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Integrating All Mobility Systems to Reduce Traffic Congestion

by

Nasser Al Suwaidi

**A Capstone Submitted in Partial Fulfilment of the Requirements for
the Degree of Master of Science in Professional Studies:**

City Science

Department of Graduate Programs & Research

Rochester Institute of Technology

RIT Dubai

Fall 2020

RIT

**Master of Science in Professional Studies:
City Science**

Graduate Capstone Approval

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Graduate Capstone Title: **Integrating All Mobility Systems to Reduce
Traffic Congestion**

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Acknowledgments

I would like to thank everyone who contributed one way or another in the completion of this work. I express my deepest gratitude to my parents for their endless support during my knowledge seeking journey.

The completion of this work could not have been possible without the guidance of my mentor and the professors in this program. The professors provided numerous ways of easy communication during this difficult time.

In addition, I wish to express my sincere appreciation for my colleagues in Road and Transport Authority in Dubai for making it possible to get my master's degree by being supportive in every way possible.

Abstract

The problem of traffic congestion is common in most urban areas with associated negative impact on the social, economic, and ecological well-being of its residents. Traffic congestion is a common phenomenon in the city of Dubai with its large population and high rate of car ownership. To tackle the problem, this study looks at integrating all mobility systems in the city as a possible solution to the traffic congestion menace. The research methodology involves thematic analysis of secondary data on the subject derived from online databases and libraries. The thematic analysis revealed that Dubai had all the factors needed to integrate mobility system. The city has multiple public transport options, dedicated infrastructure, and mobility hubs close to populated areas. The integration would also offer smart solutions for reducing road accidents that are a major cause of congestion. Smart solutions identified include sharing real-time traffic information and the use of smart street signs to notify road users. The Road and Transport Authority (RTA) facilitates smart initiatives like the integration of all mobility systems through policy formulation. Currently, the body has projects like ‘Smart Traffic Systems’ that help in reducing congestion in the road. All efforts to integrate the mobility systems in Dubai are in line with the vision of Smart Dubai that seeks to improve the livability of the city by leveraging information, data, and available resources.

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Chapter 1

1.1 Background

Growth of Urban Centers: Dubai

The growth of urban centers has escalated in the previous decades as more people move from rural areas to cities across the globe. In fact, 70% of the global population is expected to live in an urban area by 2050. Cities across the globe are growing in land mass and population size since they offer people access to more infrastructure and amenities that make life easier. In fact, the rate of growth of cities in the United States grew by 10.7% within the first decade of the twenty first century signaling the rise in the number of people moving into these urban areas. Although cities grow, they do not do so at the same rate nor uniformly. The deviation in growth rate depends on the location of the city, industries and job opportunities present, as well as the cost of living. The future growth of urban populations has been shown to be concentrated in a few nations. A bulk of urban population growth will occur in India at 416 million new inhabitants, China with 255 million people, and the African nation of Nigeria, is expected to grow its urban population by 189 million people (UN, 2018). These three nations will account for a total of 35% of global urban growth by the year 2050. Overall, the global urban population is expected to grow rapidly between 2018 and 2050.

A city that has shown tremendous growth in the past few decades has been Dubai in the UAE. Among the Gulf cities, Dubai has probably received the most attention from urban studies scholars who sought to understand factors that lead to the growth of a city. Dubai, much like Abu Dhabi and Doha, has transformed from a relatively small fishing village to one of the biggest metropolis in the world in just two decades (Breslow, 2020). The growth of the city can be attributed to the administration embracing economic liberalism and a desire to become a huge metropolis with massive projects highlighting the growth of the city.

Dubai's urbanization has been divided into four phases, however, a review by Al Awadi (2017) has shown that the Gulf city developed in six phases. Each stage had an impact on urban housing and the development and growth of the community. The significant periods in Dubai's history include: 1900 to 1955, 1955 -1970, 1971 – 1994, 1995 -2008, 2008 -2013, and 2013 to present (Alawadi & Benkraouda, 2017). In the first significant period from the early 1900s up

until the mid-1950s, the growth of the city was minimal because of little economic activity in the region. The urban region was sparsely populated and had no substantial housing program. The period between 1955 and 1970 was when oil was discovered in the area. However, the city failed to take full advantage of this resource since oil was not yet commercialized. However, during the early stages of 1970, the UAE federal government established a large-scale housing program known as “Sha-biyaat” to provide affordable housing to its growing populace in urban areas (Alawadi & Benkraouda, 2017). Between the 1970s and the 1990s, Dubai had commercialized its massive oil reserves leading to an influx in cash that helped in developing planned suburban growth. At that time more people settled in the city as the national housing program expanded. In the 1980s, the neighborhoods began to change and grow with a tendency to sprawl. The settlements and housing has since expanded along the Gulf shores of the nation. The fourth distinct phase of growth was between 1995 up to the financial crisis of 2008. During the period, Dubai sought to diversify the economy away from oil dependency by attracting international capital (Sbia et al., 2017). This period was marked by “bigness” where large-scale urbanism and architecture dominated (Alawadi & Benkraouda, 2017). However, in 2008 the financial crisis led to a halt in the boom years of the city with construction slowing down significantly. Between 2008 and 2013, Dubai adopted a more modest approach to urbanization that was focused on fine-grained mixed-used development. Finally, from 2013 to present Dubai has witnessed a resurgence in financial activities and “bigness” in urban development with the organization of Expo 2020. The city has seen speculative and mega-projects set up within the time frame to increase the international profile of the city. In this last phase, there has been no significant changes in housing forms and programs in the region with suburban growth still on upward trajectory.

