Step 2 resulted in ranking of the selected variables based on AHP analysis results. The outcome of this step was a final set of criteria that are validated by the panel of experts, later on, in step 3.

Step 3: This step presents the criteria selection framework that comprises of government prioritization for particular smart mobility solutions and customization mechanism from the survey results that allows for the inclusion of common users and mobility expert's values and preferences as shown in figure 4.1 below. These values and preferences were further validated by panel of experts for the possible transition towards smart mobility.

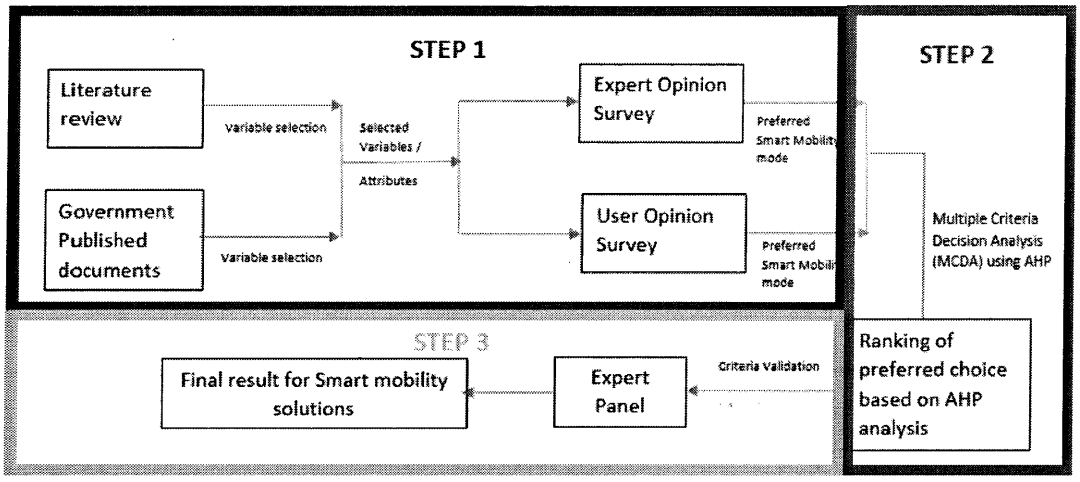


Figure 4.1: Selection of Criteria and modes for framework design

4.2 Critical Review

As explained earlier in this section, this methodology has been selected to identify government's future plans and their selected smart solutions for achieving the goal of smart mobility based network. All the documents and policies identified for this task were linked and lined under the Vision 2030 goals specifically related to smart mobility as mentioned below [Source : National Transport and Logistics strategy (NTLS), 2019]:

i. Capture new mobility modes and leverage new technologies that are relevant for transport

ii. Improve mobility and reduce travel time through regulation, technology, and better infrastructure

Under Vision 2030 plan, a spatial frame has been structured to see hierarchy and relevant policies and strategies to undergo the process of transition from current transportation network to smart mobility network in future. Figure 4.2 is showing the captured spatial frame from vision 2030 plan.

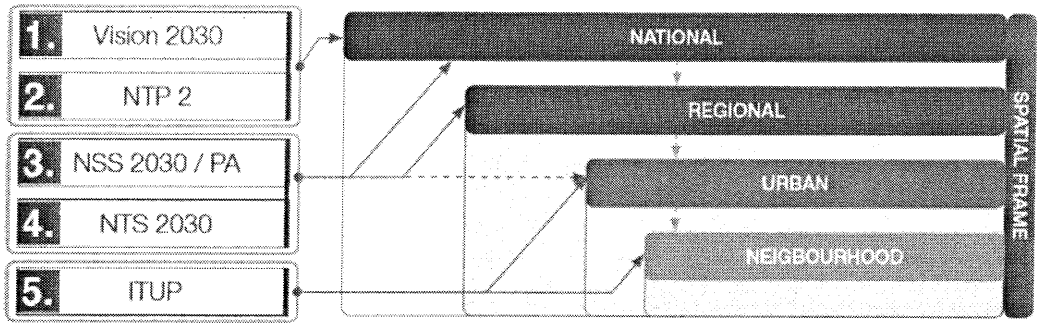


Figure 4.2: Spatial Frame of Saudi Arabia for 2030 (Source: ITUP, 2019)

Based on spatial frame shown in figure 4.2, this methodology researched thoroughly the following three frameworks:

i. National Spatial strategy (NSS),

ii. National Transport and Logistics strategy (NTLS), and

iii. Integration between Transportation and the multi-dimensions of Urban Planning of Saudi Arabia (ITUP)

4.2.1 National Spatial Strategy (NSS)

NSS 2030 is a planning tool including national policies & directives to guide urban development to maximize spatial impact and to support the achievement of vision 2030 targets. This would be achieved through the establishment of smart urban system, and the diversity of regions & cities to enhance quality of live. Moreover, NSS 2030 will set up governance & implementation policies, to face current and future urban challenges and to achieve vision 2030 objectives, and to insure the alignment with other sectorial policies on all national, regional and local levels of NSS 2030 as shown in figure 4.3 below.

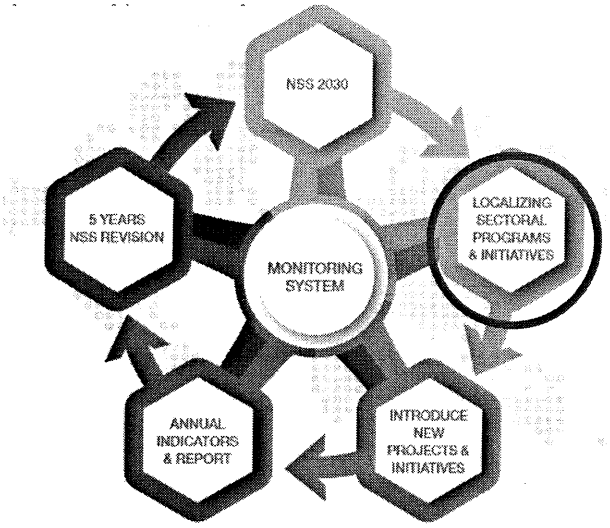


Figure 4.3: NSS 2030 Framework of moving forward (Source: NSS, 2020)

From the NSS framework shown in figure 4.3, it is identified that one of the key step involves local programs and initiatives. In case of urban and neighborhood initiative programs, NSS identify NTLS and ITUP as the local initiative programs for moving forward in terms of achieving regional and national goals related to smart mobility. NTLS and ITUP documents/strategies will be discussed in coming sections.

NSS Methodology

To ensure a successful implementation of NSS 2030, 28 policies are being put forward. Each policy is clearly linked with specific Vision 2030 Strategic Objectives. Each policy requires a set of actions and mobilization of specific stakeholders. They are divided into 6 chapters as shown in figure 4.4. It could be also be seen that chapter 2 solely deals with the goal towards smart and sustainable infrastructure within cities.

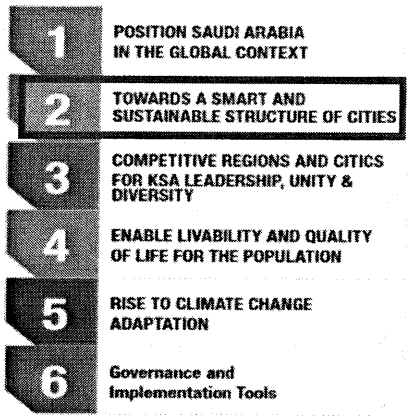


Figure 4.4: Chapters of NSS Policies (Source: NSS, 2020)

4.2.2 National Transport and Logistics Strategy (NTLS)/Model

NTLS offers an integrated strategic view for the overall transport and logistics sector, including priority initiatives and funding requirements. It also provides guidance to different entities operating within the sector to develop their own strategies. NTLS has developed five main tech themes to move towards smart futuristic transportation system. Figure 4.5 shows the five themes identified by NTLS for achieving smart mobility goals within the kingdom.

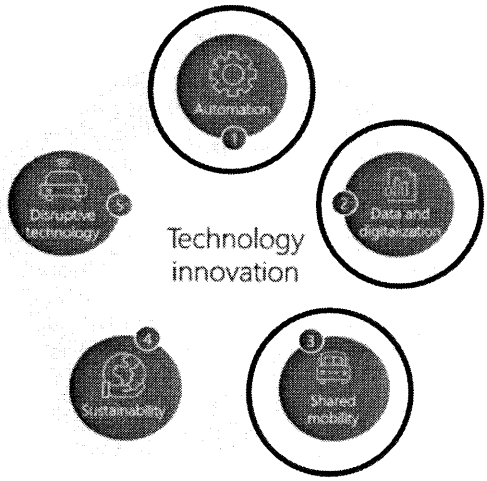


Figure 4.5: Five main tech themes under NTLS Model (Source: NTLS, 2019)

Out of these five themes, first three themes directly links with the identified smart mobility elements in chapter 3 of this study. The three main themes are as follows:

- Automation: Reduce manual interventions across the value chain, through automation in logistics and transportation. Autonomous vehicles (cars, buses, trucks).
- Data and digitalization: Leverage big data and analytics to predict and manage demand / traffic, enhance supply chain logistics and provide customized user experience. Vehicle interaction to everything (V2X), smart road infrastructure, Augmented reality (AR), virtual reality (VR), IoT
- Shared mobility: Leverage shared mobility options for micro mobility (scooters, bikes) and urban mobility (cars, vans).

NTLS Model

NTLS proposed many different pilot projects under each developed tech theme for moving forward. This strategic documents also find out key performance indexes for monitoring and evaluation of the progress for each plans and projects under the specific tech themes.

NTLS has set the target of different plans by 2030 for example in case of public transport it is intended to achieve 15% modal shift out of total trips in cities by 2030.Pilot projects have already been started in 2020 related to main tech themes.

4.2.3 Integration between Transport Planning And Management and Multi Dimensions Of Urban Planning Of Saudi Arabia (ITUP)

ITUP is an initiative to strengthen integration between land use and transport planning to enhance overall livability in Saudi cities considering Vision 2030 of Saudi Arabia.

The broader mission of the ITUP project is defining an integrated urban and transport planning system for the Kingdom that builds on the nation's current strengths and unique values by learning from international best practice and state-of-the-art technologies to help position KSA as a pioneering and successful global model of excellence.

ITUP identifies four key dimensions of integrations in their initiative strategy with smart solutions and technology among the four key identifiers as shown below in figure 4.6.

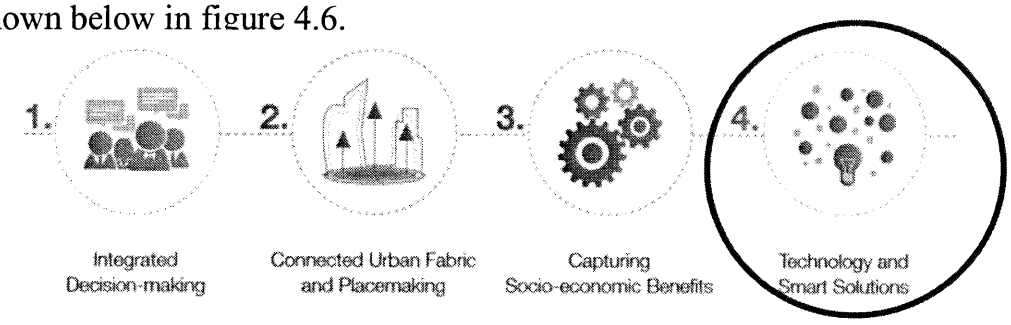


Figure 4.6: Four Key identifiers by ITUP

Smart Solutions Modeling

ITUP recognizes different methodologies to move towards their goal of achieving better livability through smart solutions put under their plan. Only smart mobility related methodologies are presented from ITUP document in this study which are as follows:

I. Promotion of cleaner vehicle engine technologies and fuels

II. Promotion of e-commuting and e-commerce

III. Embracing new technologies that support the sharing economy, such as Mobility as a Service (MaaS)

IV. Create micro-simulation model for all networks to study the impact (in the implementation stages of ITUP

4.3 Questionnaire Survey

This section of the report discusses the data collection through online questionnaire survey. The purpose of this survey was to find the potential of using new technologies and ways of transportation from the perspective of both a 'common user' and 'experts' sitting in various public and private transport related institutes. A common user in this survey is called by the term "Mobility Users" whereas transport related experts (professionals) were named "Mobility Suppliers".

Online questionnaire was developed using the Question Pro platform. The survey questionnaire consisted of multiple logical segments which deploy themselves based on the response of the survey participant; the logical questions are crafted carefully by perceiving the logic-sequence of induced responses to the questions asked. For instance, if the participant respond to a question that "they are mobility users", as a logical sequence, they will not be asked certain questions related to "Mobility Suppliers". Also this way, general users could be separated from the selected users who work in mobility (transport) sectors and are called Mobility supplier in this study report. Feedback provided by the users and mobility suppliers may help understand their expectations and needs, and eventually may positively influence the

transition of smart mobility solutions into current mobility system/network. Hence, the data collection from the survey questionnaire comprised of four phases:

1. Developing of survey by focusing on different aspects and factors helping in achieving smart mobility transition.
2. Testing the data collection and responses as a pilot survey. Pilot survey was conducted within close circle of author and supervisors for testing purposes.
3. Data was collected for the study sample through the developed online survey via web link. Online survey links were shared around the connected network through different social media and also sent directly to selected public/private mobility entities to get direct feedback on the status quo.
4. Careful selection and filtering of survey responses in case of unfinished or rushed survey results based on time spent/taken for the completion of survey.

4.3.1 Development of Online Questionnaire Survey

A non-probability sampling method has been used in this study, which is the convenience sampling (online survey method). This method has been selected to consider only educated group of common users and few selected public and private professionals in transport industry. Supplier survey was controlled by a password so that it is carried out by researcher's targeted professionals. Online questionnaire was developed using question pro platform and basic structure can be seen in figure 4.7 below. The online survey was available in both "English" and "Arabic" languages for the responder's

convenience and they were given the choice before starting the Basic Questions sections as shown below.

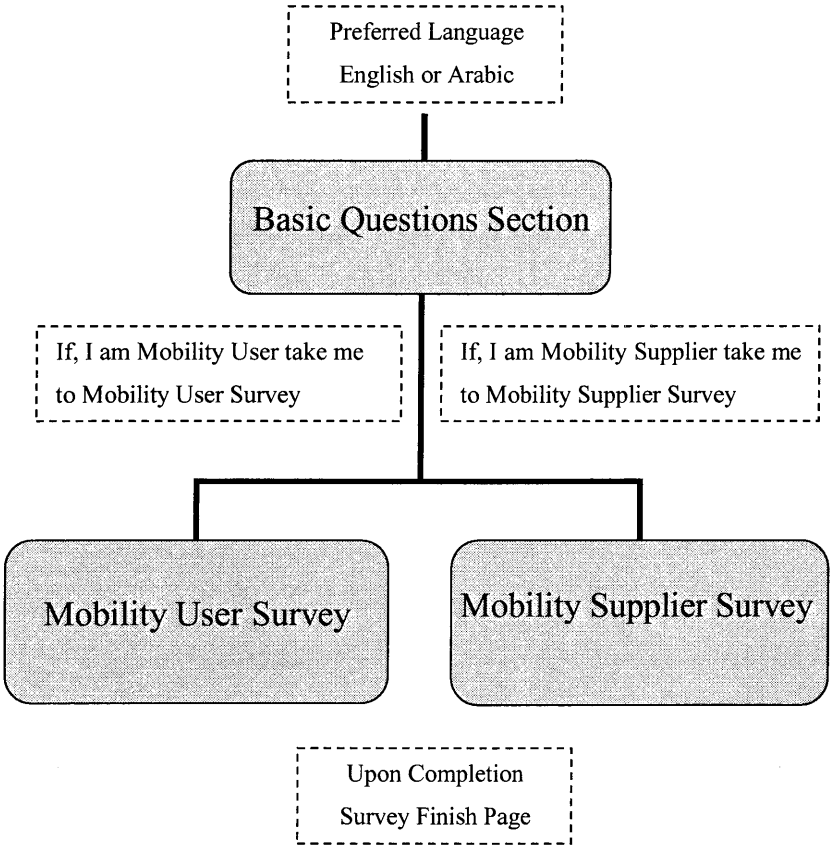


Figure 4.7: Structure of Online Questionnaire Survey

4.3.2 Data Collection through Online Questionnaire Survey

To begin with, an online pilot questionnaire was sent to several colleagues, who can be regarded as experts in the field of smart mobility, during December 2021. Following that, the questionnaire was finalized and was distributed online, as mentioned before. The result of the questionnaire was collected separately via two sets of links i.e. 1) Mobility Users survey, and 2) Mobility Supplier survey. The data were collected from the 26th

December 2021 until 28th February 2022. Participants were introduced to the objectives and the purpose of questionnaire before they would filling it.

In case of **Mobility user survey**, the number of total responses was 326 participants, 63 participants said they work in industry related to transport and mobility therefore they were not included in this set of survey sample as they don't come under the category of common mobility user who do not have professional association with mobility industry, therefore remaining 263 participants were considered for further screening and analysis. Out of remaining 263 samples, further 58 (22%) surveys were considered as dropped out or not completed. Therefore, the study sample of 205 participants were finalized for the analysis.

Mobility supplier survey, which was sent to selected organizations and professionals, was password controlled. Even though the survey was sent to selected audience still there was an added question similar to user survey about affiliation with mobility sector. This question added further check and balance over the mobility user survey. The number of total responses was 70 participants, 15 said they don't work in industry related to transport and mobility therefore they were removed from the survey sample. Out of remaining 55, 10 (18%) surveys were dropped out (not completed) thus also not considered for the data analysis. So, total final responses qualified for the analysis comes out to be 45.Out of total 250 survey samples including both common user and mobility experts, 40 (19%) responses were in English while rest of 210 (81%) responses were observed in Arabic language.

4.3.3 Research Questions

As mentioned earlier, based on the current literature review on smart mobility and the purpose of this study, various questions have been identified

and used for further analysis. These questions lead to conclusions that reveal the Saudi citizens and residents' point of view on the smart city objectives, elements, and applications. Total 250 participants completed the survey. This included 205 general users and 45 transport experts. As suggested by (Hair et al., 2010), the minimum sample size should be between 10 to 15 times the number of observed variables. As the user survey contained 16 questions, the sample size would be 12.81 times the number of observed variables (205 participants/16 observed variables). Noy and Govini (2018) used 22 online questionnaire out of total 118 survey sample in their study. The study was targeting transportation experts and entrepreneurs related to smart mobility. Similarly, Xydis et .al (2021) carried out a smart mobility study based on the opinion of 61 transportation experts through the survey questionnaire. On the basis of the above studies, it seems that smaller sample sizes are considered acceptable for surveys focused on experts, as it would be considered similar to focus group. Hence, the sample size of supplier survey in this study may also be justified.

The research questions correspond to two main categories: the first category includes the participants working as a transport professional while the second category includes the participants that are not working in traffic or transport related field.

i. User Survey

ii. Mobility Supplier Survey

In order to analyze the extent to which smart mobility options, as it is understood by general users and the facilitators of smart mobility, are preferred, the results of the survey are presented in two parts.

The demographic features formed the questionnaire's first section. This section was the common part for both set of surveys i.e. User survey and Supplier survey. The second part presents general beliefs and preferences of the common users and experts with respect to today's transport's condition in Saudi Arabia. See Appendix for the questionnaire surveys for both User survey and supplier survey.

4.4 Multiple criteria weight selection

This section of the chapter presents a methodological approach for criteria selection and then assigning weights based on the ranking suggested by the mobility experts. To determine the precise interdependencies among selected multiple criteria for the smart mobility solutions, the analytic hierarchy process (AHP) is applied. AHP process was carried out using Microsoft Excel. Five (5) criteria have been selected for the multiple criteria analysis. The criteria were selected based on the previous research and are already identified and discussed as an important challenge for the smart mobility ecosystem in the chapter 3 of this present research. Table 4.1 shows the selected criteria for the multiple-choice criteria selection.

Table 4.1: Selected Criteria for AHP analysis.

No.	Criteria	Description
1	Cost	Cost of the technology, implementing costs and maintenance costs
2	Flexibility	Comfortable accessibility and wider network coverage
3	Infrastructure	Available infrastructure and need of new infrastructure (includes also all the accessories of the technology being considered)

4	Safety	Accident safety measures including security and comfort
5	Speed	Speed of the smart mobility mode (less time of travel)

The analytic hierarchy process (AHP) developed by Saaty, (2008) is one of the common methods used for pairwise comparison data. In this method, multiple criteria are compared pair-wise through the use of the hierarchy process. Figure 4.8 is showing the selected hierarchy structure for this study. It is important to mention that only upper level criteria are selected for the pairwise comparison as ranking of the smart mobility modes or solutions are selected based on the research method and questionnaire surveys as discussed in section 4.2 and 4.3 of this chapter.