Currently, the estimated population of Dubai inhabitants currently stands at 3.4 million. This population size represents a 3.69% annual growth rate in population in the city from 2015 where the number of inhabitants has grown by 477,277 people. The city covers an area of 4,114 square kilometers with a population density of 762.6 persons per square kilometer (Breslow, 2020). Dubai, the capital of the Dubai Emirate, is the most populated emirate. However, a review of the demographics show that only 15% of these inhabitants are native residents while the remaining 85% are expatriates. Some of the most populous expatriate populations include Indians, other Asians such as Pakistanis, Bangladeshis, and those from the

Philippines. Somalis and British expatriates round up some of the most common inhabitants of the city.

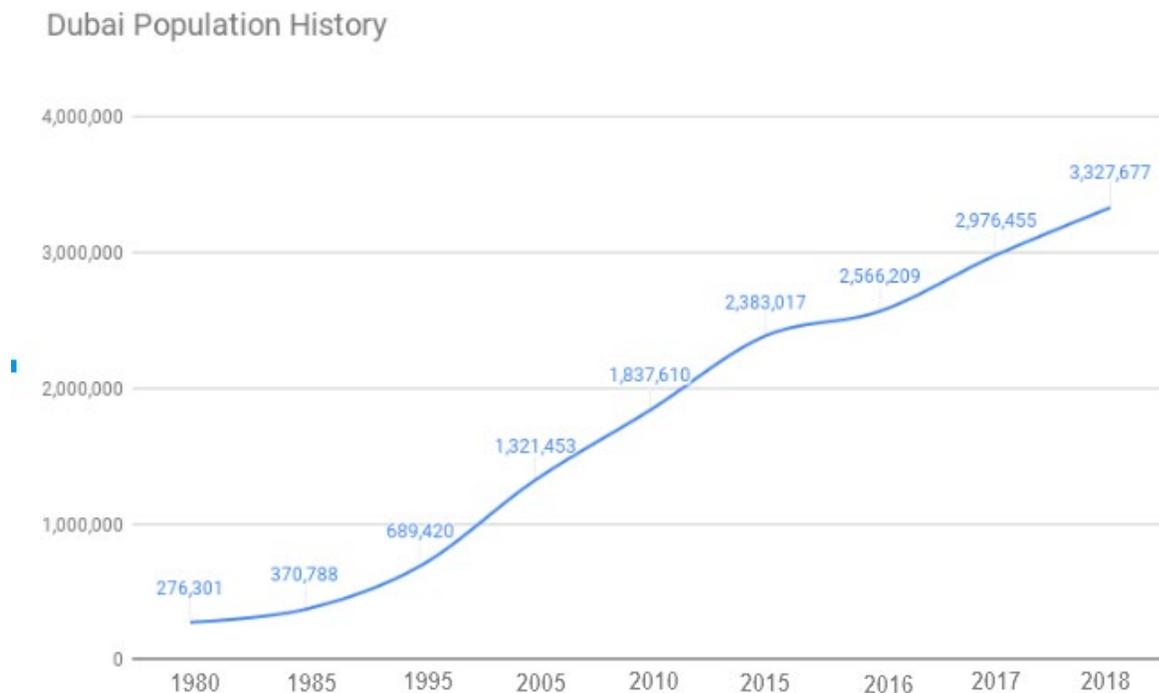


Figure 1: Graph showing the increase in population size in Dubai from 1980 to 2018 (GMI, 2020)

Traffic Congestion

One of the biggest challenges brought about by the rapid expansion of urban areas like Dubai is the rise in traffic congestion and jams. As more individuals move into urban areas and acquire a car, the level of congestion in most major cities is expected to increase as a result. Traffic congestion is an inescapable condition in many large and growing urban centers like Tokyo, Cairo, and Sao Paulo (Downs, 2018). The traffic snarl-ups, especially during peak-hours, are a reflection of how people in society function. The existing road network has to cope with the demands of several commuters and vehicles with competing needs. Traffic snarl-ups are as a result of mobility problems caused by how society in urban centers are set up. People often go to work or school at around the same times leading to predictable traffic congestions in urban areas. In major metropolitan areas, the overlap leads to situations where roads are overwhelmed with vehicles at the same time leading to major traffic congestions. Some commuters stay in traffic for long periods of time ranging in hours.

The traffic congestion is particularly bad in Dubai which is the most congested city in the UAE and ranks 79th globally. In the major city, the average commuter spent 80 hours in traffic in the year 2018 (Maceda, 2019). The traffic congestion in the city is worse than in Vancouver, Cape Town, Austin, and Manchester. In comparison, Abu Dhabi has a much lower traffic congestion issue compared to Dubai with the average commuter spending a total of 50 hours sitting in their vehicle during peak traffic in the year 2018. The traffic in Dubai is worse during the evening rush hours compared to those in the morning. In the morning hours, the congestion level is approximately at 34% with the figure rising to 48% during the evening as commuters are making their way back home from work or school (Logistics Middle East Staff, 2019). In Dubai, a bulk of the congestion happens on roads rather on highways.

In Dubai, and around the globe, traffic congestion is quickly becoming a major issue in urban areas. Traffic congestion is harmful to the social, economic, and climatic well-being of individuals. On a social level, traffic congestion raises the levels of frustration and anger that drivers feel when on the road. In this frustrated state, drivers are more likely to cause accidents as they try to force their way through the jam. Traffic congestions also pose a serious risk to the health of city inhabitants. The emissions from cars in traffic lead to visual, sound, and air pollution that could adversely affect the health of people. Urban traffic jams are loud and visually chaotic for persons living in the city. The air pollution caused by the emission of burnt fuel from cars seriously affects the health of individuals. Particulate matter from car emissions can cause long-term respiratory illnesses and premature deaths to those affected. The emissions also contribute to greenhouse gases leading to climate change that could harm individuals. Economically, traffic congestions in cities lead to loss of productive time for workers and an increase in consumption of fuel. Long traffic snarl-ups make workers late for their duties compromising its achievement as well as their productivity. Cars also consume more fuel in traffic translating to a higher cost for the driver. All these issues pose a serious risk on the social, economic, and physical wellbeing of the city as a whole.

Factors Contributing to Traffic Congestion

Tackling the issue of congestion in major urban cities like Dubai first requires an understanding of the underlying factors contributing to the issue. One possible factor is land consumption and use in many major cities. Cities across the globe are undergoing urban sprawl as the population increases and commercial and residential areas move away from the center of

the city. People are increasingly living farther from their places of work leading to the development of complex transits and long commutes on the road. In the United States, the trend is particularly noticeable as 30% to as much as 60% of the land mass in an urban region is set aside for the roads and parking lots (Here Mobility, 2019). Residential properties are far from the city center and its services meaning more people use automobiles for daily commutes increasing the chances of traffic congestions.

Aging infrastructure also contributes to traffic congestion in major cities. The infrastructure in major cities are under enormous strain given the demands placed upon it. There is always a need to upgrade and improve existing infrastructure to make transport more efficient. Infrastructure, however, incurs large maintenance costs making it expensive to keep infrastructure up-to-date for most countries across the globe. Cities facing challenges of aging infrastructure tend to experience high levels of traffic congestions since they have reduced mobility.

Cities that have a common infrastructure shared between passenger traffic and movement of freight cargo also tend to experience increased traffic congestions. Globalization, improved manufacturing, and online shopping have increased the demand on the movement of freight. Goods are on the transit between nations and within cities at an increasingly fast rate. In major urban cities like Dubai that are well connected to the international market as well as have a growing population with a high consumer purchasing power with access to online shopping sites, the amount of freight transported is large. In such cities, the mixture of freight cargo and passenger traffic on the same infrastructure is an underlying cause of long traffic snarl-ups.

The large number of vehicles on the road in urban areas like Dubai also lead to heavy congestion (Akmal Abdelfatah et al., 2015). Road congestion is the main problem on the roads of Dubai with commuters spending an average of 80 hours annually stuck in a traffic jam. The UAE city is heavily reliant on taxis and personal cars. Car ride hailing apps and services like Uber and Careem are also wildly popular in the city further increasing the number of vehicles on the roads (Here Mobility, 2019). There is one car for every two Dubai residents and a vehicle density of 540 cars per 1000 individuals making it the highest in the entire region (Abouelhamid, 2020). The number of vehicles on Dubai's roads continue to grow at an estimated rate of 8.2% per annum with an increasing population raising demand (Abouelhamid, 2020). The Road

Transport Authority of Dubai also estimates that 450,000 cars entered the city from other cities in the nation with peak traffic observed during the morning and evening rush hours.

Integrated Mobility Systems

One of the possible solutions touted in handling the problem of traffic congestion is the introduction of an integrated mobility system. The integrated mobility system is one of the key aspects of future smart cities and involves mobility providers collaborating to promote their services to commuters on a single platform. An integrated mobility system links different transportation modes together giving the commuter more options allowing them to efficiently utilize public transit to move around a large urban area. An individual, for example, could take a train into the city followed by an e-bike ride to their front office. Alternatively, they have the option of choosing from different other modes of transport such as the bus or car sharing to ensure that they arrive at their destination in good time.

The term integrated mobility also refers to the relationship where different public transport nodes share information on bookings, reservations, and payments on a single platform. A real-time sharing of data allows users to plan out their commute ahead of time and take advantage of the various public transit options available in the city. This integration of different public transportations makes it easier for people to leave their vehicles at home and choose to use public transit which reduces the level of congestion on the streets.

An integrated mobility solution for a city is made up of three important factors: transportation options, mobility hubs, and adjustment infrastructure. An integrated mobility system that covers a large metropolitan should have options to offer its commuters. A multimodal transportation system gives the commuters options making use of mass transit systems appealing in the integrated model. Secondly, there should be mobility hubs which serve to connect all these different modes of transport. The location of the hub is near areas where human traffic is high like in near malls, housing centers, and places of employment. Finally, the integrated mobility system also has infrastructure adjustments that reflect this specialized form of urban transport solutions. In the United States, there are High Occupancy Vehicle (HOV) highway lanes that are specifically designed to handle special buses and ride sharing vehicles to make the use of alternatives to personal vehicles more appealing to commuters.

The decision to integrate mobility system is one that holds a lot of potential benefits for cities around the globe. Integrated mobility solutions improve social inclusion by providing its citizens with access to services and low cost transportation options. In Japan, for example, in the city of Tayoma, the mobility plan is specifically catered for the aging population with trams that have low floors as well as improving access to free public transport. In cities like Dubai, an integrated mobility system has the potential of bringing the same benefit as people from all cadres of life and social classes within the city will have access to affordable public transport. Integrated mobility also has some substantive economic benefits for cities and its occupants. An integrated mobility solution allows people to have better access to their activities in a city making the location ideal for places of work, tourism, and for investors. The integrated system encourages more people to use public transit over personal vehicles helping in the reduction of greenhouse emission caused by having plenty of vehicles on the streets. Noise pollution is also minimized with better use of public spaces.

Overall, the concept of an integrated mobility system is meant to solve the urban density challenge facing many major urban centers. Interoperability of different public transit modes in a city is a critical means of decongesting cities and encouraging more of the city residents to adopt the use of public transit. Time and money is saved in such a system because congestion is expensive as people in the United States, for example, lose close to \$160 billion each year in traffic with valuable man hours lost and extra fuel consumed while in jams. A mobility solution integrating all public transport on one platform makes commuting within a major urban area like quick, flexible, cheap and more efficient for citizens. The move will also lead to a reduction in the congestion issues plaguing major cities like Dubai in the UAE.