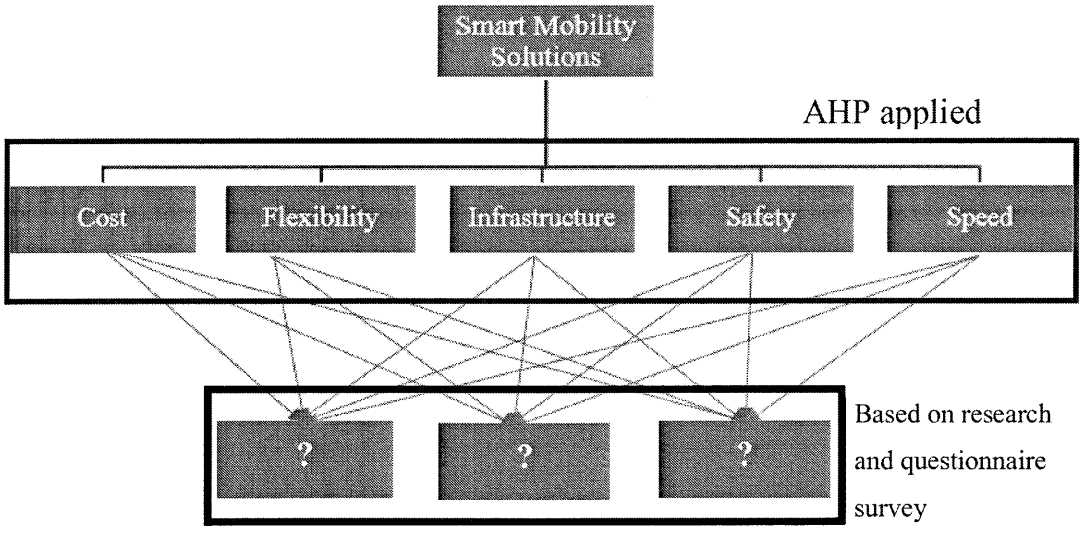


Figure 4.8: Hierarchy Model for smart mobility variables

Similar to Supplier survey from section 4.3, the questionnaire for mobility experts was developed for the pair-wise comparison of the selected five variables. Experts were asked to give their preference for the respective

variables. For example, how much is the cost importance in comparison to safety in the context of smart mobility. The experts chose on a linguistic scale from equal importance to extreme importance.

Şahin and Yurdugül, (2018) stated that most commonly used sample size, for AHP method, ranges between 2–100 experts. Darko, et.al, (2019) mentioned that there is no such minimum sample size for carrying out AHP analysis and cited studies using sample size between 4 to 9 experts. Therefore, for weighing the criteria, 20 transport experts were selected for the pair-wise comparison questionnaire to rank the selected variables for smart mobility solutions. Based upon the discussion of above studies, such sample size can be considered sufficient for this analysis.

Chapter Five

Results and Discussion

5.1 Results and Discussion – Research Based Method

5.2 Results and Discussion – Questionnaire Survey

5.3 Results and Discussion – Multiple Criteria Analysis

5.4 Smart Mobility Model and Framework

5.5 Validation of the Framework

Chapter Five: Development and Validation of Framework

This chapter will discuss the results from the both types of methodologies used in this study. This was done through research of national policies, programs and data analysis from the questionnaire survey.

5.1 Results and Discussion – Critical Review

The three identified frameworks/documents were carefully analyzed for the identification of all the key plans, future technologies, their challenges and timelines related to smart mobility system.

Each of the three documents are discussed in this chapter with focus only in smart mobility plans, technologies and their potential time-frames for execution. Then all the identified smart mobility solutions are summarized at the end of each section for better understanding of the readers.

National Spatial Strategy (NSS)

As mentioned above in methodology, NSS has developed 28 polices for achieving goals and objectives. This study identifies two policies, Policy 5 and Policy 18, which are directly related to smart mobility solutions. These policies are meant for helping achieving the transition towards smart mobility network system in Saudi Arabia.

Policy 5 – NSS

Policy Statement: Focus on smart technologies to increase global competitiveness and reinforce economic development of the regions

Key Objectives related to Smart Mobility

- Emerging technologies represent great opportunities to confirm the Kingdom's global competitiveness ranking.

- New technologies will reinforce economic development of the regions and will require specific conditions to attract investments and highly qualified people.
- These new technologies will reduce the costs for urban services and will upgrade traffic management within cities

Actions Required

- Develop new technologies in the following seven sectors including Transportation
- Adapt smart cities program and IT application.

Program | Initiatives for moving forward

- National Transport and Logistics Strategy (NTLS)

Policy 18 – NSS

Policy Statement: Integrate land use and transportation planning to increase efficiency of cities and regions

Key Objectives related to Smart Mobility

- Cities will benefit from new approaches in planning and management to reduce costs of public services, increase attractiveness of cities, and the offer of services and activities in communities.
- A better integration of land use and transportation planning, for example by following the Transit-Oriented Development (TOD) concept applied in many large cities worldwide, will facilitate more rational management of cities.

Actions Required

- Implementing mass transportation (metro, BRT, LRT) in cities
- Adopting Complete Streets measures to accommodate all modes of transportation by reducing dominance of the automobile within cities,

converting streets back into spaces for people and promoting walkability.

- Give priority for public transit for common road usage.
- Giving priority for public transit in shard uses of roads

Program | Initiatives for moving forward

- Strengthening Integration between Transportation and the multi-dimensions of Urban Planning of Saudi Arabia (ITUP)

Key Findings – NSS

"A strategic tool for cross-sectoral operation" that will provide a link between the programs, initiatives and projects prepared by all ministries and public agencies and also by the private sector and civil society. Key findings from the strategic document of NSS can be seen in figure 5.1 below:

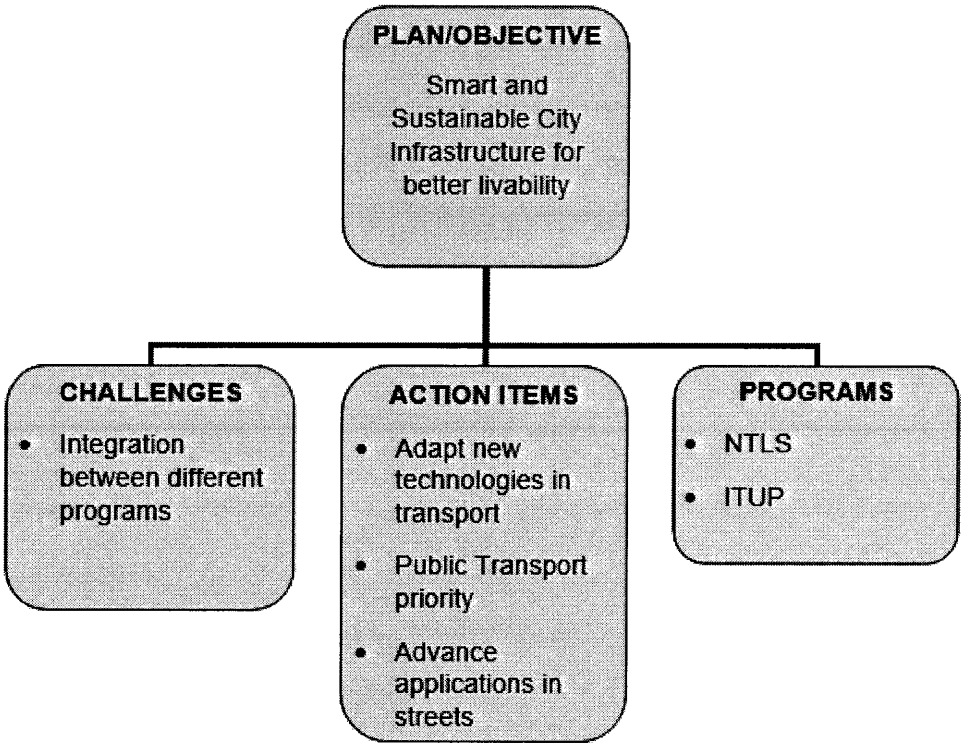


Figure 5.1: NSS Main Key Points

The identified smart mobility elements in this present research falls in line with the above recommended solutions from NSS. Table 5.1 shows the potential connection/link between smart mobility elements (solutions) of this study and NSS's identified smart solutions.

Table 5.1: NSS Smart Solutions vs. Thesis Study Smart solutions

Sr No	NSS's Smart Solutions for transportation	Thesis Study Smart Mobility Solutions	Connection/Link
1	Adaptation of New Technologies	ITS	Indirect
2	Advance streets to accommodate all modes of transportation	Public Transport/ITS	Indirect
3	Public Transport Priority	Public Transport	Direct

National Transport and Logistics Strategy (NTLS)

Challenges

There are different challenges being faced by NTLS however specific challenges related to smart mobility have been identified as follows:

- Technology expertise
- Infrastructure readiness
- Regulatory approvals

Future Plans

Few of the future plans under NTLS initiatives are as follows:

- Automated trucks to pilot "Highway point-to-point" (i.e. constrained autonomy) in KSA by 2025
- Implementation of AV trucks and training of drivers to use them appropriately
- KSA's city (e.g., Riyadh or Jeddah) as the first global city with an at scale pilot of autonomous vehicles by 2023-25
- KSA to become a hub for testing piloting autonomous vehicles with ~1000 Avs on the road
- Leading AV companies such as Waymo, Cruise, etc. to test and refine their technologies in Riyadh
- Number of AVs to gradually ramp up to position KSA as a leader in AV technology in the future

Key Findings – NTLS

Multimodal, Sustainable, and Futuristic Transport and Logistics Sector led by national capabilities to Transform KSA into a Global Logistic Hub. Key findings from the strategic document of NTLS can be seen in figure 5.2 below:

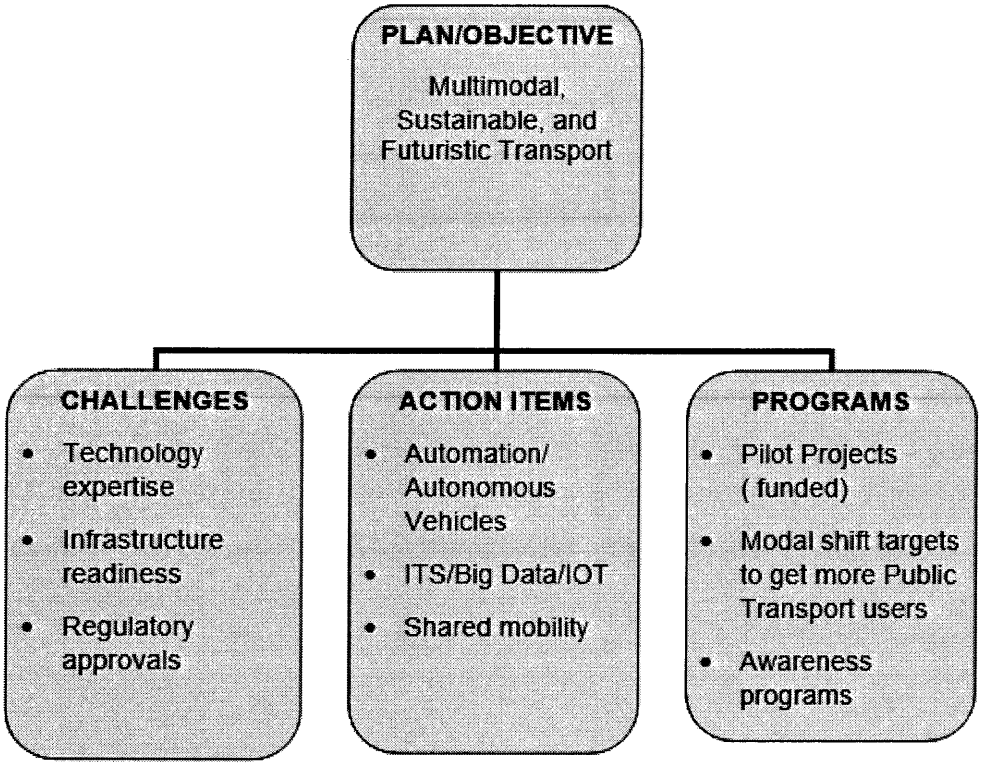


Figure 5.2: NTLS Main Key Points

The identified smart mobility elements in this present research falls in line with the above recommended solutions from NSS. Table 5.2 shows the potential connection/link between smart mobility elements (solutions) of this study and NSS's identified smart solutions.

Table 5.2: NSS Smart Solutions vs. Thesis Study Smart solutions

Sr No	NTLS's Smart Solutions for transportation	Thesis Study Smart Mobility Solutions	Connection/Link
1	Automation/ Autonomous Vehicles	ITS/Autonomous Vehicles	Direct
2	ITS/ Big Data	ITS	Direct
3	Shared Mobility	Shared Urban Mobility	Direct
4	Public Transport Priority	Public Transport/ITS	Direct

Integration between Transport Planning And Management and Multi Dimensions Of Urban Planning Of Saudi Arabia (ITUP)

Main objective of the ITUP is to make Smart solutions as enabler for integration at all levels of urban and transport planning, governance, marketing and promotional strategies, online public engagement etc. Following are the identified actions required in the light of smart mobility solutions.

Action Required

- Demand-based autonomous public transport - Sign agreements between public transportation and private ride-sharing companies for first-mile/last-mile integration. - Offer incentives for selecting more environmentally friendly transit options.
- Integrated passenger / transit information - Collate and simplify travel information and booking, supporting multi-modal journeys and seamless transportation options. - Provide transportation services such as access to bike sharing, car sharing and other services.
- Integrated ticketing - Create a trip planner, and website and app for a "one stop shop" for all transportation services, regardless of mode and ownership
- Traffic safety - Form Vision Zero strategies and road redesign strategies, identifying "zones" for traffic safety improvements and adopting the "complete streets" concept.
- Adaptive traffic signaling to ensure smoother transit flows - Install signal technology in traffic signals and transit vehicles

Time Frame of 5-10 years are considered or required to implement all measures for recommendation above.

Key Findings – ITUP

Learning from the international experience of integrating technology and using smart principles in planning and mobility, key recommendations are proposed under ITUP initiative program. Key findings from the strategic document of ITUP can be seen in figure 5.3 below:

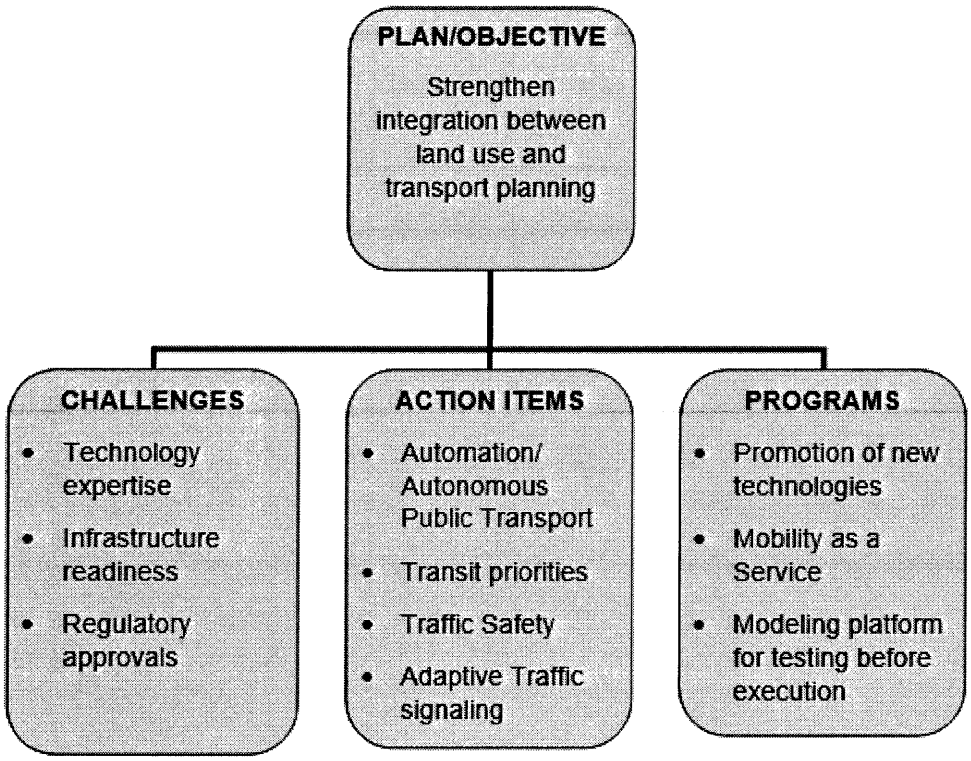


Figure 5.3: ITUP Main Key Points

The identified smart mobility elements in this study falls in line with the above recommended solutions from ITUP. Table 5.3 shows the potential connection/integration between smart mobility elements (solutions) of this study and ITUP's identified smart solutions.

Table 5.3: ITUP Smart Solutions vs. Thesis Study Smart solutions

Sr No	ITUP's Smart Solutions for transportation	Thesis Study Smart Mobility Solutions	Connection
1	Autonomous Public Transport	Public Transport/Autonomous vehicles	Direct
2	Integrated passenger/transit information	Public Transport/ITS	Direct
3	Integrated ticketing	Public Transport	Direct
4	Traffic Safety	ITS	Indirect
5	Adaptive traffic signaling to ensure smoother transit flows	Public Transport/ITS	Direct

5.1.1 Analysis of Key Findings from the Research Methodology

It was important to analyze the key findings from this section to show the most preferred smart solutions from the important government funded initiative programs. Therefore, a summary table has been devised to analyze the frequency of different smart mobility elements in each of the three discussed initiative programs in previous sections of this chapter. Results of the analysis could be seen in Table 5.4 below showing Public transport being the most mentioned and prioritized mode of transportation in the future plans of Government policies.

Table 5.4: Frequency of Smart mobility elements in different government plans/programs

Initiatives & Programs/ Smart Mobility Solutions	Shared Mobility	Autonomous Vehicles	Public Transport	ITS
NSS	☒	☒	☑	☑☒
NTLS	☑	☑	☑	☑
ITUP	☒	☑☒	☑	☑

☑ = Present directly within the initiative program

☒ = Not mentioned within the initiative program

☑☒= Mentioned but indirectly within the initiative program

5.1.2 Ranking Based On Priority in Government Programs

Based on frequency analyzed in table 5.4, all the four most mentioned smart solutions were ranked in order to see the priority in terms of government initiative programs.

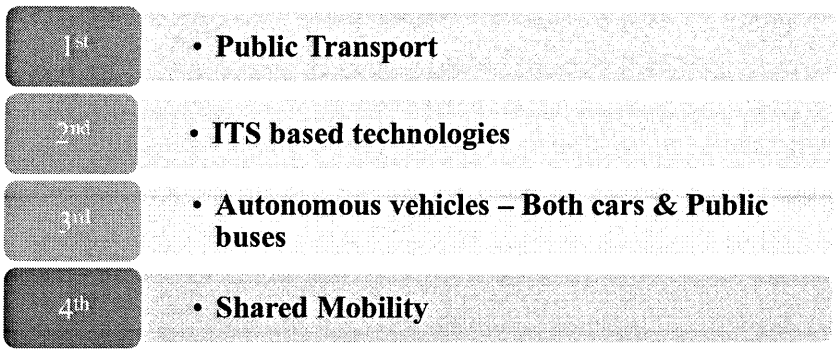


Figure 5.4: Ranking based on priority and frequency

5.1.3 Projects and Initiatives under Government Programs

Following potential projects, initiatives and program are captured under various national strategies that have come in line with ambitious targets of Vision 2030:

Public Transport

- Riyadh Metro City - The Masterplan promotes major redevelopment around metro stations to create a new central business district (CBD) based on transit orientated development (TOD) planning principles. Expected time of operation from year 2022. *Source: ITUP, (2019)*
- Development legislation and policies to support PuT services and enhance their financial sustainability, examine incentives for the use of PuT, and establishing a PuT Trust Fund. This project is placed under must- have projects in near future (5-10 years) by NTLS, 2019.

- Development public transport Masterplan for selected cities including identification of financing options. This project is placed under good to have category for future (~ 10 years) by NTLS, 2019.

ITS based technologies

- MoMRA smart city initiative – This initiative intends to bring together city data streams to support the development of climate-resilient infrastructure, for real-time management and planning, and provide open access to city data for commercial and service delivery organizations. Expected time frame is between 5-10 Years. *Source: ITUP, (2019)*
- Adaptation of traffic signals to prioritize mass-transit vehicles over privately owned vehicles to support multi-modal travel. Expected time frame is between 5-10 Years. *Source: ITUP, (2019)*
- Development and deployment of a highway traffic control management system along major corridors in the kingdom, including development of data control centers, to monitor traffic conditions and plan necessary interventions. This project is placed under must- have projects in near future (5-10 years) by NTLS, 2019.
- Design and development of GIS for MOT by designing and deploying relevant applications. This project is placed under most needed and critical projects in near future (0-5 years) by NTLS, 2019.

Autonomous vehicles – Both cars & Public buses

- Demand based autonomous public transport – Agreement phase between public transportation and private ride-sharing companies

started for the first/last mile integration. Expected time frame is between 5-10 years once agreement is signed. *Source: ITUP, (2019)*

- Trucks will likely be first to enter stage of autonomy on public roads, e.g. truck Original equipment manufacturer (OEMs) are working on. The prototype of Future Truck is expected by 2025. Hardware already exists, whereas software for complex situations (e.g. rush hour traffic) is in development. Expected time of implementation is between 2023 and 2040. *Source*: *NTLS, (2019)*
- Setting up V2X programs and pilot projects across the Kingdom for capturing new mobility modes and leverage new technologies. This project is placed under good to have category for future (~ 10 years) by NTLS, 2019.