1.2 Statement of The Problem

This project seeks to explore integrating mobility systems as a possible solution to the troubles bedeviling Dubai because of incessant traffic congestion. Traffic congestion is the main problem facing the transport sector in the UAE leading to exploration of novel solutions. The research will involve a review of literature on integrated mobility systems and correlate it with how approach can help solve the issue of traffic congestion in Dubai. This study aims to contribute further in helping the RTA and other policy makers consider integrated mobility systems in dealing with the growing issue of traffic jams.

1.3 Project Goals

1. Explore integrated mobility systems as a means of promoting the use of alternative modes of transport to personal vehicles.
2. Define ways in which cities like Dubai can prepare and integrate their mobility systems.
3. Exploring smart approaches to integration like the use of mobile applications.
4. Contributing in lowering traffic jams in the city of Dubai.

1.4 Research Methodology

Research Design

The study will adopt a descriptive design in addressing the relevant research questions. Descriptive research designs refer to studies that advocates for obtaining information on a specific topic, explaining the phenomenon as it exists, and its applicability in the present and future. The research design helps shed answers on the question of the where, what, who, when, and how of a research problem. The reason for choosing this design is because it can be applied in a situation where the phenomenon under investigation is completely independent of the intervention of the researcher. Descriptive research design has the advantage of acting as a precursor for future research and interventions (Silverman, 2016). The choice of adopting a descriptive design was also driven by the need to understand the limitations that exist in the integration of mobility systems. Identifying limitations helps spur innovation and set the stage for more focused future studies on the issue. Another advantage of the design is that it is useful in gaining rich data that form the basis for making recommendations.

Qualitative Research

A qualitative approach was adopted to meet the objectives of the study. Qualitative research involves the collecting and analyzing non-numerical data to gain better understanding of a concept or theory. Qualitative studies are common in subject areas where the phenomenon under study cannot be quantified numerically (Silverman, 2016). One of the advantages of using qualitative research in this study is that it is flexible in its application (Silverman, 2016). The second advantage of a qualitative study is that it gives one a better understanding of the social

reality (Silverman, 2016). Quantitative numeric data alone cannot capture the totality of the human lived experience.

Secondary Data

The qualitative research method for meeting the study objectives involves secondary research. Secondary research involves collecting and analyzing existing data in the form of texts, pictures, audio, or video recordings (Largan & Morris, 2019). This research method is a common way of conducting systematic investigations in which the researcher is wholly dependent on already existing data. The decision to utilize a secondary research method for the qualitative study was inspired by the numerous advantages that secondary research hold. Firstly, secondary research is simple to conduct since all the data is easily accessible. Secondly, secondary research was chosen because of it is a cost effective and time-saving means of gaining more understanding on a topic (Largan & Morris, 2019). Thirdly, secondary research helps in the identification of gaps in existing literature on the topic. The gaps identified in literature can serve as the basis for future studies and further improve understanding of a certain topic.

Data Collection

Secondary data was collected through the internet, libraries, and organizational reports. Online data involves all information gathered from the internet and is widely regarded as one of the most popular ways of obtaining secondary data. Online data is preferred because the internet provides access to a large pool of study resources that are both free and paid. The internet is home to millions of useful information sets and can be used to get data on a wide array of subjects.

In this study, data was collected online from scholarly databases like Google Scholar, ProQuest, and JSTOR. The databases were queried using the following keywords: “traffic management”, “integrated mobility system”, “infrastructure”, “cost”, “Dubai traffic”, and “Dubai smart city”. The results were then filtered to meet the following inclusion criteria. First, only data published from 2015 to present day was included in the study. Older studies and data sets were not allowed because they failed to reflect timely data that is relevant to the subject matter. The concept of integrated mobility services as a tool for reducing congestion in cities is relatively new and quickly evolving. Old data sets from before 2015 might contain information that is not reflective of the current state of the system. The second inclusion criteria used to filter the data from the online query was that the data had to be from peer-reviewed journals, government

websites, and books that contained relevant information. Information from commercial sources and online encyclopedias were excluded from the study because the data on these platforms can be edited and may contain bias making them unreliable.

After applying the filters excluding older data sets and those with unreliable information, a total of 10 articles were identified as relevant to the objectives of the study. The articles and government reports included in the study are summarized in the table below.

Author(s)	Title	Summary	Relevance to Study Objectives
Adela (2019)	The role of the roads and transport authority (RTA) in the transformation of Dubai into a smart city	The paper looks at the role RTA plays in pushing for smart innovations in Dubai	High
Breslow (2020)	The smart city and the containment of informality: The case of Dubai	A look at the Smart Dubai project and its driving factors.	High
Abouelhamid, I. (2020)	Conceptual Development Solutions for Traffic Jams & Accidents in Dubai City	A profile of transportation in Dubai and solutions for congestion	High
Akmal Abdelfatah et al. (2015)	Trends and causes of traffic accidents in Dubai	A look at the main causes for traffic in the city of Dubai	High
Benevolo et al. (2015)	Smart mobility in smart city	Smart mobility supported by ICT reduces traffic and	High

		improves the lives of people in a smart city	
Chang et al. (2017)	Is there more traffic congestion in larger cities? -scaling analysis of the 101 largest U.S. urban centers	A look at the influence of population and city size on traffic levels in the United States.	Medium
Khalid (2019)	Towards a smarter solution for reducing road traffic accidents in Dubai	How traffic accidents and traffic can be reduced in ‘Smart Dubai’	High
Motta (2015)	Integrated mobility: A research in progress	A delve into integrated mobility where green and shared public transport replaces private car ownership.	High
Sturari et al. (2016)	An integrated mobility system using real-time data for traffic simulation.	Gives a basis for using existing surveillance technology on roads to better manage traffic through a Simulation of Urban Mobility (SUMO)	High
RTA (2020)	Annual Report Roads and Transport Authority 2019	A rundown of the progress done in	Medium

		developing Dubai's transport system	
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Table 1: Sources used in the research analysis

The data collected from these articles met the inclusion criteria set in the study that would ensure that the data is timely, relevant, and free of bias. All the data collected was from either peer-reviewed sources or from the official Dubai Roads and Transport Authority website. 9 out of the 10 sources were of high relevance to the study while one was of medium relevance. The relevance was determined by how well it addressed the following: Integrated mobility systems, Dubai, Traffic congestions, Smart cities and Smart applications. If a paper addressed 0 to 1 issue only, then it was weakly relevant, a score of 2-3 was considered medium, while more than 3 of the issues mentioned warranted a high level of relevance.

1.5 Limitations of the Study

The study had two limitations. The first was the reliance on secondary data. Secondary data has the disadvantage of propagating possible biases of the original authors. Future studies should seek a mixed approach that includes a primary data collection to get firsthand information on the topic. The second limitation is a shortage in literature on integrated mobility systems in Dubai and its surrounding neighbors leading to the use of a small number of articles for the study.

Chapter 2 – Literature Review

2.1 Introduction

The literature review section will explore peer reviewed articles, submissions, and data from official government websites to gain a better understanding of research conducted on integrated mobility as a solution to traffic congestion. The review explores research and data on cities, their growth and the subsequent traffic congestions witnessed. The review will then look at content that is specific to Dubai and its burgeoning as a major business and touristy hub as well as the problem of congestion in the city. The review will look at some smart solutions to curb traffic congestion and explore research that has been conducted on integrated mobility systems as well as its application in an area like Dubai.

Cities and Traffic Congestion

The growth of urbanization globally has been a major driving factor in the increase in traffic congestion. Chang et al. (2017) came to the conclusion that a rise in the population and size of city was directly related to the level of congestion experienced on its infrastructure. The authors of the study looked at 101 cities across the United States of America and identified that larger cities have more congestion compared to small ones. The largest cities with more than 3 million inhabitants, however, have almost equal levels of congestion defying the scaling relationship that exists between urban size and congestion. The authors go further and quantify the effects of traffic congestion in these cities stating that the urban centers recorded a total of 4.8 billion hours of travel delays in 2011 and led to the consumption of an excess of 8.419 million cubic meters of fuel in the same time period. Similarly, Abouelhamd (2020) identified transportation and traffic systems as the spine of a city because it allows it to grow and improve accessibility to resources. The author conducted a review of the transport in Dubai and some of the common challenges facing the residents and the Road Transport Authority in Dubai. The author stated traffic congestion as one of the biggest problems on Dubai roads with high economic costs to the city and a cause of stress and inconvenience for residents. Much like Chang et al. (2017), Abouelhamd attributes the traffic jams to the growth of the city's population and number of vehicles on the streets.

The impact of the traffic jams are far reaching. Hussein (2018) conducted an analysis of the effect of traffic congestion between Sharjah and Dubai on the commuters. The findings of the study showed that 71% of commuters almost always ended up in traffic jams on their way to work and this increases to 80% when coming back in the city. A survey conducted on the drivers showed that a majority felt like they wasted productive time on the road. The subjects also reported that traffic jams impacted them physically as well. The main complaints were back pain (68.9%), headaches (66.2%), and neck and leg pains (61.2%). Psychologically, the respondent's complaint of having a bad mood, stress, frustration, and nervousness when stuck in traffic. Similarly, Khalid (2019) links increased traffic congestion to the road to a rise in the incidence rate of accidents in Dubai.

Dubai's Transportation

Dubai's transport system is as complex and includes both public and private transit options. Abouelhamd (2020) conducted an in-depth analysis of the circumstances surrounding transportation in the Gulf city. A look at the history of transportation in Dubai shows that investment in the sector really growing after the discovery of oil in 1966 when the government had enough resources to build new infrastructure and expand existing ones. The Dubai authorities built a new port, the Dubai International Airport, a terminal building, and the world's largest man-made harbor. The government made a decision in the 1980s to invest in tourism infrastructure further expanding the city and soon mega-building and skyscrapers lined-up the Gulf coastline. According to Abouelhamd (2020), the development of Dubai has mostly been driven by road infrastructure. A majority of Dubai's investments go into building highways, bridges, and tunnels and this has led to it having some of the widest roads and land transportation networks in the world.

Dubai has one of the highest number of privately owned vehicles in the region. Khalid (2019) noted that the number of cars on Dubai roads had been on a steady rise in the past decade with estimates of more people owning cars up to 2024. Abouelhamd (2020) explains that the large number of vehicles in the city is because of low oil prices and affordability of vehicles. The city has been car-oriented since the late 1960s till date with a ratio of 564 vehicles for every 1000 residents. The use of private vehicle still accounts for the largest share of commuter options at 76% while public transit only makes up 14.4% and taxis at 9%. Private cars dominate the roads of Dubai.

Public transportation options in Dubai remained poorly developed in the past but have since been upgraded mainly to serve tourism. According to Abouelhamd (2020), the city's public transport was bad and sparsely distributed with buses as the main means of moving around as of 2008. The public transport sector mainly served students and workers since a majority of residents preferred private transport. The government of Dubai made concerted efforts to upgrade the sector to better serve the growing tourist demand. Dubai has metro and tram lines with the metro lines established in 2009 and covering a length of 74.6 km and the tram line opened in 2014 covering a distance of 10.6 km across the city. Currently, the trams run on three main lines with plans of expanding this figure to seven. The Public Transport Agency (PTA) still provides bus services with an extensive network covering the city of Dubai and its environs. To meet the needs of the tourists who want to travel along the coastal areas, the city set up a ferry transport system. The public transport network are well connected in the city. Overall, Dubai's transport network is expansive and includes both private and public modes helping residents move around the large metropolitan area.