Shared Mobility

- In terms of mobility, although it will take time for MaaS to mature full scale in Saudi cities, the Delilat Arriyadh App and presence of Uber & Careem are initial step towards MaaS. *Source: ITUP, (2019)*

5.2 Results and Discussion – Questionnaire Survey

The software program that was used for this calculation was the Statistical Package for the Social Sciences (SPSS). Descriptive and cross table analysis were performed among the variables in the questionnaire. In addition, statistical tests were applied to check if there is any kind of dependency between the categorical variables that are related to each asked question (See appendix). The Chi-Square statistic test, with a significance level of 5%, was used to test if there is any relationship or dependence between the selected variables. With p-value less than 0.05, the result would be declared statistically significant, and that the independence hypothesis would be rejected. In other words, there will be a dependency between the variables. Pearson's Chi-square is also used to check whether each observation is independent of all the others (i.e., one observation per subject); and no more than 20% of the expected counts are less than 5 (Yates et al., 1999).

USER SURVEY

The first six questions (as shown in Table 5.5) constituted the questionnaire's first section and were common questions for all participants, as stated earlier. When it comes to the first question ("Are you"), relatively a balance seems to observe between the number of men and women that participated in the survey. More specifically, 38.5% (79 in total) of the participants were women, whereas men participants come out to be 61.5% (126 in total). The second question was about the age of the participants. Out of the total respondents, 24.42% (50 in total) were from 18 to 24 years old; 39.5% (81 in total) were from 25 to 34 years old; 20.5% (42 in total) were from 35 to 44 years old; 7.8% (16 in total) were from 45 to 54 years old; 4.4% (9 in total) were from 55 to 64 years old and, lastly, a small percentage of 3.4% (7 in total) were older than 64 years old. Most

of the respondents in common user survey correspond to 25 to 34 years of age.

The third question was simply considering the residing status of the participants and results show 98.5% (202) of the total participated were in Saudi Arabia while rest of merely 1.5 % (3) were responding from other country. It should be noted that these 3 respondents were also permanent residents of Saudi Arabia, as showed by their other answers, and were outside Saudi Arabia temporarily at the time of survey. The fourth question was related to the regions of the responders within Saudi Arabia. The idea behind this was the contribution of major regions in this questionnaire study. Most of the participants (52.2%, which corresponds to 107 persons in total) belong to the Eastern Province, whereas relatively a higher percentage of 22.0% (45) was observed from Riyadh Region. Makkah/Jeddah region contributed 9.3% (19) of the total participants while rest of 16.5% responders were living in various other regions as shown in Table 5.5 below.

Education level was being asked in question five where major percentage of 59.5% (122 in total) hold a Bachelor's degree and participants with Master's degree came out to be second highest responders with 15.6% (32 in total). Last of the six demographic related question was related to familiarity with the term of Mobility and statistics show a balance answers of Yes (45.4) and No (54.6%) were observed from the participants. See Appendix for the questionnaire surveys for both User survey in both English and Arabic.

Table 5.5: Demographic Frequency Table – User Survey Result

		Count	Percentage %
Q1 - Are you	Male	126	61.5%
	Female	79	38.5%
	Prefer not to answer	0	0.0%
Q2 - What is your age	Under 18	0	0.0%
	18-24	50	24.4%
	25-34	81	39.5%
	35-44	42	20.5%
	45-54	16	7.8%
	55-64	9	4.4%
	Above 64	7	3.4%
Q3 - I am based in	Saudi Arabia	202	98.5%
	Other	3	1.5%
Q4 - My region in Saudi Arabia is	Riyadh	45	22.0%
	Eastern Province	107	52.2%
	Makkah/Jeddah	19	9.3%
	Madina/Tabuk	9	4.4%
	Asir	3	1.5%
	Jizan	5	2.4%
	Tabuk	3	1.5%
	Ha'il	1	0.5%
	Najran	0	0%
	Northen Region/Al Jawf	2	1.0%
	Other	11	5.4%
Q5 - What is the highest degree or level of school you have completed	High school	19	9.3%
	Some college	22	10.7%
	Trade/vocational/technical	6	2.9%
	Bachelors	122	59.5%
	Masters	32	15.6%
	Doctorate	4	2.0%
Q6 - Were you familiar with the term " Smart Mobility" before this survey	Yes	93	45.4%
	No	112	54.6%

After the demographic surveys **in second section of the questionnaire,** eight (8) questions were asked to those respondents who chose *"They don't work in mobility/transport related industry"*.

Question 1: My company/work is a part of the following sector:

Common users were asked whether they work or not, and in case of working which sector they are associated with. Out of 205 participants, 121 of them (59 %) answered they work in private sector, 44 (21.46%) said they work in public sector, 13 participants (6.34%) were not working and 27 (13.17%) opted the option of others, which included freelancers, PhD students etc. The results are shown in figure 5.5 below.

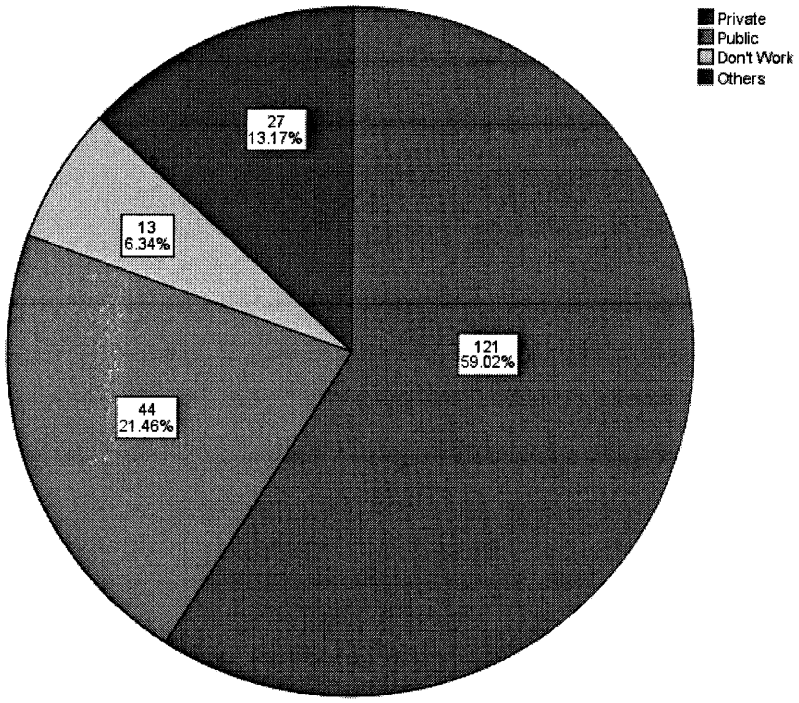


Figure 5.5: Working sectors of the participants

Question 2: In your opinion, how much satisfied are you with current mobility (Transport) options in your country

Question 2 asked the participants to evaluate the current transport options in Saudi Arabia. This question gives an insight to what common users think of the transportation infrastructure available to them. Results show that approximately 1/3rd of the participants are neutral in this regard

(64, 31.22%). Still, almost the same number of responders said they are unsatisfied with the current mobility options with 62 (30.24%). Around 19% persons were very unsatisfied while very few participants were very satisfied with percentage of nearly 6% out of total responders. The results are shown in figure 5.6 below.

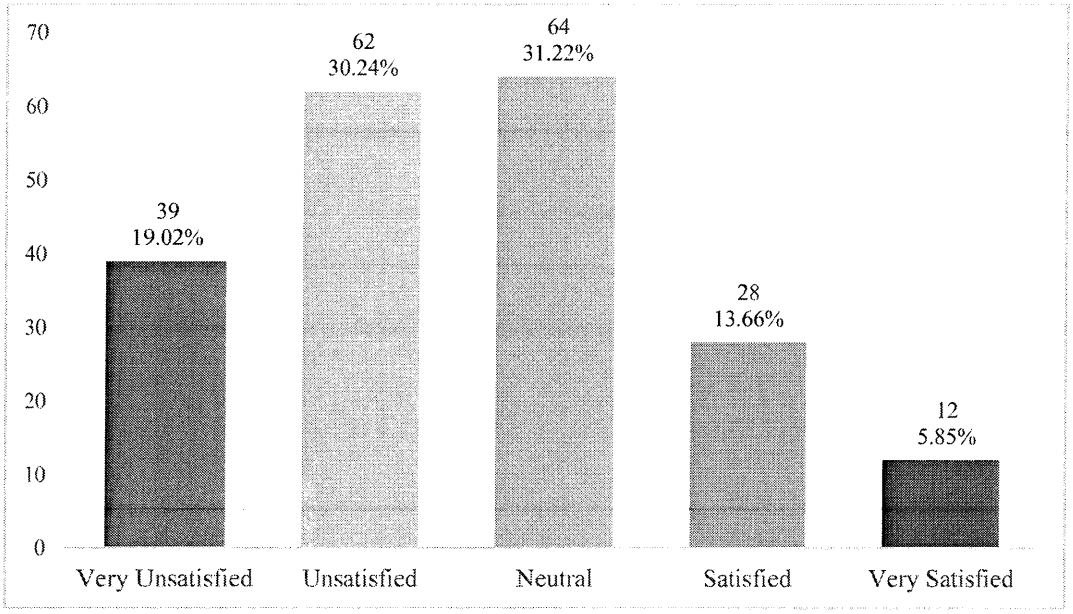


Figure 5.6: Opinion survey regarding the existing transportation system

Since the question was an important variable in figuring out the common user perspective, therefore, statistical tests are applied to check if there is any kind of dependency between the demographical variables that are related to each research question. The Chi-Square statistic test, with a significance level of 5%, was used to test if there is any relationship or dependence between gender and their opinion regarding current mobility options. The p-value < 0.002 is less than 0.05 which means that the result is statistically significant, and that the independence hypothesis is rejected. In other words, there is a dependency between the variables and this means that gender is indeed related to the satisfactory opinions.

No other demographic variable showed significant relation with question 2 statements therefore it means that the independence hypothesis cannot be rejected. In other words, the variables are not likely to be associated, thus age, education, regions and familiarity with the mobility terms are not a significant factor for a satisfaction with the current mobility options in Saudi Arabia. See appendix for all the results for statistical analysis.

Question 3: Have you ever heard about alternative (different) mobility (transport) solutions before this survey?

In this question, it was investigated if age, gender, familiarity with the smart mobility term and education are determinant factors for a better knowledge of existing alternative mobility solutions. From the 205 participants, 103 (50.2%) said they know the alternative mobility options while almost same number of participants (102, 49.8%) were ignorant of the term "Alternative mobility solutions". Just like previous question, only question involving "Gender" made significant relation with the p-value of 0.027, which is less than 0.05 which means that the result is statistically significant, and that the independence hypothesis is rejected. In other words, there is a dependency between the variables and this means that gender is indeed related to the fact that the participant has heard the term or not. The results can be seen in figure 5.7 below. Results also show that 59% of the women were unknown to the term of alternative mobility solutions therefore it can be said that generally men are more familiar with the term as compared to women.

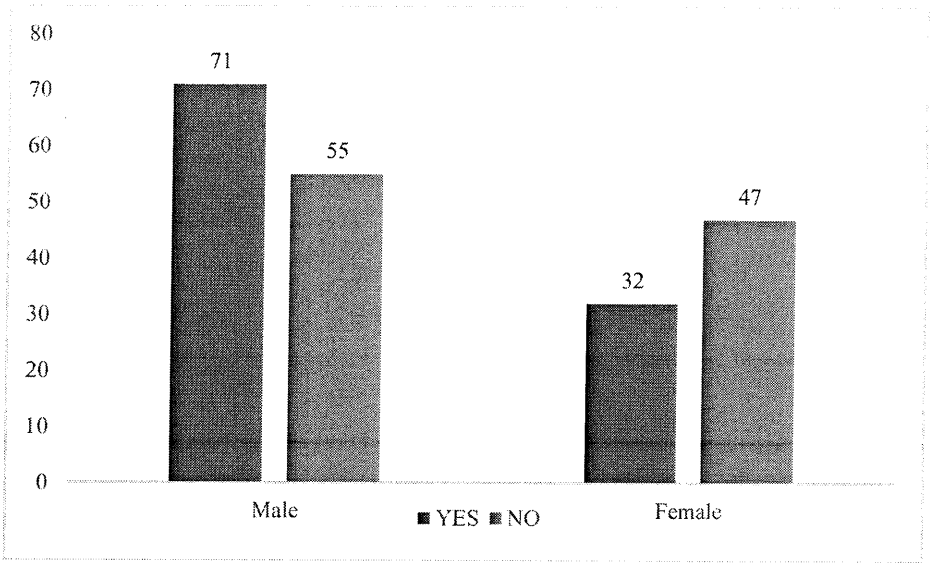


Figure 5.7: Opinion survey regarding the existing transportation system

Question 4: Do you think it is important to have several alternative (different) mobility (Transport) solution in your country

This question was asked to find the point of view from a common user perspective about the importance of alternative mobility solutions. From the previous question, it was quite evident that majority of the participants didn't know the alternative mobility options therefore statistical analysis involving chi-square was carried out between the question "have you heard the terminology of alternative mobility" and "do you think it is important to have different alternative mobility options". But the results show high p value of 0.68 showing that no such relation could be possible between them.

Results show that very high number of participants said it is very important to have such alternative options despite the fact that 50% of them never heard of these alternative options. The reason could be the presence of explanatory phrases in the questions for the participants for their better understanding. Out of 205, 168 (82%) stated it is very important to have

such solutions while just over 16% responders said it is just important to have them in the transportation network. Table 5.6 is showing the breakdown of analysis, highlighting the fact that majority of users are in the favor of alternative mobility solutions.

Table 5.6: Need of Different alternative mobility solution

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	Yes	87	15	1	0	0	103
	No	81	18	1	1	1	102
	Total	168	33	2	1	1	205

Question 5: Which alternative mobility solutions you want to see implemented in your country (Multiple Options can be checked)

This question was one of the open-ended questions for asking the participants their choices. This could be really important information for the stakeholders to see the different possible choices from the common user perspective. That helps in gauging acceptability of alternative mobility solutions from common masses in the country. Results show that public transport was top choice among the common user participants with 46% of the total participants ranking public transport as their priority. Autonomous vehicles was selected by 20% participants while both ride sharing and car sharing were among the third priorities with the participants around 15% for each.

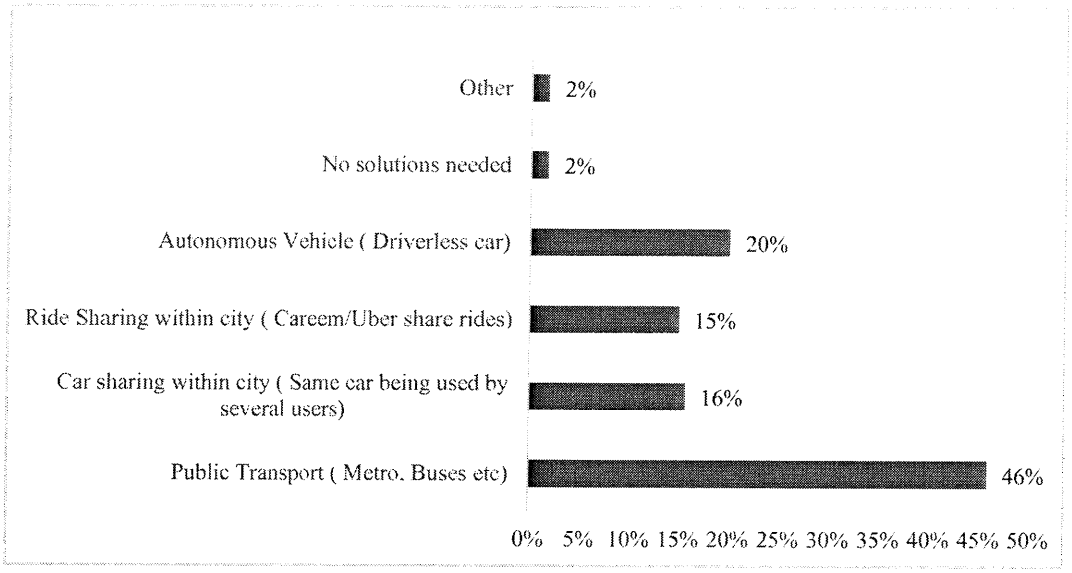


Figure 5.8: Choice of common users for alternative mobility solutions

Based on frequency analyzed in figure 5.8, among the mentioned smart solutions, prioritized options by the common users could be ranked as shown in figure 5.9. This ranking closely matches with the ranking by the government as shown in figure 5.4.

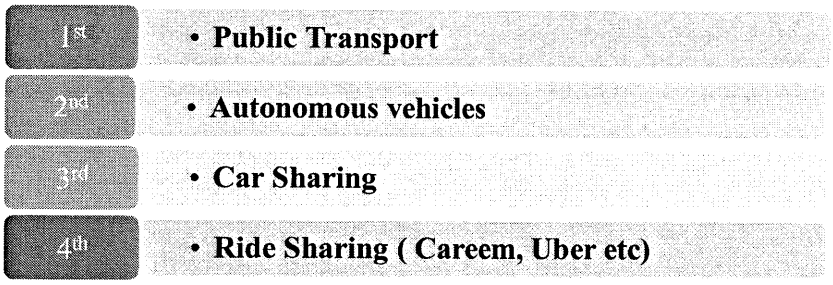


Figure 5.9: Ranking based on the choice of participants

Question 6: Please rank top 3 from the following mobility (Transport) solutions in order of your interest:

This question was similar in nature with previous question, the reason to ask the question is to verify the responder's choice when it comes to mobility solutions. Here it is asked to find the interest of experts when it comes out to choice of mobility options. Similar results were achieved under this question in comparison to question 7 therefore showing the

reliability of the questionnaire results. Public transport remains the priority choice while ride sharing solution was the least ranked choice as shown in figure 5.10 below. Public transport was ranked first by 137 users, autonomous was ranked first by 47 responders, car sharing was given top rank by 15 persons whereas ride sharing was the first priority of only 6 users. Autonomous vehicles was 2nd best option of the majority of users with 71 responses. Car sharing was selected by 85 users as 3rd priority and ride sharing was selected as 4th option by 83 persons.

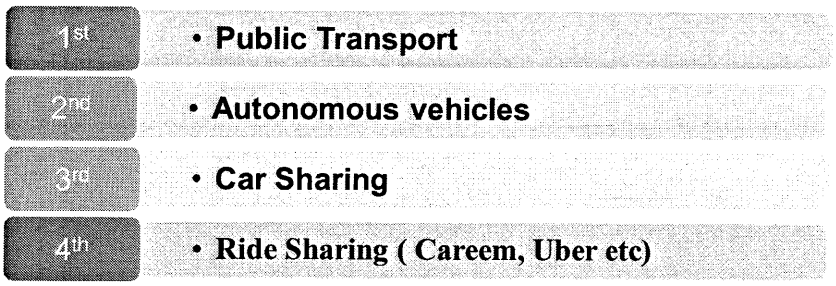


Figure 5.10: Ranking of mobility solutions by common user

Question 7: What do you prefer from the following to travel within city?

This question poses an importance in terms of responder's personal choice of traveling within city. The options of traveling included private cars, taxi and same list of new alternative mobility solutions. Results show majority of the common users prefer their own private cars for the traveling. Thus 161 (78.54%) participants selected Cars as their preference, 22 (10.73%) selected public transport and very few selected other remaining options as their preference. The results are shown in figure 5.11.

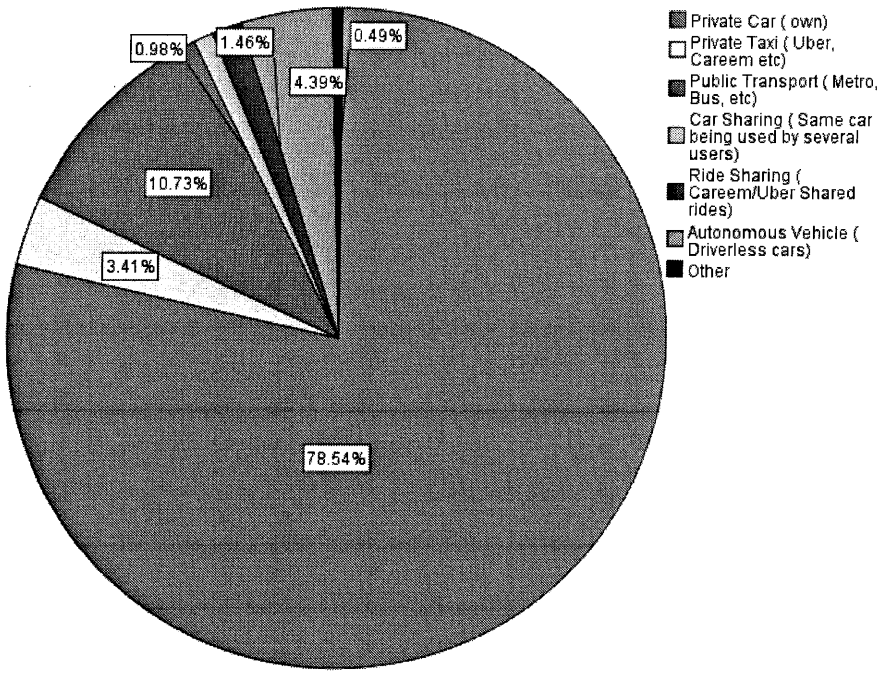


Figure 5.11: Participants preference of traveling within city

As one option is being selected by over 75% therefore no relation could be derived between the traveling choice and other demographic variables in the questionnaire. It was interesting to observe that, despite people ranking public transport as a top priority in question 6, they selected car as their top priority in comparison to other mobility solutions. The obvious reason is the car dependency for last many decades. It shows the limitation of stated preference data, which can be helpful in rating future scenarios, but at the same time, may have such consistency issues with the responses.