Solutions to Traffic Congestion

The issue of traffic congestion in cities and possible solutions have been the focus of several studies. Researchers like Khalid (2019) looked to some smart ways of reducing accidents on roads that are a major causative reason for long traffic jams. The research was based on a logistics regression method created to forecast injuries. The author proposes utilizing software interventions like smart warnings to drivers when approaching possible black zones. Koźlak and Wach (2018) suggest reducing traffic congestion by reducing the need to travel and the number of passenger cars on the road. The two researchers conducted a case study analysis of Poland to understand the underlying factors causing traffic congestion and possible means of curbing the same. The authors also proposed improving the functioning of public transport as well as investing in expanding infrastructure as the most effective ways of reducing congestion.

Integrated Mobility System

An integrated mobility system has been touted as one of the ways of reducing traffic congestion in major urban areas. Integrated mobility systems allow commuters to access multi-modal transport from one single source. Audouin and Finger (2019) go further to term ICT-supported integrated mobility schemes as the bundling of different transport options for easy access by the commuters to a service that is as competitive and comparable to one using private

cars. The authors conducted a cross-analysis of different jurisdictions to understand the role that authorities play in the integration of mobility systems. The authors noted that a well implemented integrated mobility system reduces the use of private cars by residents and promotes the use of alternate public transportation options. Systems such as smart cards and integrated mobility platforms support the ease of access to interconnected public transport modes. Ortegon-Sanchez and Tyler (2016) also agree with the assertions of Audouin and Finger (2019) on the role that integrated mobility systems can have on reducing the population's dependence on private cars. In their 2016 study, Ortegon-Sanchez and Tyler looked at Panama City and Barranquilla's efforts to upgrade and improve their public bus transport system. The authors noted that expanding the public transport system for the Caribbean port cities would require closer integration for easier commuting by tourists coming into the area.

Integrated mobility systems have also been touted as an important aspect of smart cities. Benovolò et al. (2015) were proponents of technology playing an important role in managing traffic in the smart cities of the future. The study delved into the aspects needed to create a smart city. The authors suggested that issues that have long plagued major urban centers like traffic and road accidents can be tackled by utilizing technology. An integrated mobility system supported by technology will expand options for commuters and reduce some of the long standing social and ecological issues associated with traffic and congestion. Sturari et al. (2016) also advocated for closer integration of technology in finding solutions to mobility challenges in cities across the globe. The researchers looked to propose an infrastructure that would combine mobile and fixed sensors from already existing systems like sensors on traffic lights and GPS information to create a Wireless Sensor Network. The authors believed that the information gathered on travel time and congested segments would help reduce traffic. The research is an illustration of the importance that integrated mobility systems that share real-time data have on tackling the problem of long hours in traffic jams for residents of major cities like Dubai.

Application of Integrated Mobility Systems in Dubai

An integrated mobility system would help reduce the traffic jams witnessed in the city of Dubai. The authorities of Dubai continue to make efforts to turn the metropolitan into a smart city. According to Abouelhamid (2020), the UAE government is committed to implementing an Intelligent Transport System (ITS) that would allow for an increase the compound annual growth rate of the nation by 9% between 2017 and 2023. The government of Dubai, in particular,

intends to invest heavily in the transport sector with intense infrastructure projects expected to increase the issue of traffic congestion. Abouelhamid (2020) goes further to explain that the RTA had approved the introduction and expansion of a Smart Traffic System that would cost just north of \$160 million. The smart traffic system cover in the city will increase from 11% to 60% allowing for better sharing of real-time traffic data, reduce congestion, and follow updated maps of the public transit options available in the city. The role of the RTA in making implementing these measures are supported by Adela (2019) who investigated the contribution of the RTA to the realization of Dubai smart city. The RTA was established with the goal of coordinating and implementing all road and transport development measures. Adela (2019) explored the RTA projects in place that help in realizing the Dubai smart city dream as well as their economic viability. The author noted that the authority had put in place initiatives which increase the importance of information and communication technology in coordinating transport.

The central and local authorities play a critical role in the application of integrating mobility systems as a measure to tackle traffic congestion. According to Audouin and Finger (2019), central governments can act as the ultimate enablers of integrating mobility systems within its borders. National governments provide the vision, political support, financing, as well as legislation and network governance that allows for integrated mobility systems to be set up in cities like Dubai. The authors also noted that city governments also have a role to play involving the setting up of quantitative based vision and goals for such a system. The research condemns local governments that take a laissez-faire approach to managing traffic and implementing smart city projects.

Successful implementation of an integrated mobility system requires that people are incentivized to use public transit instead of private cars. Xiong et al. (2020) recognized that the choice of transport for commuters is influenced by the cost, speed, and convenience. The authors stated that major cities like Dubai should encourage people to choose public transit using both logic and financial incentives. The residents of an area can receive information on the cost-benefit of using public transit over private cars. Increasingly more commuters are drawn to solutions like integrated mobility systems because of the environmental benefits that it poses. Safraz et al. (2015) also recognized the importance of convincing the masses to adopt the use of mass transit in an integrated mobility system. The authors highlight factors such as cost and

environmental protection as strong incentives for the masses to adopt a greener approach to transportation.

Conclusion

The review of literature reveals that plenty of research has been conducted on traffic congestion and an integrated mobility system as a possible solution. Urban areas are growing in size, population, and vehicle density leading to traffic congestion. The traffic congestion causes a myriad of economic, physical, and environmental harm to cities and their residents. Dubai's transport sector also faces the issue of congestion given since rapid expansion after the discovery of oil in 1966. The city has invested in highways, tram lines, metro lines, a bus system, and ferries. Despite the heavy investment in the public transport segment it still accounts for a small portion of the commuter choice. Other studies have proposed possible solutions to congestion with suggestions of incorporating technology and reducing the number of vehicles common in literature. An integrated mobility system is a means of reducing the public's reliance on private cars with its merits discussed by several authors. Research indicates that application of an integrated mobility system in Dubai requires support from both the national and local governments as well as incentives for residents. The literature review, however, revealed that studies on the application of integrated mobility systems in Dubai and the greater Middle East region remains limited presenting an opportunity for filling this gap.