Question 8: Do you believe alternative mobility (transport) solutions help Traffic congestion and safety

All the common users were then asked about the relationship between alternative mobility solutions and traffic congestion along with traffic

safety. It is an important debate in the world about the role of ITS and autonomous vehicles in Traffic safety.

Majority of the common users 158 (77.1%) said they surely believe that new mobility solutions help in congestion and safety directly while rest of 47 responders (22.9%) were with the opinion against it with their answer "No".

MOBILITY SUPPLIER SURVEY

The demographic feature questions formed the **questionnaire's first section** similar to Common user survey explained in previous sections. The first six questions (as shown in Table 5.7) constituted the questionnaire's first section and were common questions for all participants as stated earlier.

When it comes to the first question ("Are you"), the number of men were dominant participants against women. More specifically, 91.1% (41 in total) of the participants were men, whereas women participants come out to be 6.7% (3 in total). Lower women participation also shows the fact that fewer women working in transport related industry. This lower number is due to the fact that, traditionally in Saudi Arabia, women employment in the technical sectors is lower than the men. The second question was about the age of the participants. Out of the total respondents, 51.1% (23 in total) were from 25 to 34 years old; 28.9% (13 in total) were from 35 to 44 years old; 11.1% (5 in total) were from 45 to 54 years old and lastly 8.9% (4 in total) were from 55 to 64 years old. Most of the respondents in mobility supplier survey corresponds to 25 to 34 years of age.

The third question was simply considering the residing status of the participants and results show all of the total participated persons were in Saudi Arabia. The fourth question was related to the regions of the responders within Saudi Arabia. Most of the participants (57.8%, which

corresponds to 26 persons in total) belong to the Easter Province, whereas second highest percentage of 33.3% (15) was observed from the region of Riyadh. The rest of 8.9% responders were living in various other regions as shown in Table 5.7 below.

Education level was being asked in question five, where major percentage of 62.2% (28 in total) hold a Bachelor's degree. The participants with Master's and Doctoral degree came out to be second joint highest responders with each having percentage of 17.8% (8 in total). Last of the six demographic related question was related to familiarity with the term of Mobility and expectedly majority of the mobility supplier users said Yes (86.7%) while few said No (13.3%). See Appendix for the questionnaire surveys for both Supplier survey in both English and Arabic.

Table 5.7: Demographic Frequency Table – Supplier Survey Result

		Count	Percentage %
Q1 - Are you	Male	41	91.1%
	Female	3	6.7%
	Prefer not to answer	1	2.2%
Q2 - What is your age	Under 18	0	0.0%
	18-24	0	0.0%
	25-34	23	51.1%
	35-44	13	28.9%
	45-54	5	11.1%
	55-64	4	8.9%
	Above 64	0	0.0%
Q3 - I am based in	Saudi Arabia	45	100.0%
	Other	0	0.0%
Q4 - My region in Saudi Arabia is	Riyadh	15	33.3%
	Eastern Province	26	57.8%
	Makkah/Jeddah	2	4.4%
	Madina/Tabuk	2	4.4%
	Asir	0	0.0%
	Jizan	0	0.0%
	Tabuk	0	0.0%
	Ha'il	0	0.0%
	Najran	0	0.0%
	Northen Region/Al Jawf	0	0.0%
	Other	0	0.0%
Q5 - What is the highest degree or level of school you have completed	High school	1	2.2%
	Some college	0	0.0%
	Trade/vocational/technical	0	0.0%
	Bachelors	28	62.2%
	Masters	8	17.8%
	Doctorate	8	17.8%
Q6 - Were you familiar with the term " Smart Mobility" before this survey	Yes	39	86.7%
	No	6	13.3%

After the demographic surveys, **in second section of the questionnaire,** sixteen (16) questions were asked to those respondents who chose *"They work in mobility/transport related industry"*.

In these sixteen questions, the respondents were asked to rank a list of travel attributes and different future transport scenarios in terms of probability and desirability. These set of questions were aimed to collect information from the mobility experts to get an industrial perspective on top of general or common users of mobility in Saudi Arabia. These perspectives will assist government initiative programs and policies for future considerations and plans.

As the main objectives of this survey set was to get options and desirability from the current mobility experts therefore no significant relations between the variables were needed. Also the survey sample of expert opinion is usually smaller and precise thus no chi square or any other relationship statistics were carried out.

Question 1: My company/work is a part of the following sector:

Experts were asked about their industry group to get an idea of their professional whereabouts. Out of 45 participants, 17 of them (37.78 %) answered they work in government/public sectors, 13 (28.89%) were working as consultants, 7 participants (15.56%) were working in logistics and importantly 5 (11.11%) belong to ministries. The results are shown in figure 5.12 below

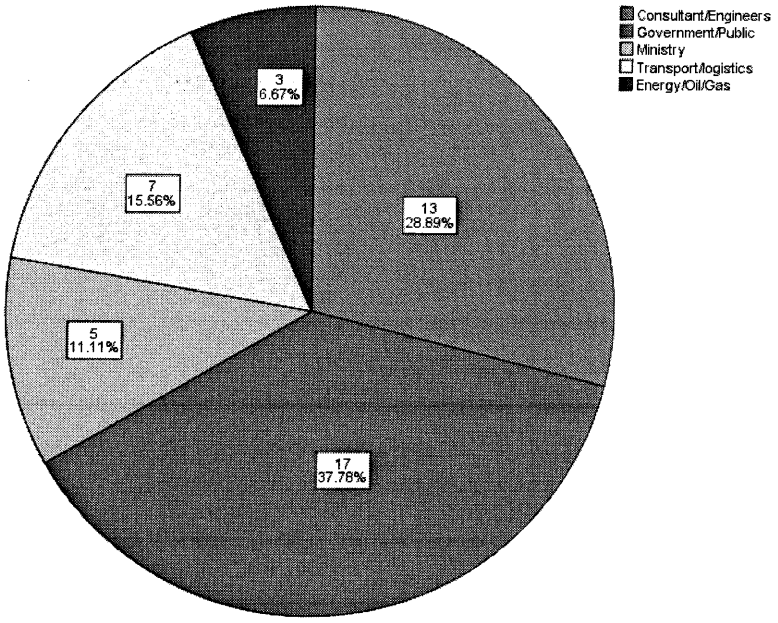


Figure 5.12: Working sectors of the participants

Question 2: Does your organization directly involved in Smart Mobility Initiatives?

This was important question to understand the expert opinions about the initiatives in the context of smart mobilities. Majority of the expert participants said their respective organizations are directly or indirectly involved in smart mobility initiatives. Thus, their opinion does hold importance in the consideration of coming questions regarding the options and challenges. Total 16 (35.56%) participants said their organizations are directly involved whereas 17 (37.78%) participants said their companies are partially involved in smart mobility programs. 8 (17.78%) responders said no about the involvement while some 4 (8.89%) experts were not sure about their role in the initiatives. The results are shown in figure 5.13.

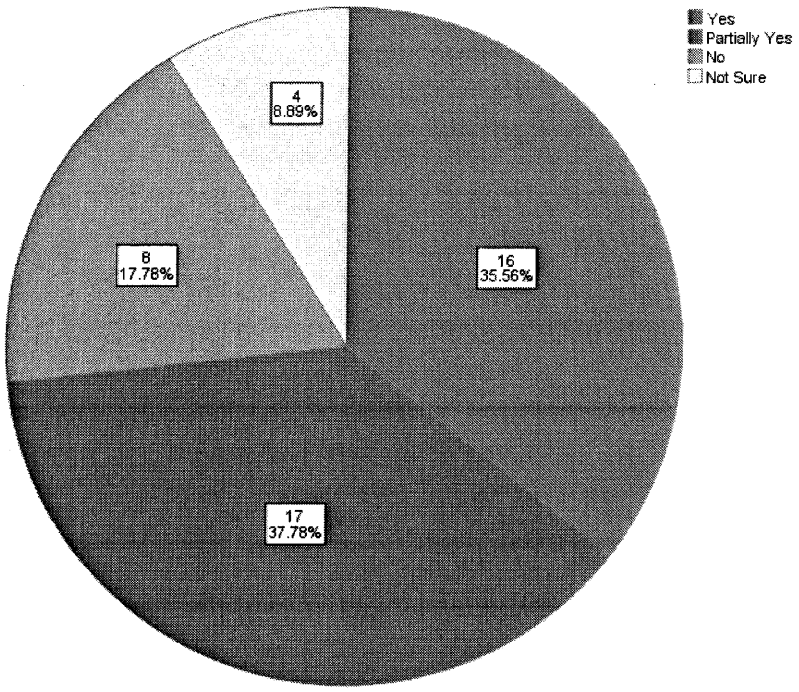


Figure 5.13: Role of the expert's organization in smart mobility initiatives

Question 3: Are you decision maker in your company?

Next question was also important to get the view of point from the decision makers within mobility industries. Comparative analysis will be carried out by comparing this question with the upcoming opinion based open ended questions.

Results show that 16 (36%) experts were decision makers in their organizations and remaining 29 (64%) were not in the seat of decision making.

Cross table statistical analysis was carried out between the questions of decision makers and organization role in smart mobility initiatives as shown in table 5.8 below. Results show that 14 of total 16 decision makers work in an organization which is directly involved in the smart mobility projects or programs.

Table 5.8: Decision makers and their Organizations

		Q2 - Does your organization directly involved in Smart Mobility Initiatives?				
		Yes	Partially Yes	No	Not Sure	Total
Q3 - Are you decision maker in your company	**Yes**	**10**	**4**	2	0	16
	No	6	13	6	4	29
Total		16	17	8	4	45

Question 4: My responsibility in my company is?

The question was then asked about the role of respective participants in their companies. Results show that most of the participants (78%) work locally in their cities and municipalities and rest of 22% experts have regional responsibilities. Further comparative analysis show that 8 out of 16 decision makers are also responsible for the regional level initiatives as shown in table 5.9. These decision makers will be ranked higher than the other experts in term of opinions and ranking of mobility solutions in coming questions.

Table 5.9: Decision makers and their Organizations

		Q4 - My responsibility in my company is?		Total
		Local	Regional	
Q3 - Are you decision maker in your company	**Yes**	**8**	**8**	**16**
	No	27	2	29
Total		35	10	45

Question 5: In your opinion, how much satisfied are you with current mobility (Transport) options in your country

Question 5 asked the participants to evaluate the current transport options in Saudi Arabia. This question gives an insight to what expert users think of the transportation infrastructure available to them. Results analysis show that a high proportion of participants are neutral in their opinion about this issue, with the number of 17 (37.78%). Still, another major proportion of responders said they are unsatisfied with the current mobility options with 15 (33.33%) choosing the option of "Unsatisfied". Around 18% participants were "very unsatisfied" while very few participants were satisfied with percentage of nearly 10% out of total responders. The results are shown in figure 5.14 below

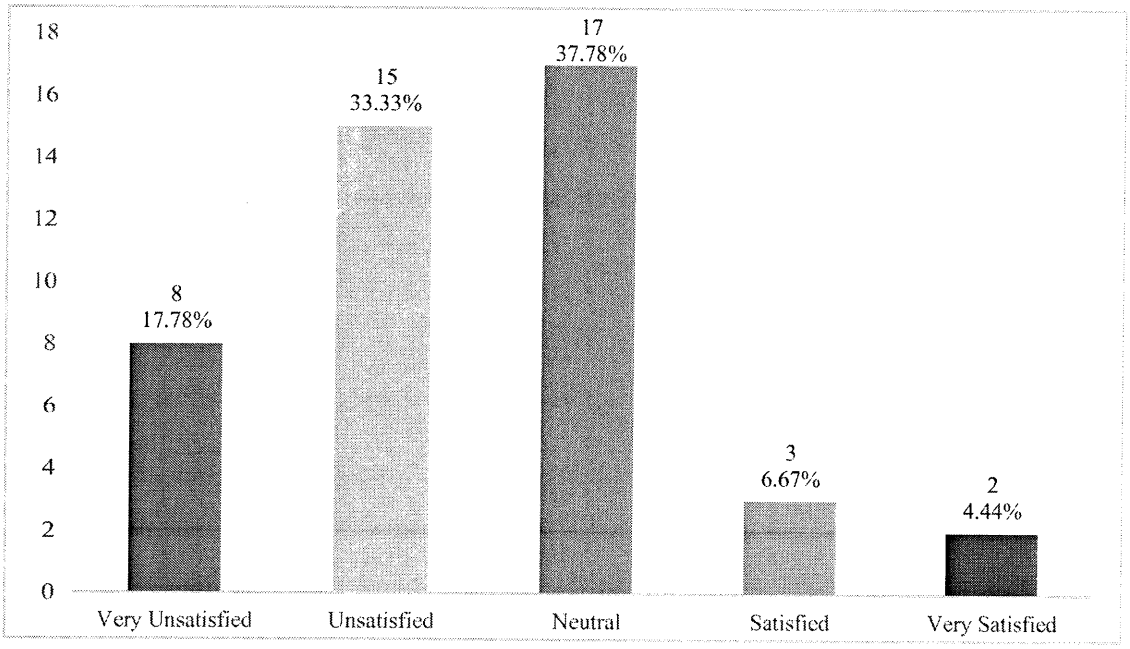


Figure 5.14: Opinion survey regarding the existing transportation system

It is quite evident that more than 50% experts are in the opinion of poor existing mobility options and transportation systems. Further analysis show 8 out of 16 decision makers are unsatisfied while rest of 8 are neutral

in their stance. Therefore it could be said that decision makers and experts from the mobility industry are also unsatisfied with the existing transportation systems.

Question 6: Do you think it is important to have several alternative mobility solution in your country

This question was asked to find the point of view from an expert user perspective about the importance of alternative mobility solutions. From the previous question, it was quite evident that majority of the participants are not satisfied with the current mobility system thus expectedly 39 (86.70%) participants said it is "Very Important" to have several different mobility solutions in Saudi Arabia. 5 (11.1%) participants said it is "Important" to have such options while only 1 participant said it is not that important.

Question 7: Which alternative mobility solutions you want to see implemented in your country (Multiple Options can be checked)

This question was an example of open-ended questions for asking the participants their choices. This could be really important information for the stakeholders to see the different possible choices from the expert and decision makers' perspective. Results show that public transport was top choice among the expert users with 44% of the total participants ranking public transport as their first priority. Autonomous vehicles was selected by 18.68% participants while both ride sharing and car sharing was among the other priorities with the participants selecting around 16.48% and 20.88%, respectively.

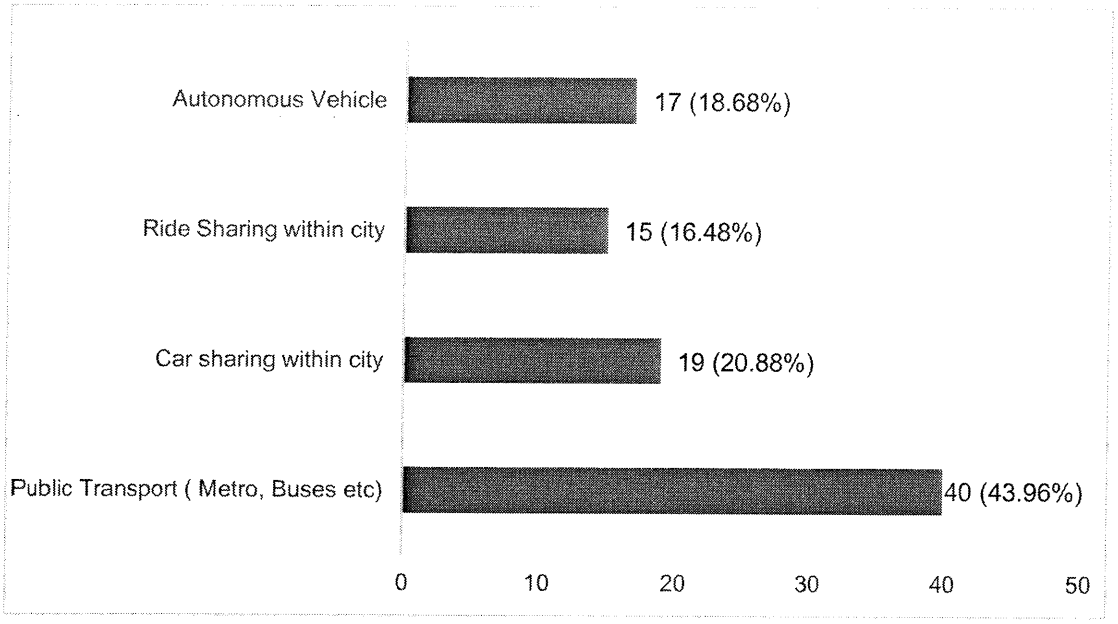


Figure 5.15: Choice of expert users for alternative mobility solutions

Based on frequency analyzed in figure 5.15, among the mentioned smart solutions, prioritized options by the expert users could be ranked as shown in figure 5.16 below to see the priority in terms of government initiative programs as shown in figure 5.4.

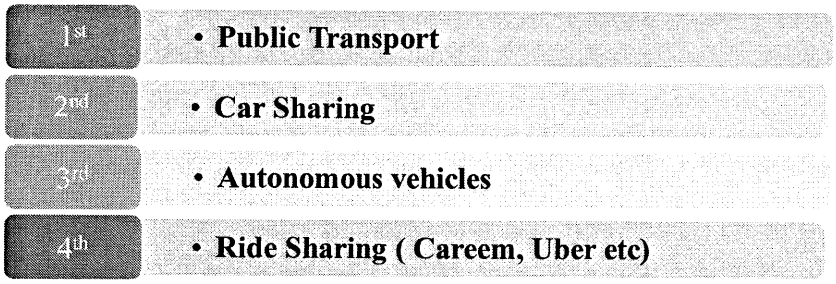


Figure 5.16: Ranking of mobility solutions by expert users

Comparison was made between two sets of conducted surveys for drawing out the choice of ranking among the smart mobility options. Table 5.10 shows that both users and experts ranked the public transport at top and ride sharing at bottom. Only difference was noted in the second choice, with users opting autonomous vehicles as their second choice while experts chose car sharing. The potential reason of selecting autonomous vehicles as their third choice by the experts could be their knowledge of challenges associated with implementation of AVs.

Table 5.10: Comparison of ranking between user and supplier surveys

Position/ Rank	Smart Mobility options
1	Public Transport
2	Autonomous vehicles
3	Car sharing
4	Ride sharing

Ranking obtained from the User Survey

Position/ Rank	Smart Mobility options
1	Public Transport
2	Car sharing
3	Autonomous vehicles
4	Ride sharing

Ranking obtained from the Supplier (experts) Survey

Question 8: Please rank top 3 from the following mobility solutions in order of your interest:

This question was similar in nature with previous question, the reason to ask the question is to verify the responder's choice when it comes to mobility solutions. Here it is asked to find the interest of experts when it comes out to choice of mobility options. Similar results were achieved under this question in comparison to question 7 therefore showing the reliability of the questionnaire results. Only minor change is the Autonomous vehicle ranked 2nd and car sharing option coming 3rd under the asked question. Public transport remains the priority choice while ride sharing solution was the least ranked choice as shown in figure 5.17 below.

Public transport was ranked first by 36 responders, autonomous was ranked first by 5 responders, and car sharing was given top rank by 3 persons whereas ride sharing was the first priority of only 1 user. Autonomous vehicles was 2nd best option of the majority of users with 14 responses.

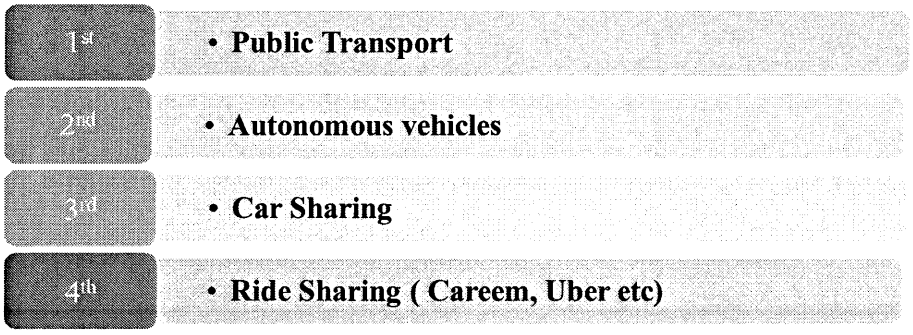


Figure 5.17: Ranking of mobility solutions by expert users

Similar to question 7, comparison was made between user and supplier surveys to observe the potential difference of opinions. Table 5.11 shows that both users and experts ranked all four options in the same order based on their interest. No difference was observed in this case, as this

question was focusing on the interest rather than the implementation thus experts also gave the same opinion as prevailed among the common users.

Table 5.11: Comparison of ranking between user and supplier surveys

Position/ Rank	Smart Mobility options
1	Public Transport
2	Autonomous vehicles
3	Car sharing
4	Ride sharing

Ranking obtained from the User Survey

Position/ Rank	Smart Mobility options
1	Public Transport
2	Autonomous vehicles
3	Car sharing
4	Ride sharing

Ranking obtained from the Supplier (experts) Survey

Question 9: What do you prefer from the following to travel within city?

This question poses an importance in terms of responder's personal choice of traveling within city. The options of traveling included private cars, taxi and same list of new alternative mobility solutions. Results show majority of the mobility suppliers prefer their own private cars for the traveling. Thus 33 (73.33%) participants selected Cars as their preference, 9 (20%) selected public transport and very few selected other remaining options as their preference. The results are shown in figure 5.18.