Chapter 3- Project Description

The project will involve thematic analysis of relevant secondary data on integrating mobility systems in Dubai. The project seeks to better understand the concept of integrated mobility systems and how it can be applied in Dubai to help reduce traffic congestion. The city of Dubai is facing a period of unprecedented growth with the population of the Middle Eastern metropolitan rising leading to issues of traffic congestion. The city is a business and tourism hub that is home to millions of locals and foreign expatriates working within its borders. The growth of Dubai is a good case study of the impact that rapid urbanization has on infrastructure and transportation. In 2020, the population of the city stands at approximately 3.4 million residents with the figure expected to rise steadily in the coming years. Dubai is expected to grow at a rate of 10.6% annually with continuing rise in employment opportunities in the city and its growing appeal to tourists from across the globe. All these factors coupled with the high rate of private car ownership in the city it is not surprising that the city residents spend the longest hours in traffic compared to all other parts of the region as the demand of commuters surpasses the capacity of the available infrastructure.

The issue of traffic congestion within the city poses serious risk to the economic, social, and physical wellbeing of the population. Traffic congestion in the city of Dubai leads to economic losses as commuters lose precious man hours in traffic every day. Commuters also spend more on fuel with incessant traffic leading to higher consumption rates. Tourism, which is an important economic activity in the city, is also adversely affected by traffic jams since it reduces mobility and increases frustrations amongst visitors. Socially, traffic jams have a negative impact on commuters since it leads to an increase in levels of aggression and frustration. More accidents are caused in traffic jams as frustrated commuters seek alternative ways of going around particularly bad snarl-ups. The issue is self-compounding since an accident caused will further escalate the traffic jam causing more frustrations amongst road users. Physically, traffic congestions in the city of Dubai and other cities leads to visual, sound, and air pollution. Residents are exposed to increased levels of greenhouse emissions and loud noises that are detrimental to the health of residents. The air pollution in urban areas have been linked to

approximately 400,000 premature deaths each year in Europe as well as long-term respiratory health conditions

Chapter 4 - Project Analysis

The data collected was then thematically analyzed to determine the main ideas that resonated with the objectives of the study. Thematic analysis is a way of analyzing qualitative data from written text to identify patterns and ideas that are prevalent and common (Largan & Morris, 2019). The analysis method involves six processes that the data collected went through before the results were concluded.

The first step was familiarization. This step calls for getting to know the data collected and the information contained in the articles. At this stage, it went through a thorough overview of the data collected and the content of each of the 10 sources selected. Then notes were taken and summaries were concluded of each article.

The next step in thematic analysis was coding. The process of coding involves highlighting phrases and sentences in the articles that are relevant to the overall study objectives and that are repeated in various studies. A shorthand label was then assigned to represent these texts and phrases making it easier to refer back to them. The process has to be thorough with the codes made for the main ideas communicated in the selected sources. At this stage, new codes can be generated while others eliminated. The main codes for the data collected included 'Smart Dubai', 'traffic', 'RTA', 'Integrated Mobility Systems', 'public transport', and 'accidents' among others.

The third step was to generate themes. At this stage, the codes were reviewed to identify patterns present so as to come up with themes. Themes act like an umbrella cover for many codes thus they are broader. The codes that appear irrelevant at this stage are discarded as the data set is condensed to a smaller and more practical themes that can be used to come up with valid outcomes.

The fourth step in the process was reviewing the themes. At this stage, the themes identified have to be looked at again to ensure that they are the correct representation of the data collected. The step involves going back to the source and looking for any vital information that could be missing. Some themes identified earlier were discarded while others were split into two.

The fifth step was defining and naming the themes. The themes from the data collected included: 'Integrated Mobility Systems', 'Traffic and Accidents', 'RTA', and 'Smart Dubai'. Integrated Mobility Services refers to a system of commute where several modes of public transit are connected and can be accessed from a single point. Traffic and accidents is a theme identified in the literature highlighting the role that accidents play in causing congestion in Dubai roads. RTA is the authority in charge of road transport in Dubai and play a critical role in any intended changes. Finally, Smart Dubai refers to the city's future plan of improving the lives of its residents by offering smart solutions to everyday problems. Finally, the sixth step of the thematic analysis process is writing up the results. Each theme is addressed in that section.

4.1 Proposed Dubai Integrated Mobility System

Requirements

The establishment of a Dubai Integrated Mobility System is one where multiple modes of public transport are connected and easily available to commuters from a single access point. Integrating different modes of transport gives commuters flexibility and options beyond the use of private vehicles encouraging more commuters to take up public transport options. The city has the pre-requisite requirements for the successful implementation of an integrated mobility system.

An integrated mobility system is composed on three critical parts: transportation options, mobility hubs, specific infrastructure. The city of Dubai has several public transport options with bus services, several kilometers of metro lines, trams, ferries, bike sharing and car sharing services which can be integrated to allow for better flexibility and mobility for the city's residents and tourists. The city of Dubai also has a ferry system, metro lines, and trams that offers commuters with fast and reliable transportation options in the area. The city's extensive bus network of 1518 vehicles that covers approximately 82% of the urban area is well connected, however, there is a need to further integrate the same with the light rail tram system and the 72.25 kilometer metro to have a truly integrated mobility system (Abouelhamid, 2020). The city also has taxis, limos, car-sharing, and ride-hailing services that can also be integrated into the unified mobility systems. RTA has recently introduced a new mobility system which is bike sharing by Careem that will have access to Dubai's implemented cycle paths and future cycle paths that will cover 524 kilometers by 2022.