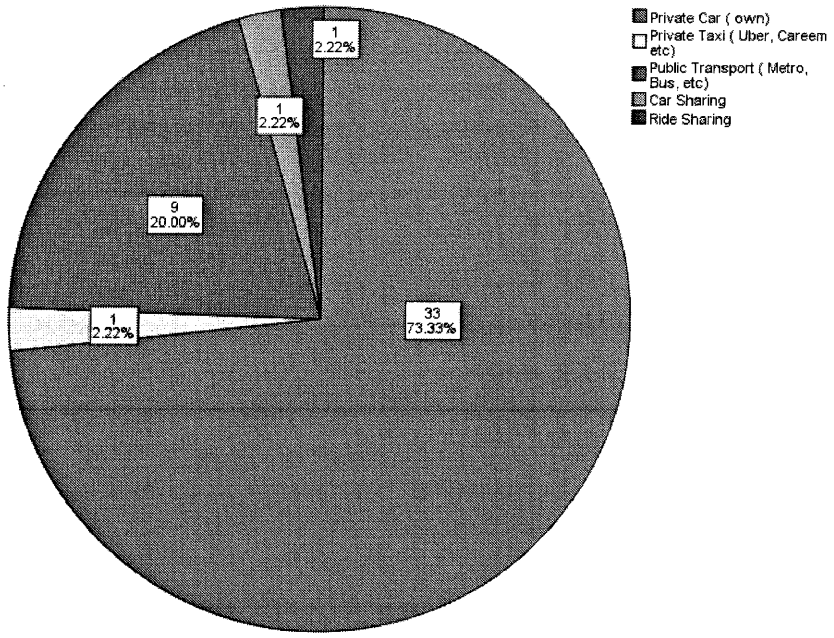


Figure 5.18: Participants preference of traveling within city

Further cross table statistical analysis showed 11 decision makers out of 16 preferred their own cars over the other mobility options as shown in table 5.12 below. The results of this question are same as that for a similar question in user survey. It shows that both users and decision makers have significantly high biasness towards car use which could be attributed to the decades old culture of car dependency.

Table 5.12: Cross table analysis between traveling preference and decision makers

		Q9 - What do you prefer from the following to travel within city					Total
		Private Car	Private Taxi	Public Transport	Car Sharing	Ride Sharing	
Q3 - Are you decision maker in your company	Yes	10	1	3	1	1	16
	No	23	0	6	0	0	29
	Total	33	1	9	1	1	45

Question 10: Do you believe alternative mobility (transport) solutions help Traffic congestion and safety?

All the expert were then asked about the relationship between alternative mobility solutions and traffic congestion along with traffic safety. It is an important debate in the world about the role of ITS and autonomous vehicles in Traffic safety. Also in Saudi Arabia whether it is Saudi 2030 vision or ITUP, different transport programs and policies are giving emphasis towards "Vision Zero strategies" and identifying different traffic safety improvements.

Majority of the experts (37, 82.2%) said that they surely believe that new mobility solutions help in congestion and safety directly while rest of 8 experts (17.8%) were with the opinion against it with their answer "No". 14 out of total 16 decision makers were also in the belief, that these mobility solutions would help congestion and safety. The results can be seen in Table 5.13 below.

Table 5.13: Opinions for Alternative mobility solutions helping congestion and safety

		Q10 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety		
		Yes	No	Total
Q3 - Are you decision maker in your company	Yes	14	2	16
	No	23	6	29
Total		**37**	**8**	**45**

Question 11: Which alternative mobility solutions are you already offering or planning in the future? (Multiple Options can be checked)

Experts were then asked about the current or future projects related to mobility solutions offered or planned by their respective organizations. The results of this question will help the study by focusing on the offered or planned projects by the stakeholders. Study can also recommend government or public entities about the potential projects which could help them in designing future frameworks and initiatives. Analysis show that public transport projects were among the most planned or offered by the organizations of the participants. Almost 50% responders selected public transport being offered or planned, whereas autonomous vehicles were also being planned projects with responders selecting the option with almost 20%. Micro mobility and cycling were also listed in other categories by the 2 participants, the results can be seen in figure 5.19 below.

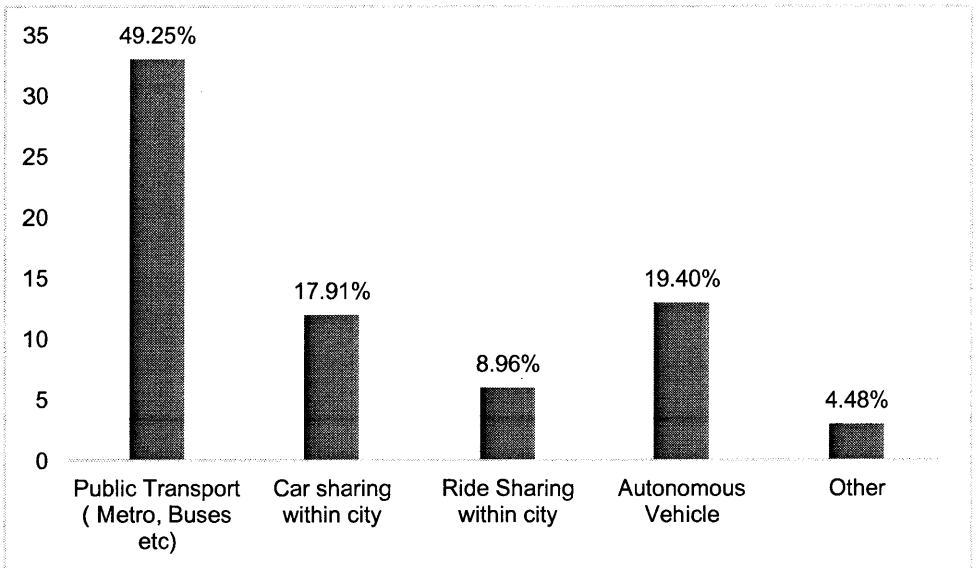


Figure 5.19: Mobility solution projects offered or planned by stakeholders' organizations

Comparative analysis was also carried out between public and private sector for more details about project offering. Results show that public

sector is offering or planning more projects of public transport and autonomous vehicles. Though private sector is also targeting public transport but more car and ride sharing projects are observed than the public sectors. Figure 5.20 is showing the comparative analysis between the public and private sectors

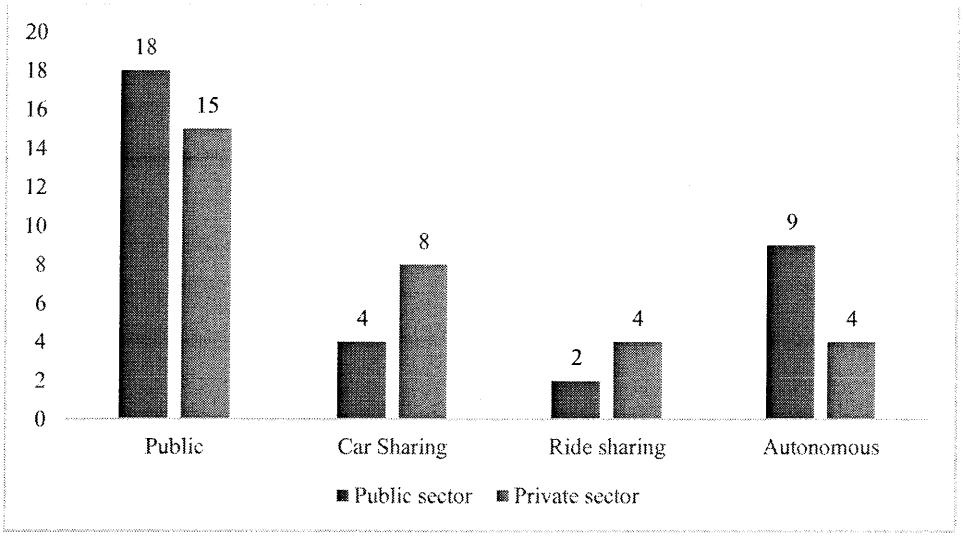


Figure 5.20: Comparison between public and private sector – Future projects

Question 12: What are the biggest challenges to offer smart mobility solutions at national level? (Multiple Options can be checked)

This is one of the most asked questions in various smart mobility surveys in the literature review. Maldonado et al. (2020) stated that smart mobility plans and framework design requires participation from the expert of industry so that the stakeholders can identify the challenges and propose improved actions. Similarly, Noy and Govini, (2018); Radu (2020) and Xydis et .al (2021), all asked the participants for the potential challenges associated with smart cities and mobility.

Results from the survey analysis show that participants agreed that various challenges exist when it comes to implementation of smart mobility in Saudi Arabia. Majority of the responders chose more than three

different challenges from the list. Challenge of cooperation and integration was selected by 27% of the total selections whereas issues with development costs, policies and goals all were selected more than 20% by the expert users. 9% participants think that transparency also poses a challenge towards adoption of smart mobility. The results are shown in figure 5.21.

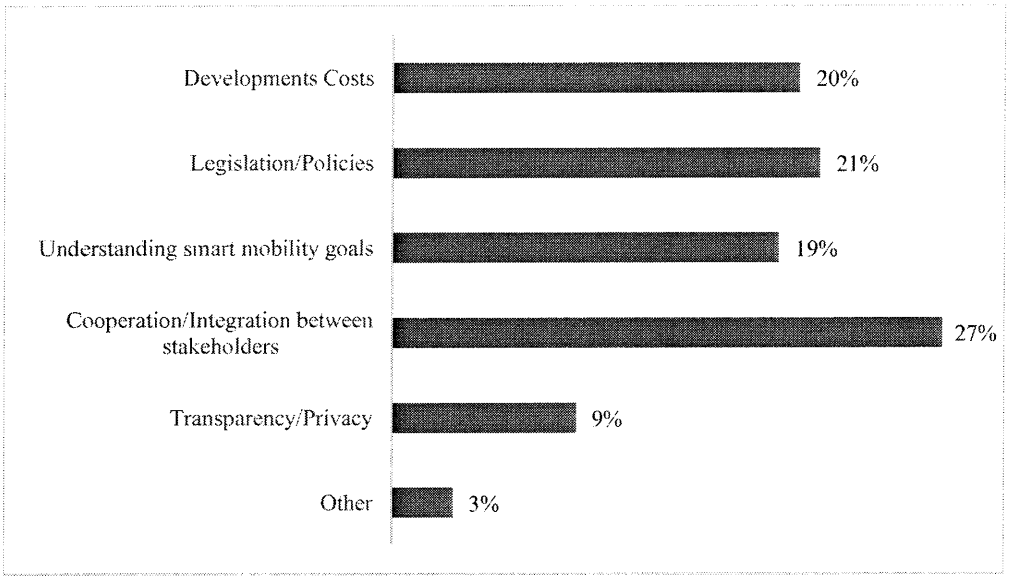


Figure 5.21: Challenges associated with the smart mobility solutions

Comparative analysis was carried out between public and private sector for more details about challenges in smart mobility solutions. Results show that public sector experts consider costs, policies and goals among potential challenges. Though private sector mentioned integration between the stakeholders as their main concern along with the other challenges shown in Figure 5.22.

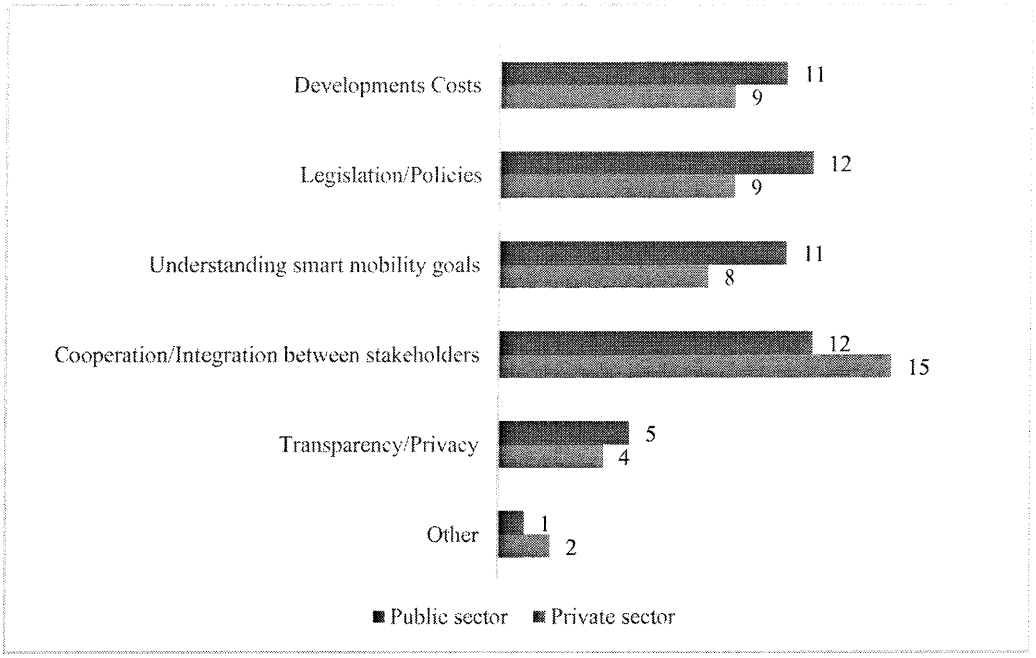


Figure 5.22: Comparison between public and private sector – Challenges

Question 13: How would you rate your Organization's ability to contribute in Smart Mobility Solutions?

In this question, participants were asked about the preparedness of their respective organizations. This question will help understanding the readiness of the stakeholders in terms of smart mobility services. Analysis showed that 36 (80%) out of the total participants think their organizations are either fully or somewhat prepared whereas only 9 (20%) of the total said their respective organizations are not prepared at all as shown in figure 5.23. Most of the unprepared organizations (6 out of 9) belong to private logistic companies.

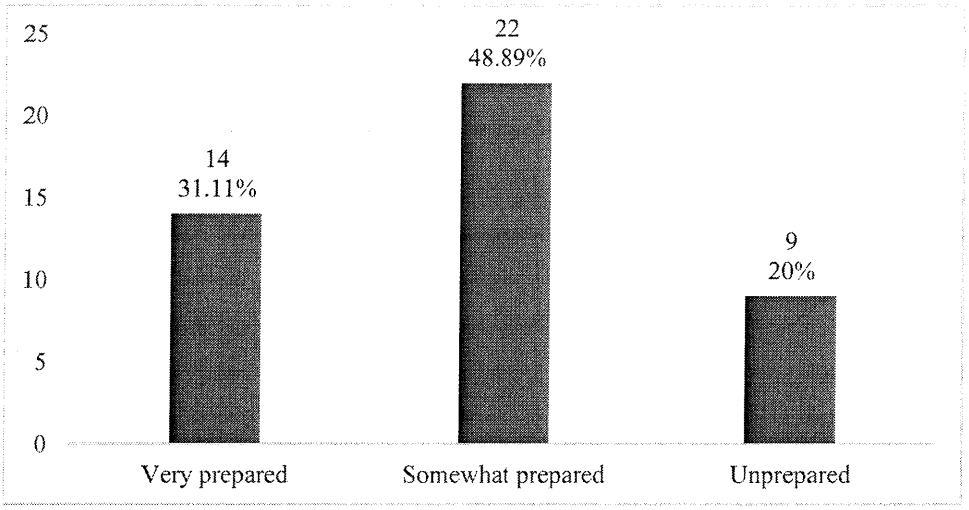


Figure 5.23: Readiness of mobility suppliers

Further statistical analysis showed that majority of the decision makers (8) think their organizations are either fully or somewhat prepared whereas only 3 of them said their respective companies aren't prepared at all as shown in table 5.14 below.

Table 5.14: Decision makers and the contribution potential of their organizations

		Q13-How would you rate your Organization's ability to contribute in Smart Mobility solutions?			Total
		Very prepared	Somewhat prepared	Not prepared	
Q3 - Are you decision maker in your company	Yes	8	5	3	16

Question 14: Who, in your opinion, could be the best placed to offer smart mobility solutions/services

In question 14, participants were asked to give opinion regarding the best placed organizations to offer these new smart technologies. Results show that most of the responders selected more than the 3 sectors from the list. The public organizations were selected 30 times (22.22%) by the users

whereas transport/logistics sector was opted by 29 times (21.48%). Participants also think ministries are an important sector responsible of smart solutions therefore this option was selected 19 times (14%) by the expert users. Results are summarized in table 5.15.

Table 5.15: Best placed organizations selected by expert users

Industry/Sectors	Selection by Participants	Selection percentage
Automotive	12	8.89%
Consultant/Engineers	16	11.85%
Government/Public	30	22.22%
Ministries	19	14.07%
Transport/logistics	29	21.48%
Media, Entertainment	8	5.93%
Energy/Oil/Gas	8	5.93%
Telecommunication services	7	5.19%
Software services	6	4.44%

Question 15: Do you think it is a good idea to develop "PILOT STAGE FOR SMART MOBILITY PROGRAM AND POLICY" before large scale deployment

This is one of the most important question being asked to the expert users under the study questionnaire. It was important to know the point of view from the decision makers and stakeholders in the mobility sector what they think about the pilot programs. The opinion in this question will strengthen the case to go for pilot stage project/programs instead of large scale deployment. Graziotin, (2013) also stated that many pilot tests across the world failed due to different challenges, therefore, giving the

stakeholders an opportunity to make mistakes and learn from them. Otherwise any mistakes in large scale deployment may have a high cost. Different smart mobility initiatives in Saudi Arabia, such as NTLS, also focuses on pilot projects before large scale deployments.

Analysis show that 43 (98%) expert users and stakeholders think it is important to start with Pilot stage projects for the smart mobility solutions.

Question 16: Has Covid-19 affected the progress of strategy towards smart mobility solutions within your organization?

Considering the ongoing issue of COVID-19, it was interesting to ask the expert participants about the possible effect in the progress of the strategies for smart mobility, if any. 22 participants out of 45 answered "Yes" the progress was affected due to covid-19 whereas 6 participants were sure that there is no issues faced due to COVID-19. 17 experts out of total 45 were "unsure" whether covid-19 affected the progress or not. Results are shown in figure 5.24 below.

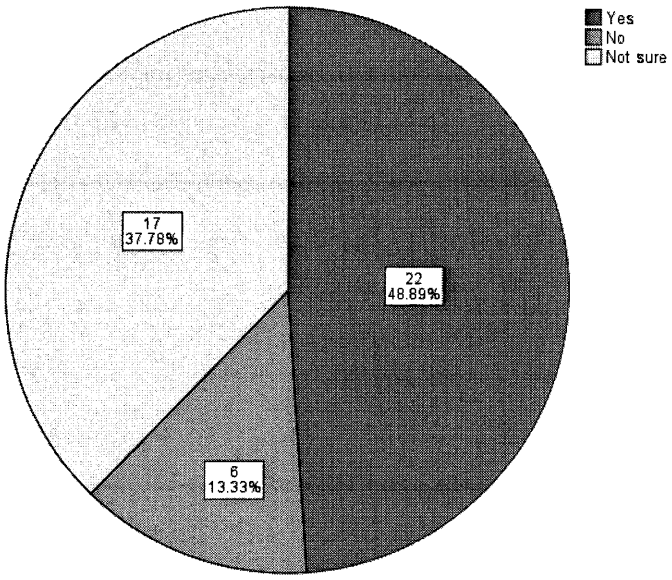


Figure 5.24: Effect of Covid-19 on the progress of smart mobility projects

Further cross table statistical analysis between this question and the organizations of the participants show that government sector was among the most affected sector, due to COVID-19, based on the questionnaire results.

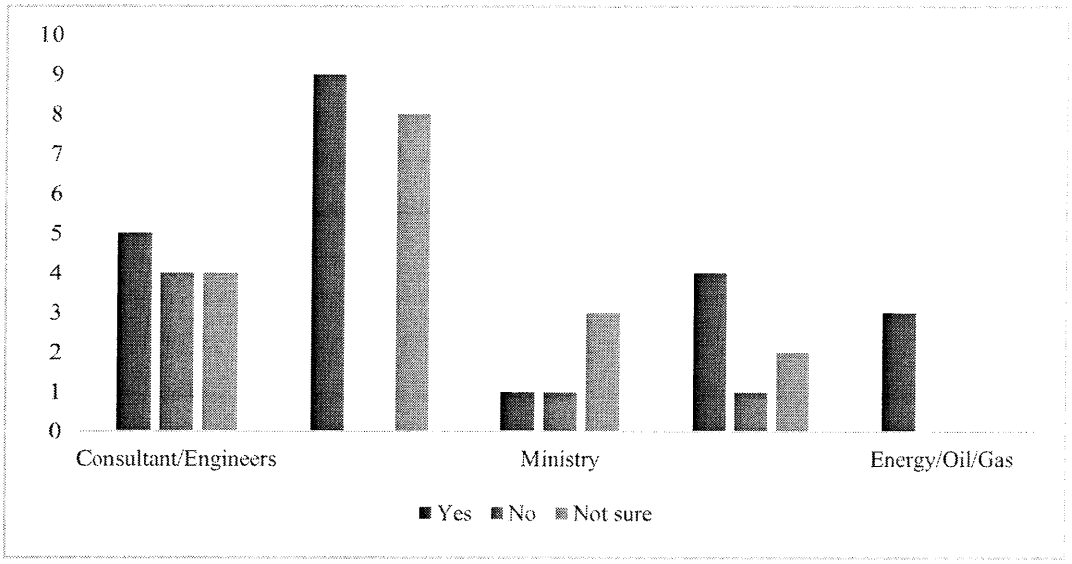


Figure 5.25: Effect of Covid-19 on the progress of smart mobility projects

5.3 Results and Discussion – Multiple criteria analysis

In this section the pair-wise comparison questionnaire results were evaluated to find the importance of each criteria, in comparison to the other in pairs. This was on the saaty's scale 1 to 9 considering the 5 criteria as mentioned before in table 4.1. The calculations were done using Microsoft excel sheet created by Goepel, (2013).

Answers from the 20 responses of the experts were filled in a pair-wise comparison matrix. After that each value in the each column of the filled matrix was divided by the sum of the respective column to calculate its normalized score. The yielded normalized score was then put in the Normalization matrix as shown in Table 5.16 below.

Table 5.16: Normalized Pair-wise comparison matrix

Matrix 5x5		Cost	Flexibility	Infrastructure	Safety	Speed
		1	2	3	4	5
Cost	**1**	1.0	0.95	0.90	0.41	0.94
Flexibility	**2**	1.05	1.0	1.34	0.43	1.21
Infrastructure	**3**	1.12	0.74	1.0	0.35	0.79
Safety	**4**	2.45	2.32	2.88	1.0	3.65
Speed	**5**	1.06	0.82	1.27	0.27	1.0

Consistency ratios were calculated based on the equation (5.1) and (5.2) shown below. With λmax the calculated principal eigenvalue - either based on the priority eigenvector derived from row geometric mean method (RGMM) or derived from Eigenvector method (EVM) – the consistency index CI is given as:

$$CI = \frac{\lambda max - N}{N-1} \quad \ldots\ldots\ldots\ldots (5.1)$$

The consistency ratio CR is calculated using:

$$CR = \frac{CI}{RI} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5.2)$$

The CR comes out to be less than 0.1 for the analyzed matrix therefore the answers from the 20 experts are consistence for ensuring the research answers and results.

As we can see from Table 5.17, Safety is ranked with the highest importance by the experts and not surprisingly, safety is among the most considerable parameters for mobility modes. Because of the multifaceted nature of road accidents, experts around the world have been actively trying solve this problem for many years. As a result of policies and

concepts like "Vision Zero", road traffic safety policies have been seen as potentially promising on a global scale, (Safarpour et al., 2020). Safety has also become an important parameter when it comes to smart mobility initiatives in Saudi Arabia. According to National spatial strategy (NSS), (2020), Saudi Arabia tends to move forward with the objective of improving life quality, better safety and security of their citizens. Furthermore, Goal eleven of Vision 2030 also makes it a priority to make urban cities more resilient, secure and sustainable with a strong focus on making them safer. Thus, during policy and planning phases, safety should be given priority over other parameters for ensuring trust from the stakeholders. Rest of the parameters are closely packed from the weightage perspective and experts think infrastructure should have least importance when comparing against selected parameters shown in table 5.17.

Table 5.17: Ranking of variables based on weightage

Variable	Weightage	Ranking
Safety	41.0%	1
Flexibility	16.9%	2
Cost	14.4%	3
Speed	14.3%	4
Infrastructure	13.4%	5

5.4 Roadmap and framework towards Smart Mobility

A roadmap for smart mobility could play an important role as a strategic tool for the desired outcome and includes the following the major milestones needed to reach it as shown in figure 5.26. In line with the vision 2030 and other government initiatives, these milestones should be finished within 5 years so that actual execution of smart mobility project may start in time to achieve desire objectives.

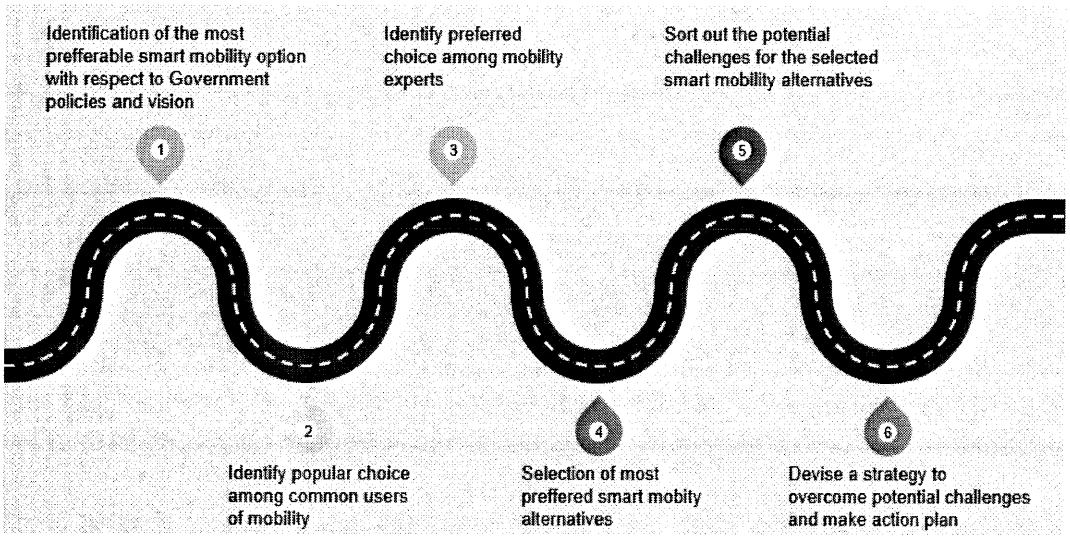


Figure 5.26 Smart Mobility Roadmap

This research study identified alternative smart mobility solutions, their challenges, priority among users and mobility experts, key stakeholders and key smart mobility variables, after conducting literature review, going through the public policies, programs and detailed analysis of the questionnaire survey.

Comprehensive framework, developed and implemented (partially) in the course of this research, can be seen in Figure 5.27. This framework identifies key areas and elements for shifting towards new smart mobility options and provides dimensions to work along for achieving a successful shift.

This framework will help stakeholders in anticipating the benefits of smart mobility, clarifying the term and definition of smart mobility concepts, and identifying the problems faced during transition towards it. The framework identifies different dimensions such as social aspects (safety), economic aspects (costs), environmental aspects (sustainability) and technological aspects (key SM variables) (Tarek & Nasreldin, 2023; Butler et al., 2020). These dimensions can be used by local government at respective stages during smart mobility transition. The key four components of proposed framework are found to be in line with already existing studies in literature. Simonofski et al., (2023) proposed framework based on government policy and stakeholder analysis. Similar to the findings of this present research, Maldonado et al., (2020) found traffic safety, cooperation among stakeholders and government policies among the key identified drivers. The key variables within framework of this present research also coincide with the variables identified by Francini et al., (2021) as transformation domains for the smart mobility: cost, sustainability, governance, living, and people. As suggested by this study, Alanazi, (2023), also encouraged to conduct pilot studies for smart mobility before full scale implementation can be undertaken.

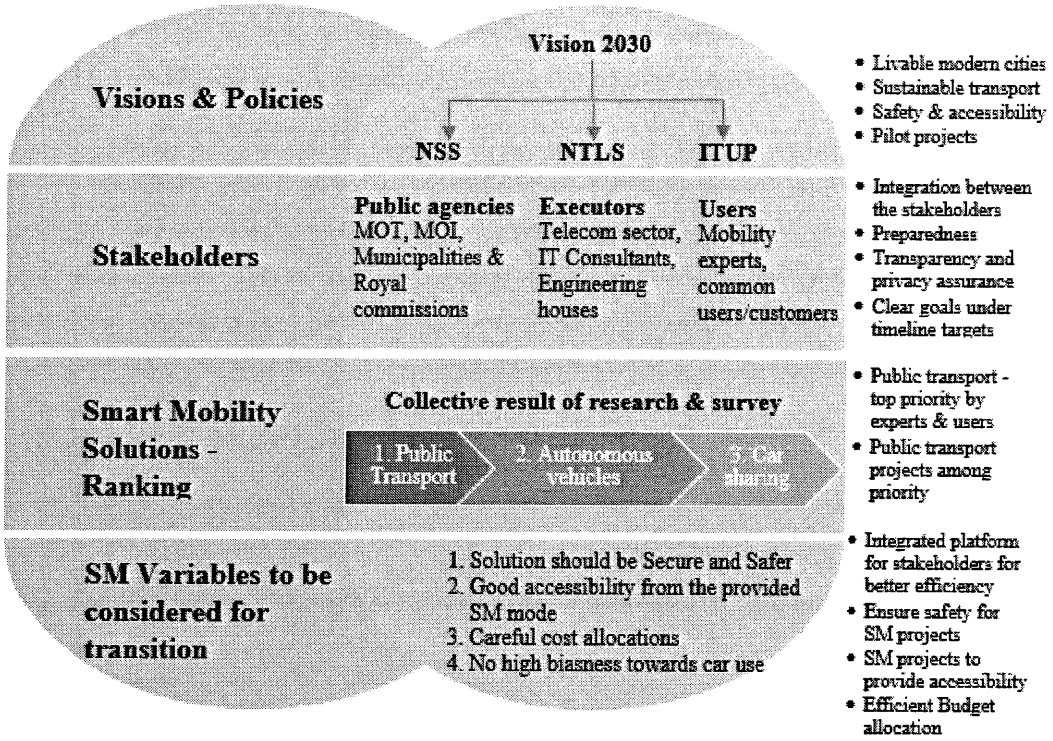


Figure 5.27 Smart Mobility Executed Framework

5.5 Validation of the Developed Framework

This research study is focused on the development of a framework, designed for the transition of Smart Mobility in Saudi Arabia. A questionnaire was developed for the purpose of validating the basic parameters of created framework design in section 5.4 (Haller et al., 2018). In this survey, 5 experts from the field of Transport and Mobility were asked to complete a survey that asks questions about Smart Mobility. The selected experts belonged to vice ministries, chief executive officers and deputy ministers. Online questionnaire was developed using the Question Pro platform. The questionnaire comprised of eight (8) questions. The first four questions were targeting demographic and general questions whereas the last four questions target the validation of the designed framework.

5.5.1 Results of Validation Questionnaire

When it comes to the first question ("What is your gender"), all five participants were men. Traditionally in Saudi Arabia, women employment in the technical sectors and decision maker is lower than the men.

The second question was about the highest degree achieved by the selected experts. All the respondents were having at least graduate education in the fields of related to transportation. 3 participants (out of 5) had the post-graduate degree (masters of PhD). To get an idea of where Experts work, question three asked about their industry group. Out of 5 participants, 3 of them answered they work in government/public sectors, and rest of the 2 belonged to private mobility sector.

In question four, participants were asked whether their respective organizations are directly involved in smart mobility initiatives or not. This was important question to ensure that the answering experts have strong understanding about the initiatives in the context of smart mobility. All of the expert participants said their respective organizations are directly involved in smart mobility initiatives.

The responses to question 2 to 4 served as a justification of selection of these participants for the validation survey. It is because they were selected by the researcher on the basis of their professional and educational background.

Afterwards, three specific questions were asked for validating the created framework design in present research.

Question 5: Do you agree or disagree with the following ranking of preferred smart mobility modes for Saudi Arabia:

1. *Public Transport*
2. *Autonomous Vehicles*
3. *Car Sharing*

This question was directed towards the observed ranking of preferred smart mobility options in research study. 4 out of 5 participants were agreed over the ranking order of the study whereas 1 participants appeared to be in disagreement. Since 80% of the participants agreed with the ranking, it can be said that "Experts agree with the ranking results of this research study".

Question 6: Would you agree or disagree with the following ranking of the smart mobility elements for implementing smart mobility modes in Saudi Arabia:

1. *Safety (Accident safety measures including security and comfort)*
2. *Flexibility (Comfortable accessibility and wider network coverage)*
3. *Cost (Cost of the technology, implementing and maintenance costs)*

To determine the preferences of smart mobility initiatives during implementation, question six was asked about the smart mobility elements. Similar to the results of question five, 80% of the experts agreed with the ranking suggested by this research study. One participant did not agree with the ranking order. As 80% (4 out of 5) of the respondents agreed with the ranking, it can be said that "experts are in agreement with the results of this study".

Question 7: Do you agree or disagree with the following statement: "*Governance failures cause complications and inefficiency of the smart mobility paradigm, especially at the implementation level*"

Among the major findings of this study is the fact that lack of integration leads to governance issues, which impedes the implementation of smart mobility initiatives. All five participants agreed to this statement.

Thus it can be concluded that "This study's results have been endorsed by experts"

Lastly, experts were asked for any suggestions regarding the study, one of the participants advised the usage of smart apps in mobile phones such as parking apps, car sharing apps etc.

From the results of this questionnaire survey, it is evident that ***"The results of this study are agreed upon by the experts"***

Chapter Six

Conclusions and Recommendations

6.1 Conclusions and Contributions

6.2 Recommendations

6.3 Future study

Chapter Six: Conclusions & Recommendations

6.1 Conclusions and Contributions

This research study has been focused on developing and validating a strategic framework for the transition to smart mobility. This section will provide the important conclusions from the results of this study. The results of this research would contain the information that will make the resulting framework address the needs of all major KSA initiatives and stakeholders. As there is no framework available in Saudi Arabia for achieving smartness in mobility sector, thus the proposed strategic framework will help the local stakeholders at every step in the direction of smart mobility applications. This research study will also help stakeholders in their decisions regarding the preferred mode choice and key variables in smart mobility.

This research included use of a variety of research approaches to achieve its objectives. Firstly, a comprehensive literature review was done in the topics of smart mobility, their advantages and associated challenges. Based on the literature review, smart mobility ecosystem was developed for the study objectives. Detailed research was carried out in smart mobility solutions by going through the national and regional policies, strategies and the published white papers by the government agencies. Moreover, questionnaire survey was developed for the common users and mobility experts for their opinion and reviews regarding the current and future mobility systems. In the end, following conclusions were drawn from this study:

- Governance failures cause complications and inefficiency of the smart mobility paradigm, especially at the implementation level

- Stakeholders in urban transformation must have technical and governance aptitudes to achieve smart mobility for their city in the future.
- Public participation in mobility development projects is important to ensure their input in the decision-making.
- All the key mobility components, technologies, and stakeholders need to be integrated with each other under one platform/system i.e. Smart Mobility Ecosystem
- The following are the major challenges posed against smart mobility transition:
    - The integration between public and private agencies
    - Quantification of social and economic benefits
    - Open data and privacy issues
    - Public opinion and acceptance
- Public Transport came out to be the most preferred smart solutions from the important government funded programs
- Questionnaire survey shows that nearly 50% of common users consider public transport as their top priority for a new alternative mobility solution.
- Due to car dependency for many years, around 80% of common users still prefer cars for their personal trips
- Similar to common user survey, around 46% mobility experts think public transport as the best alternative smart mobility option.
- Study survey shows that more than 70% of mobility experts also prefer their own cars over other mobility options again due to long term car dependency inside the Kingdom.
- Survey results show that public transport projects are being offered or planned by the organizations of about 50% of mobility experts.

- Autonomous vehicles are in the agenda of implementation by the organization of about 20% of mobility experts
- Study survey shows that mobility experts think integration of stakeholder systems is the biggest challenge for achieving smart mobility followed by public policies and development costs
- Most of the unprepared organizations for the smart mobility belong to private logistics companies.
- Analysis show that 43 (98%) expert users and stakeholders think it is important to start with Pilot stage projects for the smart mobility solutions.
- According to the results of a questionnaire survey in the present research, experts consider safety to be one of the most important aspects of smart mobility.
- There is consensus among experts regarding the results of the study, which were presented in the present research.

6.2 Recommendations and Future

As per this research, top priorities among the smart mobility solutions have been determined, along with the potential challenges. However, there are some limitations in the research. In order to provide better and accurate results, following recommendations have been formulated from this study research:

- Increasing the sample size of survey in future smart mobility studies for more coverage and versatility in the responses. This study could not get much higher sample sizes due to high percentage (20%) of dropout or incomplete surveys. Also it was difficult to convince users to complete the survey from other regions. The reasons could

be the use of online platform only. Paper/forms surveys and physical interviews could have increased the sample size of the study.

- Most of the respondents in user surveys correspond to 25 to 34 years of age. Thus fewer information available for other age groups. It is recommended to target responders of all age groups for the future surveys.
- The number of men were dominant participants against women in this study research. It would be interesting to evaluate the observations from more women participants in the future researches.
- More than 80% responders from user and expert categories belong to either Eastern province or Riyadh region. Therefore, it is also recommended to reach out to all the major regions of Saudi Arabia to get more insights and feedback from the stakeholders.
- Based on the results of this study, it is recommended to focus on the immediate implementation of public transport projects in the selected cities of Saudi Arabia.
- On the basis of survey results, safety should be given priority among the mobility modes during implementation of smart mobility initiatives.
- It is also recommended to carry out public awareness campaigns for the smart mobility solution, in particular Public Transport. Other smart mobility solutions may include revised policies towards cars, congestion fees, parking fees in the city centers, roads tolling and emission control.

6.3 Future Study

Based on this research, some studies are recommended, following the results of this study, in order to provide better clarifications and connections, such as:

- Study of smart mobility survey in KSA with country wide coverage targeting bigger representative sample size against the population.
- Study the integration between public and private stakeholders in smart mobility.
- Investigation study of developmental costs associated with the ICT in smart mobility.
- Study of implementation framework and smart city architectures.

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Appendix

- Questionnaire Survey (User and Supplier) in Arabic
- Questionnaire Survey (User and Supplier) in English
- AHP Questionnaire Survey (MCDA)
- Framework Validation Questionnaire Survey
- SPSS output sheet

التنقل الذكي (النقل) إستطلاع المستخدم

التنقل هو ببساطة خيار للسفر من مكان إلى آخر. حاليًا ، في المناطق الرئيسية داخل المملكة العربية السعودية ، يسافر الناس باستخدام سياراتهم الخاصة أو من خلال خدمات سيارات الأجرة الفردية

في حالة التنقل الذكي ، فإنه يوفر خيارات جديدة ومختلفة يسهل الوصول إليها وأكثر أمانًا وصديقة للبيئة, فيما يلي خيارات التنقل الذكي المختلفة لأخذ أرائكم الثمينة عبر هذا الاستطلاع البسيط

-النقل العام (الحافلات العادية ، حافلات المترو ، قطارات المترو ، الترام ، إلخ.)

مشاركة السيارة (يمكن استخدام نفس السيارة من قبل أشخاص مختلفين على مدار اليوم عن طريق الوصول من خلال تطبيقات الهاتف -المحمول)

مشاركة الركوب (يمكن للمسافرين مشاركة الرحلة وتكلفة السفر مع مسافرين آخرين متجهين إلى نفس الوجهة عبر كريم أو أوبر أو أي -خدمات سيارات أجرة أخرى)

-المركبات ذاتية القيادة (السيارات ذاتية القيادة والحافلات المكوكية من أجل نقل أكثر أمانًا وصديقًا للبيئة)

.1هل أن

1. ذكر
2. أنثى
3. افضل عدم الاجابة

.2ما هو عمرك

1. تحت 18
2. 18-24
3. 25-34
4. 35-44
5. 45-54
6. 55-64
7. فوق 64

.3أنا مقيم في

1. المملكة العربية السعودية

2. أخرى

4.منطقتي في المملكة العربية السعودية

1. الرياض
2. المنطقة الشرقية
3. مكة المكرمة / جدة
4. المدينة المنورة / تبوك
5. عسير
6. جيزان
7. تبوك
8. حائل
9. نجران
10. المنطقة الشمالية / الجوف
11.) أخرى_____ (

5.ما هي أعلى درجة أو مستوى دراسي أكملته

1. المدرسة الثانوية
2. بعض من الدراسة الجامعية
3. تجاري / مهني / فني
4. البكالوريوس
5. الماجستير
6. الدكتوراه

6.هل كنت على دراية بمصطلح "التنقل الذكي" قبل هذا الاستطلاع

1. نعم
2. لا

7.أعمل في قطاع حكومي / القطاع العام في مجال مرتبط بالنقل والتنقل

1. لا
2. نعم

8.مؤسستي/عملي هو جزء من القطاع التالي

1. الخاص
2. الحكومة / القطاع العام
3. العمل التطوعي
4. أخرى_____

9.في رأيك ، ما مدى رضاك عن خيارات التنقل (النقل) الحالية في المملكة العربية السعودية

1. غير راضٍ جدا
2. غير راضٍ
3. محايد
4. راضٍ
5. راضٍ جدا

10.هل سمعت من قبل عن الحلول البديلة المختلفة للتنقل (النقل)

1. نعم
2. لا

11. هل تعتقد أنه من المهم أن يكون لديك العديد من حلول التنقل البديلة في المملكة العربية السعودية

1. مهم جدا
2. مهم
3. ليست مهمة جدا
4. لا حاجة على الإطلاق
5. لا أعرف

12. ما هي حلول التنقل البديلة التي تريد أن تراها مطبقة في المملكة العربية السعودية (يمكن التحقق من الخيارات المتعددة)

1. النقل العام (المترو والحافلات وغيرها)
2. مشاركة السيارة داخل المدينة
3. مشاركة الركوب داخل المدينة
4. مركبة ذاتية القيادة
5. لا حاجة إلى حلول
6. أخرى

13. يرجى ترتيب أعلى ثلاث مراكز من حلول التنقل التالية حسب اهتماماتك:

- النقل العام_____
- مشاركة السيارة داخل المدينة_____
- مشاركة الركوب داخل المدينة_____
- المركبات ذاتية القيادة_____

14. ماهي وسيلة التنقل المفضلة لديك داخل المدينة من الخيارات التالية:

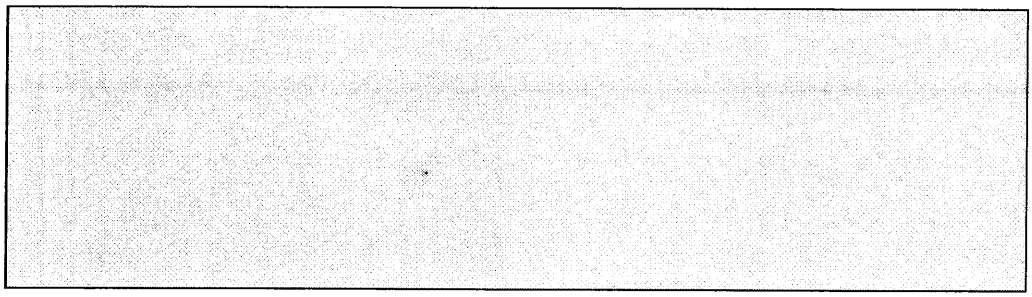
1. سيارة خاصة (تمليك)
2. تاكسي خاص (أوبر ، كريم ، إلخ)
3. النقل العام (المترو ، الحافلات ، إلخ)

4. مشاركة السيارة
5. مشاركة الركوب
6. مركبة ذاتية القيادة
7. أخرى

15. هل تعتقد أن حلول التنقل (النقل) البديلة تساعد في الازدحام المروري والسلامة

1. نعم
2. لا

16. الرجاء كتابة مقترحات ذات علاقة بالنقل الذكي



التنقل الذكي (النقل) إستطلاع الموردين / قطاع النقل

التنقل هو ببساطة خيار للسفر من مكان إلى آخر. حاليًا ، في المناطق الرئيسية داخل المملكة العربية السعودية ، يسافر الناس باستخدام سياراتهم الخاصة أو من خلال خدمات سيارات الأجرة الفردية

في حالة التنقل الذكي ، فإنه يوفر خيارات جديدة ومختلفة يسهل الوصول إليها وأكثر أمانًا وصديقة للبيئة, فيما يلي خيارات التنقل الذكي المختلفة لأخذ أرائكم الثمينة عبر هذا الاستطلاع البسيط

- النقل العام (الحافلات العادية ، حافلات المترو ، قطارات المترو ، الترام ، إلخ.)

مشاركة السيارة (يمكن استخدام نفس السيارة من قبل أشخاص مختلفين على مدار اليوم عن طريق الوصول من خلال تطبيقات الهاتف - المحمول)

مشاركة الركوب (يمكن للمسافرين مشاركة الرحلة وتكلفة السفر مع مسافرين آخرين متجهين إلى نفس الوجهة عبر كريم أو أوبر أو أي - خدمات سيارات أجرة أخرى)

- المركبات ذاتية القيادة (السيارات ذاتية القيادة والحافلات المكوكية من أجل نقل أكثر أمانًا وصديقًا للبيئة)

.1هل أنت

1. ذكر
2. أنثى
3. افضل عدم الاجابة

.2ما هو عمرك

1. تحت 18
2. 18-24
3. 25-34
4. 35-44
5. 45-54
6. 55-64
7. فوق 64

.3أنا مقيم في

1. المملكة العربية السعودية
2. أخرى

.4منطقتي في المملكة العربية السعودية

1. الرياض
2. المنطقة الشرقية
3. مكة المكرمة / جدة

4. المدينة المنورة / تبوك
5. عسير
6. جيزان
7. تبوك
8. حائل
9. نجران
10. المنطقة الشمالية / الجوف
11. أخرى_____

5. ما هي أعلى درجة أو مستوى دراسي أكملته
1. المدرسة الثانوية
2. بعض من الدراسة الجامعية
3. تجاري / مهني / فني
4. البكالوريوس
5. الماجستير
6. الدكتوراه

6. هل كنت على دراية بمصطلح "التنقل الذكي" قبل هذا الاستطلاع
1. نعم
2. لا

7. أعمل في القطاع الحكومي / القطاع العام في مجال مرتبط بالنقل والتنقل
1. لا
2. نعم

8. مؤسستي هي جزء من مجموعة الصناعة التالية
1. السيارات
2. استشاري / مهندسين
3. القطاع الحكومي / القطاع العام
4. الوزارة
5. النقل والخدمات اللوجستية
6. وسائل الإعلام ، الترفيه
7. الطاقة / النفط / الغاز

8. خدمات الاتصالات
9. خدمات البرمجيات
10. أخرى_____

9. هل تشارك مؤسستك بشكل مباشر في مبادرات التنقل الذكي؟
1. نعم
2. نعم جزئيًا
3. لا
4. لست متأكدا

10. هل أنت صانع القرار في شركتك/عملك
1. نعم
2. لا

11. مسؤوليتي في شركتي/عملي
1. محلية
2. إقليمية

12. في رأيك ، ما مدى رضاك عن خيارات التنقل (النقل) الحالية في المملكة العربية السعودية
1. غير راضٍ جدا
2. غير راضٍ
3. محايد
4. راضٍ
5. راضٍ جدا

13. هل تعتقد أنه من المهم أن يكون لديك العديد من حلول التنقل البديلة في المملكة العربية السعودية
1. مهم جدا
2. مهم
3. ليست مهمة جدا
4. لا حاجة على الإطلاق
5. لا أعرف

14. ما هي حلول التنقل البديلة التي تريد أن تراها مطبقة في المملكة العربية السعودية (يمكن التحقق من الخيارات المتعددة)
1. النقل العام (المترو والحافلات وغيرها)
2. مشاركة السيارة داخل المدينة

3. مشاركة الركوب داخل المدينة
4. مركبة ذاتية القيادة
5. أخرى

15. يرجى ترتيب أعلى ثلاث مراكز من حلول التنقل التالية حسب اهتماماتك:
- النقل العام_____
- مشاركة السيارة داخل المدينة_____
- مشاركة الركوب داخل المدينة_____
- المركبات ذاتية القيادة_____

16. ماهي وسيلة التنقل المفضلة لك داخل المدينة من الخيارات التالية:
1. سيارة خاصة (تمليك)
2. تاكسي خاص (أوبر ، كريم ، إلخ)
3. النقل العام (المترو ، الحافلات ، إلخ)
4. مشاركة السيارة
5. مشاركة الركوب
6. مركبة ذاتية القيادة
7. أخرى

17. هل تعتقد أن حلول التنقل (النقل) البديلة تساعد في الازدحام المروري والسلامة
1. نعم
2. لا

18. ما حلول التنقل البديلة التي تقدمها بالفعل أو تخطط لها في المستقبل؟ (يمكن التحقق من خيارات متعددة)
1. النقل العام (المترو والحافلات وغيرها)
2. مشاركة السيارة داخل المدينة
3. مشاركة الركوب داخل المدينة
4. مركبة ذاتية القيادة
5. أخرى

19. ما حلول التنقل البديلة التي تقدمها بالفعل أو تخطط لها في المستقبل؟ (يمكن التحقق من خيارات متعددة)
1. تكاليف التطوير
2. التشريعات / السياسات

3. فهم أهداف التنقل الذكي
4. التعاون / التكامل بين أصحاب المصلحة (الجهات المعنية)
5. الشفافية / الخصوصية
6. أخرى

20. كيف تقيم قدرة مؤسستك/عملك على المساهمة في حلول التنقل الذكي؟ (يمكن التحقق من خيارات متعددة)
1. مستعدة جدا
2. على استعداد إلى حد ما
3. غير مستعدة

21. من برأيك هو الأفضل لتقديم حلول / خدمات التنقل الذكي (يمكن التحقق من الخيارات المتعددة)
1. قطاع تصنيع السيارات
2. استشاري / مهندسين
3. القطاع الحكومي / القطاع العام
4. الوزارات
5. النقل والخدمات اللوجستية
6. وسائل الإعلام ، الترفيه
7. الطاقة / النفط / الغاز
8. خدمات الاتصالات
9. خدمات البرمجيات

22. هل تعتقد أنه من الجيد تطوير "المرحلة التجريبية لبرنامج وسياسة التنقل الذكي" قبل الإنتشار على نطاق واسع
1. نعم
2. لا

23. هل أثر فيروس كورونا كوفيد-19 على تقدم الإستراتيجية نحو حلول التنقل الذكي داخل مؤسستك؟
1. نعم
2. لا
3. لست متأكدا

24. الرجاء كتابة مقترحات ذات علاقة بالنقل الذكي

Smart Mobility (Transport) User Survey

Mobility is simply an option of traveling from one place to another. Currently, in major regions inside Saudi Arabia, people travel using their own private cars or through individual taxi services.

In case of smart mobility, it provides new and different options which are better accessible, safer and environment friendly. In this survey following are the different smart mobility options for your precious opinions:

- Public Transport (Regular buses, Metro buses, Metro Trains, Trams etc.)
- Car Sharing (Same car could be used by different people across the day by accessing through mobile applications)
- Ride Sharing (Passengers can share the journey and hence cost of travel with other fellow passengers going to same destination via Careem, Uber or any other taxi services)
- Autonomous Vehicles (Driverless cars and shuttle buses for more safer and environment friendly transportation)

1. Are you
    1. Male
    2. Female
    3. Prefer not to answer

2. What is your age?
    1. Under 18
    2. 18-24
    3. 25-34
    4. 35-44
    5. 45-54
    6. 55-64
    7. Above 64

3. I am based in
    1. Saudi Arabia
    2. Other

4. My region in Saudi Arabia is
    1. Riyadh
    2. Eastern Province

3. Makkah/Jeddah
4. Madina/Tabuk
5. Asir
6. Jizan
7. Tabuk
8. Ha'il
9. Najran
10. Northen Region/Al Jawf
11. Other

5. What is the highest degree or level of school you have completed?
   1. High school
   2. Some college
   3. Trade/vocational/technical
   4. Bachelors
   5. Masters
   6. Doctorate

6. Were you familiar with the term "Smart Mobility" before this survey?
   1. Yes
   2. No

7. I work in Government/Public Sector related to Transport and Mobility
   1. No
   2. Yes

8. My company/work is a part of the following sector
   1. Private
   2. Government/Public
   3. Don't work
   4. Other

9. In your opinion, how much satisfied are you with current mobility (Transport) options in your country
   1. Very Unsatisfied

2. Unsatisfied
3. Neutral
4. Satisfied
5. Very Satisfied

10. Have you ever heard about alternative (different) mobility (transport) solutions before this survey?

1. Yes
2. No

11. Do you think it is important to have several alternative (different) mobility (Transport) solution in your country?

1. Very Important
2. Important
3. Not so important
4. No need at all
5. Don't Know

12. Which alternative mobility solutions you want to see implemented in your country (Multiple Options can be checked)

1. Public Transport (Metro, Buses etc)
2. Car sharing within city (Same car being used by several users)
3. Ride Sharing within city (Careem/Uber share rides)
4. Autonomous Vehicle (Driverless car)
5. No solutions needed
6. Other

13. Please rank top 3 from the following mobility (Transport) solutions in order of your interest:

- Public Transport _____
- Car Sharing within City _____
- Ride Sharing within City _____
- Autonomous Vehicles _____

14. What do you prefer from the following to travel within city?

1. Private Car (own)
2. Private Taxi (Uber, Careem etc)

3. Public Transport (Metro, Bus, etc)
4. Car Sharing (Same car being used by several users)
5. Ride Sharing (Careem/Uber Shared rides)
6. Autonomous Vehicle (Driverless cars)
7. Other

15. Do you believe alternative mobility (transport) solutions help Traffic congestion and safety?
    1. Yes
    2. No

16. Please provide any suggestions related to smart mobility:

Smart Mobility (Transport) Supplier/Transport Sector Survey

Mobility in simple words is an option of traveling from one place to another. Currently, in majority regions inside Saudi Arabia, people travel through their own private cars only or through individual taxi services.

In case of smart mobility, it provides new different options which are better accessible, safer and environment friendly. In this survey following are the different smart mobility options for your precious opinions:

- Public Transport (Regular buses, Metro buses, Metro Trains, Trams etc.)
- Car Sharing (Same car could be used by different people across the day by accessing through mobile applications)
- Ride Sharing (Passengers can share the journey and hence cost of travel with other fellow passengers going to same destination via Careem, Uber or any other taxi services)
- Autonomous Vehicles (Driverless cars and shuttle buses for more safer and environment friendly transportation)

1. Are you
    1. Male
    2. Female
    3. Prefer not to answer

2. What is your age?
    1. Under 18
    2. 18-24
    3. 25-34
    4. 35-44
    5. 45-54
    6. 55-64
    7. Above 64

3. I am based in
    1. Saudi Arabia
    2. Other

4. My region in Saudi Arabia is
    1. Riyadh
    2. Eastern Province

3. Makkah/Jeddah
4. Madina/Tabuk
5. Asir
6. Jizan
7. Tabuk
8. Ha'il
9. Najran
10. Northen Region/Al Jawf
11. Other

5. What is the highest degree or level of school you have completed?
    1. High school
    2. Some college
    3. Trade/vocational/technical
    4. Bachelors
    5. Masters
    6. Doctorate

6. Were you familiar with the term "Smart Mobility"; before this survey?
    1. Yes
    2. No

7. I work in Government/Public sector related to Transport and Mobility
    1. No
    2. Yes

8. My Organization is a part of the following industry group
    1. Automotives
    2. Consultant/Engineers
    3. Government/Public
    4. Ministry
    5. Transport/logistics
    6. Media, Enternainment
    7. Energy/Oil/Gas

8. Telecommunication services
9. Software services
10. Other

9. Does your organization directly involved in Smart Mobility Initiatives?
    1. Yes
    2. Partially Yes
    3. No
    4. Not Sure

10. Are you decision maker in your company
    1. Yes
    2. No

11. My responsibility in my company is
    1. Local
    2. Regional

12. In your opinion, how much satisfied are you with current mobility (Transport) options in your country
    1. Very Unsatisfied
    2. Unsatisfied
    3. Neutral
    4. Satisfied
    5. Very Satisfied

13. Do you think it is important to have several alternative mobility solution in your country?
    1. Very Important
    2. Important
    3. Not so important
    4. No need at all
    5. Don't Know

14. Which alternative mobility solutions you want to see implemented in your country (Multiple Options can be checked)

1. Public Transport (Metro, Buses etc)
2. Car sharing within city
3. Ride Sharing within city
4. Autonomous Vehicle
5. Other

15. Please rank top 3 from the following mobility solutions in order of your interest:
- Public Transport _____
- Car Sharing within City _____
- Ride Sharing within City _____
- Autonomous Vehicles _____

16. What do you prefer from the following to travel within city?
1. Private Car (own)
2. Private Taxi (Uber, Careem etc)
3. Public Transport (Metro, Bus, etc)
4. Car Sharing
5. Ride Sharing
6. Autonomous Vehicle
7. Other

17. Do you believe alternative mobility (transport) solutions help Traffic congestion and safety
1. Yes
2. No

18. Which alternative mobility solutions are you already offering or planning in the future? (Multiple Options can be checked)
1. Public Transport (Metro, Buses etc)
2. Car sharing within city
3. Ride Sharing within city
4. Autonomous Vehicle
5. Other

19. What are the biggest challenges to offer smart mobility solutions at national level? (Multiple

Options can be checked)

1. Developments Costs
2. Legislation/Policies
3. Understanding smart mobility goals
4. Cooperation/Integration between stakeholders
5. Transparency/Privacy
6. Other _____

20. How would you rate your Organization's ability to contribute in Smart Mobility solutions? (Multiple Options can be checked)

1. Very prepared
2. Somewhat prepared
3. Unprepared

21. Who, in your opinion, could be the best placed to offer smart mobility solutions/services (Multiple Options can be checked)

1. Automotives
2. Consultant/Engineers
3. Government/Public
4. Ministries
5. Transport/logistics
6. Media, Entertainment
7. Energy/Oil/Gas
8. Telecommunication services
9. Software services

22. Do you think it is a good idea to develop "PILOT STAGE FOR SMART MOBILITY PROGRAM AND POLICY" before large scale deployment?

1. Yes
2. No

23. Has Covid-19 affected the progress of strategy towards smart mobility solutions within your organization?

1. Yes
2. No

3. Not sure

24. Please provide any suggestions related to smart mobility

Pairwise comparison - Smart mobility parameters

There are various important parameters or variables exist for implementing Smart mobility solutions in any country. Here we are asking our transport experts from different organizations for their feedback by comparing the selected smart mobility variables against each other.

Following are the selected five (5) variables for pairwise comparison for implementing the selected smart mobility solutions such as Public transport, Autonomous vehicles & shared mobility:

1) Cost - includes cost of the technology, implementing costs and maintenance costs.
2) Flexibility - includes quick, comfortable accessibility and wider network coverage.
3) Infrastructure - includes already available infrastructure and need new of new infrastructure (includes also all the accessories of the technology being considered
4) Safety - includes accident safety measures including security and comfort
5) Speed - includes speed of the smart mobility solutions (less time of travel)

1. How important is Cost in comparison to Flexibility in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Cost vs. Flexibility	❑	❑	❑	❑	❑	❑	❑	❑	❑

2. How important is Cost in comparison to Infrastructure in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Cost vs. Infrastructure	❑	❑	❑	❑	❑	❑	❑	❑	❑

3. How important is Cost in comparison to Safety in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Cost vs. Safety	❑	❑	❑	❑	❑	❑	❑	❑	❑

4. How important is Cost in comparison to Speed in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Cost vs. Speed	❑	❑	❑	❑	❑	❑	❑	❑	❑

5. How important is Flexibility in comparison to Infrastructure in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Flexibility vs. Infrastructure	❑	❑	❑	❑	❑	❑	❑	❑	❑

6. How important is Flexibility in comparison to Safety in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Flexibility vs. Safety	❑	❑	❑	❑	❑	❑	❑	❑	❑

7. How important is Flexibility in comparison to Speed in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Flexibility vs. Speed	❑	❑	❑	❑	❑	❑	❑	❑	❑

8. How important is Infrastructure in comparison to Safety in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Infrastructure vs. Safety	❑	❑	❑	❑	❑	❑	❑	❑	❑

9. How important is Infrastructure in comparison to Speed in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Infrastructure vs. Speed	❑	❑	❑	❑	❑	❑	❑	❑	❑

10. How important is Safety in comparison to Speed in case of selected three Smart mobility solutions

	Extreme Unimportance	Very Strong Unimportance	Strong Unimportance	Moderate Unimportance	Equal Importance	Moderate importance	Strong importance	Very Strong importance	Extreme importance
Safety vs. Speed	❑	❑	❑	❑	❑	❑	❑	❑	❑

AHP Analysis Results – All participants (20)

AHP
Multiple Input Sheet

20 = k number of participants
5 = n number of criteria

Consolidated = Weighted geometric mean off participants

C **Consolidated**

	1	2	3	4	5	6	7	8	9	10
1		0.95	0.896	0.408	0.943	0	0	0	0	0
2	1.052		1.345	0.431	1.215	0	0	0	0	0
3	1.117	0.744		0.347	0.786	0	0	0	0	0
4	2.45	2.32	2.879		3.647	0	0	0	0	0
5	1.061	0.823	1.273	0.274		0	0	0	0	0
6	0	0	0	0	0		0	0	0	0
7	0	0	0	0	0	0		0	0	0
8	0	0	0	0	0	0	0		0	0
9	0	0	0	0	0	0	0	0		0
10	0	0	0	0	0	0	0	0	0	

1 **Participant 1** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/7	1/5	1/7	1/5	0	0	0	0	0
2	7	1	3	1/5	3	0	0	0	0	0
3	5	1/3	1	1/6	1/3	0	0	0	0	0
4	7	5	6	1	7	0	0	0	0	0
5	5	1/3	3	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

2 **Participant 2** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/5	1/9	1/7	0	0	0	0	0
2	5	1	1/5	1/9	1/5	0	0	0	0	0
3	5	5	1	1/9	1/5	0	0	0	0	0
4	9	9	9	1	7	0	0	0	0	0
5	7	5	5	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

3 **Participant 3** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1	5	1	7	0	0	0	0	0
2	1	1	5	1	3	0	0	0	0	0
3	1/5	1/5	1	1	7	0	0	0	0	0
4	1	1	1	1	9	0	0	0	0	0
5	1/7	1/3	1/7	1/9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

4 **Participant 4** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/7	1/6	1/3	0	0	0	0	0
2	5	1	5	3	5	0	0	0	0	0
3	7	1/5	1	1	1	0	0	0	0	0
4	6	1/3	1	1	1	0	0	0	0	0
5	3	1/5	1	1	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

5 **Participant 5** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	7	5	1/3	1/7	0	0	0	0	0
2	1/7	1	1/3	1/7	1/7	0	0	0	0	0
3	1/5	3	1	1/7	1/7	0	0	0	0	0
4	3	7	7	1	1/3	0	0	0	0	0
5	7	7	7	3	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

6 **Participant 6** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1	3	1	3	0	0	0	0	0
2	1	1	1	1	1	0	0	0	0	0
3	1/3	1	1	1	1	0	0	0	0	0
4	1	1	1	1	3	0	0	0	0	0
5	1/3	1	1	1/3	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

7 **Participant 7** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	5	1/5	1/7	1/3	0	0	0	0	0
2	1/5	1	1/7	1/7	1/5	0	0	0	0	0
3	5	7	1	1/7	5	0	0	0	0	0
4	7	7	7	1	7	0	0	0	0	0
5	3	5	1/5	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

8 **Participant 8** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/7	1/7	1/9	1/7	0	0	0	0	0
2	7	1	7	1/3	7	0	0	0	0	0
3	7	1/7	1	1/9	1/5	0	0	0	0	0
4	9	3	9	1	7	0	0	0	0	0
5	7	1/7	5	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

9 **Participant 9** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	5	1/3	1	5	0	0	0	0	0
2	1/5	1	1/7	1	7	0	0	0	0	0
3	3	7	1	1	5	0	0	0	0	0
4	1	1	1	1	9	0	0	0	0	0
5	1/5	1/7	1/5	1/9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

10 **Participant 10** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	3	7	1	3	0	0	0	0	0
2	1/3	1	5	1/7	1/3	0	0	0	0	0
3	1/7	1/5	1	1/5	1/3	0	0	0	0	0
4	1	7	5	1	5	0	0	0	0	0
5	1/3	3	3	1/5	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

11 **Participant 11** 1 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/5	2	1	3	0	0	0	0	0
2	5	1	7	1	7	0	0	0	0	0
3	1/2	1/7	1	1	1/5	0	0	0	0	0
4	1	1	1	1	9	0	0	0	0	0
5	1/3	1/7	5	1/9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

AHP

Multiple Input Sheet

12 Participant 12 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	9	9	9	5	0	0	0	0	0
2	1/9	1	5	3	1	0	0	0	0	0
3	1/9	1/5	1	1	1	0	0	0	0	0
4	1/9	1/3	1	1	1/7	0	0	0	0	0
5	1/5	1	1	7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

13 Participant 13 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/7	1/9	1/3	0	0	0	0	0
2	5	1	1/5	1/5	1/5	0	0	0	0	0
3	7	5	1	1/5	1/5	0	0	0	0	0
4	9	5	5	1	5	0	0	0	0	0
5	3	5	5	1/5	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

14 Participant 14 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/3	1/9	1/9	0	0	0	0	0
2	5	1	1/3	1/9	1/3	0	0	0	0	0
3	3	3	1	1/9	1/3	0	0	0	0	0
4	9	9	9	1	9	0	0	0	0	0
5	9	3	3	1/9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

15 Participant 15 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	3	5	5	7	0	0	0	0	0
2	1/3	1	3	5	5	0	0	0	0	0
3	1/5	1/3	1	3	7	0	0	0	0	0
4	1/5	1/5	1/3	1	3	0	0	0	0	0
5	1/7	1/5	1/7	1/3	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

16 Participant 16 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	7	1/7	1/9	7	0	0	0	0	0
2	1/7	1	1/7	1/9	7	0	0	0	0	0
3	7	7	1	1/7	7	0	0	0	0	0
4	9	9	7	1	7	0	0	0	0	0
5	1/7	1/7	1/7	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

17 Participant 17 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/9	1/5	9	1/9	0	0	0	0	0
2	9	1	1/3	5	1/7	0	0	0	0	0
3	5	3	1	3	1/3	0	0	0	0	0
4	1/9	1/5	1/3	1	1/9	0	0	0	0	0
5	9	7	3	9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

18 Participant 18 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	1/7	1/5	1/9	1/5	0	0	0	0	0
2	7	1	7	1/5	5	0	0	0	0	0
3	5	1/7	1	1/7	1/5	0	0	0	0	0
4	9	5	7	1	7	0	0	0	0	0
5	5	1/5	5	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

19 Participant 19 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	7	7	1/9	5	0	0	0	0	0
2	1/7	1	9	1/7	1/5	0	0	0	0	0
3	1/7	1/9	1	1/9	1/5	0	0	0	0	0
4	9	7	9	1	9	0	0	0	0	0
5	1/5	5	5	1/9	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

20 Participant 20 | 1 | 01-00-1900

	1	2	3	4	5	6	7	8	9	10
1	1	5	5	1/7	5	0	0	0	0	0
2	1/5	1	5	1/7	5	0	0	0	0	0
3	1/5	1/5	1	1/7	5	0	0	0	0	0
4	7	7	7	1	7	0	0	0	0	0
5	1/5	1/5	1/5	1/7	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

Expert_Survey_Validation

Greetings! This Ph.D. research is focused on the development of a framework design for the transition of Smart Mobility in Saudi Arabia. Study author will use your valuable feedback to validate the results of this research study.
You are invited to participate in this survey as a Transport Expert to give your opinion. In this survey, only selected experts from the field of Transport and Mobility will be asked to complete a survey that asks questions about Smart Mobility.
Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential.
Thank you very much for your time and support. Please start with the survey now by clicking on the "Start" button below.

Question 1 out of 8: What is your gender?

1. Female
2. Male

Question 2 out of 8: What is the highest degree or level of school you have completed?

1. High school
2. Bachelors
3. Masters
4. Doctorate

Question 3 out of 8: What type of Institution/Organization are you representing?

1. Government
2. Private
3. Other _____

Question 4 out of 8: Is your organization directly involved in Smart Mobility Initiatives?

1. Yes
2. Partially Yes
3. No
4. Not Sure

Question 5 out of 8: Do you agree or disagree with the following ranking of preferred smart mobility modes for Saudi Arabia:

1. Public Transport
2. Autonomous Vehicles
3. Car Sharing

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree

Question 6 out of 8: Would you agree or disagree with the following ranking of the smart mobility elements for implementing smart mobility modes in Saudi Arabia:

1. Safety (Accident safety measures including security and comfort)

2. Flexibility (Comfortable accessibility and wider network coverage)
3. Cost (Cost of the technology, implementing and maintenance costs)

1. Strongly agree
2. Agree
3. Disagree
4. Strongly disagree

Question 7 out of 8: Do you agree or disagree with the following statement *"Governance failures cause complications and inefficiency of the smart mobility paradigm, especially at the implementation level"*

1. Strongly agree
2. Agree
3. Disagree
4. Strongly disagree

Question 8 out of 8: Any Comments/Suggestions are welcomed, as your feedback matters!

```
Your temporary usage period for IBM SPSS Statistics will expire in 10 days.
GET
Your license will expire in 10 days.
FILE='C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User
Survey.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
FREQUENCIES VARIABLES=Q8A1
/FORMAT=NOTABLE
/BARCHART PERCENT
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
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Comments		
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	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
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	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Q8A1 /FORMAT=NOTABLE /BARCHART PERCENT /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.73
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```
[DataSet1] C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total
User Survey.sav
```

Statistics

Q1-My company/work is a part of the following sector - Private

N	Valid	122
	Missing	83

```
graphs not yet implemented


FREQUENCIES VARIABLES=Q8A1
/FORMAT=NOTABLE
/PIECHART PERCENT
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
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Comments		
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	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
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Resources	Processor Time	0 00:00:00.14
	Elapsed Time	0 00:00:00.16

Statistics

Q1-My company/work is a part of the following sector - Private

N	Valid	122
	Missing	83

```
graphs not yet implemented


FREQUENCIES VARIABLES=Q8_O
/FORMAT=NOTABLE
/PIECHART PERCENT
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
Output Created		05-APR-2022 21:24:24
Comments		
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	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.

Contents		
Syntax		FREQUENCIES VARIABLES=Q8_O /FORMAT=NOTABLE /PIECHART PERCENT /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.12
	Elapsed Time	0 00:00:00.14

Statistics

My company/work is a part of the following sector - Other

N	Valid	205
	Missing	0

```
graphs not yet implemented


FREQUENCIES VARIABLES=Q8A1 Q8A2 Q8A3 Q8A4
/FORMAT=NOTABLE
/PIECHART PERCENT
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
Output Created		05-APR-2022 21:27:12
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Q8A1 Q8A2 Q8A3 Q8A4 /FORMAT=NOTABLE /PIECHART PERCENT /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.39
	Elapsed Time	0 00:00:00.38

Statistics

		Q1-My company/work is a part of the following sector - Private	Q1-My company/work is a part of the following sector - Government/Public	Q1-My company/work is a part of the following sector - Don't work	Q1-My company/work is a part of the following sector - Other
N	Valid	122	45	13	28
	Missing	83	160	192	177

Pie Chart

```
graphs not yet implemented

graphs not yet implemented

graphs not yet implemented

graphs not yet implemented
```

```
FREQUENCIES VARIABLES=Q8A1 Q8A2 Q8A3 Q8A4
/STATISTICS=RANGE MINIMUM MAXIMUM MODE
/FORMAT=LIMIT(50)
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
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Comments		
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	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Q8A1 Q8A2 Q8A3 Q8A4 /STATISTICS=RANGE MINIMUM MAXIMUM MODE /FORMAT=LIMIT(50) /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.03
	Elapsed Time	0 00:00:00.03

Statistics

		Q1-My company/work is a part of the following sector - Private	Q1-My company/work is a part of the following sector - Government/Public	Q1-My company/work is a part of the following sector - Don't work	Q1-My company/work is a part of the following sector - Other
N	Valid	122	45	13	28
	Missing	83	160	192	177
Mode		1	1	1	1
Range		0	0	0	0
Minimum		1	1	1	1
Maximum		1	1	1	1

Frequency Table

Q1-My company/work is a part of the following sector - Private

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private	122	59.5	100.0	100.0
Missing	System	83	40.5		
Total		205	100.0		

Q1-My company/work is a part of the following sector - Government/Public

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	45	22.0	100.0	100.0
Missing	System	160	78.0		
Total		205	100.0		

Q1-My company/work is a part of the following sector - Don't work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	6.3	100.0	100.0
Missing	System	192	93.7		
Total		205	100.0		

Q1-My company/work is a part of the following sector - Other

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	28	13.7	100.0	100.0
Missing	System	177	86.3		
Total		205	100.0		

```
NEW FILE.
DATASET NAME DataSet2 WINDOW=FRONT.
FREQUENCIES VARIABLES=VAR00001
/FORMAT=NOTABLE
/PIECHART FREQ
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
Output Created		05-APR-2022 21:41:16
Comments		
Input	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=VAR00001 /FORMAT=NOTABLE /PIECHART FREQ /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.12
	Elapsed Time	0 00:00:00.10

[DataSet2]

Statistics

VAR00001

N	Valid	205
	Missing	0

graphs not yet implemented

```
DATASET ACTIVATE DataSet1.
FREQUENCIES VARIABLES=Q9
/FORMAT=NOTABLE
/HISTOGRAM
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
Output Created		05-APR-2022 21:53:41
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Q9 /FORMAT=NOTABLE /HISTOGRAM /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.19
	Elapsed Time	0 00:00:00.22

[DataSet1] C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav

Statistics

Q33 - In your opinion, how much satisfied are you with current mobility (Transport) options in your country

N	Valid	205
	Missing	0

graphs not yet implemented

GGraph

Notes

Contents		
Output Created		05-APR-2022 21:59:40
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Syntax		GGRAPH /GRAPHDATASET NAME="graphdataset" VARIABLES=Q9 COUNT()[name="COUNT"] MISSING=LISTWISE REPORTMISSING=NO /GRAPHSPEC SOURCE=INLINE. BEGIN GPL SOURCE: s=userSource(id("graphdataset")) DATA: Q9=col(source(s), name("Q9"), unit.category()) DATA: COUNT=col(source(s), name("COUNT")) GUIDE: axis(dim(1), label("Q33 - In your opinion, how much satisfied are you with current mobility (Transport) options in your country")) GUIDE: axis(dim(2), label("Count")) SCALE: cat(dim(1), include("1", "2", "3", "4", "5")) SCALE: linear(dim(2), include(0)) ELEMENT: interval(position(Q9*COUNT), shape.interior(shape.square)) END GPL.
Resources	Processor Time	0 00:00:00.28
	Elapsed Time	0 00:00:00.32

```
graphs not yet implemented


SET TLook=None TABLERENDER=light SUMMARY=None ROWSBREAK=100 CTemplate=None TOLERANCE=1
TFit=Both CELLSBREAK=10000.
CROSSTABS
/TABLES=Q1 Q2 Q5 Q6 BY Q10 Q11 Q15
/FORMAT=AVALUE TABLES
/STATISTICS=CHISQ
/CELLS=COUNT
/COUNT ROUND CELL.
```

Crosstabs

Notes

Contents		
Output Created		05-APR-2022 23:01:46
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>

Contents		
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		CROSSTABS /TABLES=Q1 Q2 Q5 Q6 BY Q10 Q11 Q15 /FORMAT=AVALUE TABLES /STATISTICS=CHISQ /CELLS=COUNT /COUNT ROUND CELL.
Resources	Processor Time	0 00:00:00.06
	Elapsed Time	0 00:00:00.06
	Dimensions Requested	2
	Cells Available	174734

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Q1 - Are you * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	205	100.0%	0	.0%	205	100.0%
Q1 - Are you * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country	205	100.0%	0	.0%	205	100.0%
Q1 - Are you * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety	205	100.0%	0	.0%	205	100.0%
Q2 - What is your age * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	205	100.0%	0	.0%	205	100.0%
Q2 - What is your age * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country	205	100.0%	0	.0%	205	100.0%
Q2 - What is your age * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety	205	100.0%	0	.0%	205	100.0%
Q5 - What is the highest degree or level of school you have completed * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	205	100.0%	0	.0%	205	100.0%
Q5 - What is the highest degree or level of school you have completed * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country	205	100.0%	0	.0%	205	100.0%
Q5 - What is the highest degree or level of school you have completed * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety	205	100.0%	0	.0%	205	100.0%
Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	205	100.0%	0	.0%	205	100.0%
Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country	205	100.0%	0	.0%	205	100.0%
Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety	205	100.0%	0	.0%	205	100.0%

Q1 - Are you * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

Crosstab

Count

		Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey		
		Yes	No	Total
Q1 - Are you	Male	71	55	126
	Female	32	47	79
Total		103	102	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.875[a]	1	.027		
Continuity Correction[b]	4.262	1	.039		
Likelihood Ratio	4.898	1	.027		
Fisher's Exact Test				.032	.019
Linear-by-Linear Association	4.851	1	.028		
N of Valid Cases	205				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 39.31.

b. Computed only for a 2x2 table

Q1 - Are you * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country

Crosstab

Count

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q1 - Are you	Male	104	21	0	0	1	126
	Female	64	12	2	1	0	79
Total		168	33	2	1	1	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.491[a]	4	.240
Likelihood Ratio	6.775	4	.148
Linear-by-Linear Association	.310	1	.577
N of Valid Cases	205		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .39.

Q1 - Are you * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety

Crosstab

Count

		Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety		
		Yes	No	Total
Q1 - Are you	Male	99	27	126
	Female	59	20	79
Total		158	47	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.415[a]	1	.519		
Continuity Correction[b]	.224	1	.636		
Likelihood Ratio	.412	1	.521		
Fisher's Exact Test				.609	.316
Linear-by-Linear Association	.413	1	.520		
N of Valid Cases	205				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 18.11.

b. Computed only for a 2x2 table

Q2 - What is your age * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

Crosstab

Count

		Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey		
		Yes	No	Total
Q2 - What is your age	Female	29	21	50
	Prefer not to answer	35	46	81
	4	23	19	42
	5	8	8	16
	6	4	5	9
	7	4	3	7
Total		103	102	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.404[a]	5	.638
Likelihood Ratio	3.415	5	.636
Linear-by-Linear Association	.036	1	.850
N of Valid Cases	205		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 3.48.

Q2 - What is your age * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country

Crosstab

Count

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q2 - What is your age	Female	43	6	1	0	0	50
	Prefer not to answer	63	16	0	1	1	81
	4	34	7	1	0	0	42
	5	14	2	0	0	0	16
	6	8	1	0	0	0	9
	7	6	1	0	0	0	7
Total		168	33	2	1	1	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.439[a]	20	.995
Likelihood Ratio	8.853	20	.985
Linear-by-Linear Association	.278	1	.598
N of Valid Cases	205		

a. 21 cells (70.0%) have expected count less than 5. The minimum expected count is .03.

Q2 - What is your age * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety

Crosstab

Count

		Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety		
		Yes	No	Total
Q2 - What is your age	Female	41	9	50
	Prefer not to answer	63	18	81
	4	30	12	42
	5	11	5	16
	6	7	2	9
	7	6	1	7
Total		158	47	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.392[a]	5	.793
Likelihood Ratio	2.383	5	.794
Linear-by-Linear Association	.422	1	.516
N of Valid Cases	205		

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is 1.60.

Q5 - What is the highest degree or level of school you have completed * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

Crosstab

Count

		Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey		
		Yes	No	Total
Q5 - What is the highest degree or level of school you have completed	Male	10	9	19
	Female	12	10	22
	Prefer not to answer	6	0	6
	4	54	68	122
	5	19	13	32
	6	2	2	4
Total		103	102	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.961[a]	5	.111
Likelihood Ratio	11.289	5	.046
Linear-by-Linear Association	.152	1	.696
N of Valid Cases	205		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.99.

Q5 - What is the highest degree or level of school you have completed * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country

Crosstab

Count

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q5 - What is the highest degree or level of school you have completed	Male	16	3	0	0	0	19
	Female	18	4	0	0	0	22
	Prefer not to answer	6	0	0	0	0	6
	4	101	19	2	0	0	122
	5	24	7	0	1	0	32
	6	3	0	0	0	1	4
Total		168	33	2	1	1	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	59.845[a]	20	.000

	Value	df	Asymp. Sig. (2-sided)
Likelihood Ratio	18.022	20	.586
Linear-by-Linear Association	2.931	1	.087
N of Valid Cases	205		

a. 24 cells (80.0%) have expected count less than 5. The minimum expected count is .02.

Q5 - What is the highest degree or level of school you have completed * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety

Crosstab

Count

		Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety		
		Yes	No	Total
Q5 - What is the highest degree or level of school you have completed	Male	16	3	19
	Female	18	4	22
	Prefer not to answer	3	3	6
	4	92	30	122
	5	26	6	32
	6	3	1	4
Total		158	47	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.834[a]	5	.574
Likelihood Ratio	3.502	5	.623
Linear-by-Linear Association	.219	1	.640
N of Valid Cases	205		

a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is .92.

Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

Crosstab

Count

		Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey		
		Yes	No	Total
Q6 - Were you familiar with the term " Smart Mobility" before this survey	Male	70	23	93
	Female	33	79	112
Total		103	102	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	42.642[a]	1	.000		

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correction[b]	40.829	1	.000		
Likelihood Ratio	44.343	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	42.434	1	.000		
N of Valid Cases	205				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 46.27.

b. Computed only for a 2x2 table

Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country

Crosstab

Count

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q6 - Were you familiar with the term " Smart Mobility" before this survey	Male	75	18	0	0	0	93
	Female	93	15	2	1	1	112
Total		168	33	2	1	1	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.479[a]	4	.345
Likelihood Ratio	5.987	4	.200
Linear-by-Linear Association	.273	1	.601
N of Valid Cases	205		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .45.

Q6 - Were you familiar with the term " Smart Mobility" before this survey * Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety

Crosstab

Count

		Q8 - Do you believe alternative mobility (transport) solutions help Traffic congestion and safety		
		Yes	No	Total
Q6 - Were you familiar with the term " Smart Mobility" before this survey	Male	73	20	93
	Female	85	27	112
Total		158	47	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.195[a]	1	.659		
Continuity Correction[b]	.075	1	.784		
Likelihood Ratio	.195	1	.659		
Fisher's Exact Test				.739	.393
Linear-by-Linear Association	.194	1	.660		
N of Valid Cases	205				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 21.32.

b. Computed only for a 2x2 table

```
FREQUENCIES VARIABLES=Q10
/HISTOGRAM
/ORDER=ANALYSIS.
```

Frequencies

Notes

Contents		
Output Created		06-APR-2022 00:00:14
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Q10 /HISTOGRAM /ORDER=ANALYSIS.
Resources	Processor Time	0 00:00:00.11
	Elapsed Time	0 00:00:00.11

Statistics

Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

N	Valid	205
	Missing	0

Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	103	50.2	50.2	50.2
	No	102	49.8	49.8	100.0
	Total	205	100.0	100.0	

```
graphs not yet implemented
```

```
CROSSTABS
/TABLES=Q10 BY Q11
/FORMAT=AVALUE TABLES
/STATISTICS=CHISQ
/CELLS=COUNT
/COUNT ROUND CELL.
```

Crosstabs

Notes

Contents		
Output Created		06-APR-2022 00:21:04
Comments		
Input	Data	C:\Users\USER\Desktop\important Smart mobility\Spss\SurveyReport-SPSS-Total User Survey.sav
	Active Dataset	DataSet1
	File Label	Generated by Java SPSS Writer v1.88 http://spss.pmStation.com
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	205
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		CROSSTABS /TABLES=Q10 BY Q11 /FORMAT=AVALUE TABLES /STATISTICS=CHISQ /CELLS=COUNT /COUNT ROUND CELL.
Resources	Processor Time	0 00:00:00.00
	Elapsed Time	0 00:00:00.00
	Dimensions Requested	2
	Cells Available	174734

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country	205	100.0%	0	.0%	205	100.0%

Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey * Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country Crosstabulation

Count

		Q4 - Do you think it is important to have several alternative (different) mobility (Transport) solution in your country					
		Very Important	Important	Not so important	No need at all	Don't Know	Total
Q3 - Have you ever heard about alternative (different) mobility (transport) solutions before this survey	Yes	87	15	1	0	0	103
	No	81	18	1	1	1	102
Total		168	33	2	1	1	205

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.482[a]	4	.648
Likelihood Ratio	3.255	4	.516
Linear-by-Linear Association	1.836	1	.175
N of Valid Cases	205		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .50.