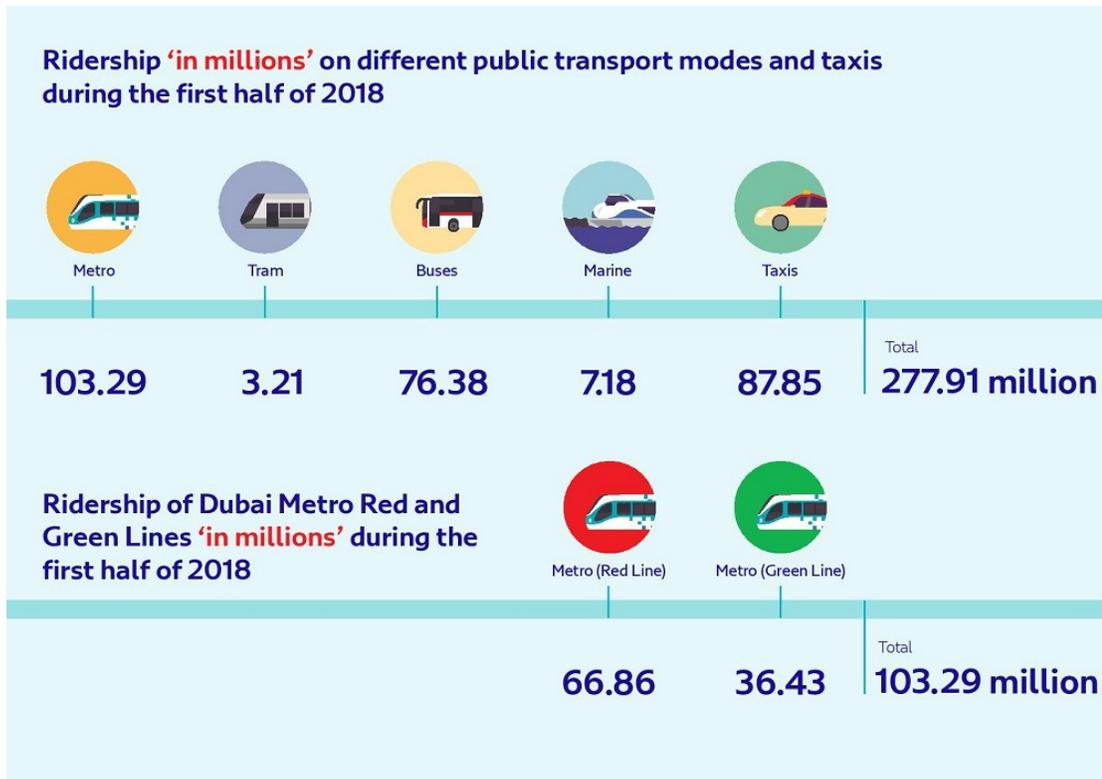


Figure 2: Public transport options and riders in the millions in Dubai (Abouelhamid, 2020)

Dubai also has the infrastructure necessary to create mobility hubs where commuters can access the interconnected transport options such as Al Rashidiya station that has bus and metro station within one station, even taxi ranks are available. A mobility hub requires property set aside and centered on providing a central point of interconnecting the different forms of public transit options available in the city. The city has plans to expand its various bus and tram terminals so that more residents can easily access these services from their homes and places of work.

Finally, an integrated mobility system needs accommodating infrastructure which the city has with an extensive road network that is characterized by very wide roads. Dubai is one of the most infrastructural developed in the globe with heavy investment into the industry from the authorities. The city has steadily increased its road network as well as its overall transport network. Since 2005, the number of public buses plying through the city has increased from 620 to 1,520 in the year 2018. Investment in marine-time services has seen a more concerted effort to explore the transport option. Ferries now transport more daily commuters than ever before. The

city of Dubai has all the three critical factors needed to ensure that an integrated mobility system is not only possible to set up but also ensure that it is successful.

Setting up the Integrated System

With the necessary infrastructure, public transport option, and mobility hubs it is possible for one to set up an integrated mobility system in Dubai. Working with the RTA and third-party providers such as Uber and Careem, an integrated mobility system would bring all these options and make it easily available for the public. The RTA ought to set up a unified, all-in-one platform that would make it easier to offer commuters transactional and informational services on all the different modes of transportation available. The platform should offer the commuter information on the different modes of transport options available and give them the options of seamlessly planning out their trip from their doorstep to their destination.

The system should also offer booking services for taxis and links to third party hail-ride providers like Uber and Careem. The system can be setup in a manner that would allow commuters to safely register for the services, quickly access information on all available modes of transport, and book an intermodal door-to-door trip at the convenience of one's mobile phone or personal computer.

The proposed integrated system would consist of a backend layer that would ensure the integration and management of the different mobility services. The front-end of the integrated mobility system will be Android and iOS applications that are customized according to the specification of the RTA. Dubai can utilize the smart mobility app to further help the integration of mobility systems. The smart mobility apps should be easily available for download so that the residents of the city can access all the transportation options in a single platform. The commuter should have the option of choosing from different transport alternatives like trams, trains, metro lines, buses, or electric bicycle. The smart mobility app is a critical component in the success of integrating mobility systems in Dubai.

Supporting Smart Innovations in Dubai

The study has revealed several technological and smart initiatives currently being used in Dubai that would help improve the integration of mobility systems. One such smart innovation is a smart crossing system that helps manage pedestrian traffic on major roads in the city since walkability is a major aspect that should be taken into consideration. The smart pedestrian signal

is a technology that operates on a system that is triggered by sensors which are connected to a ground optical system. The signals read the pedestrian traffic on the pavement before crossing and monitors the path as they cross the street. The signal is sent to the traffic lights and maintains the indicated signal until all passengers make a smooth transition across the street.

Another technology that is set to play a big role in ensuring integration of mobility systems is smooth and translates into reduced congestion is the Internet of Things (IoT). The Internet-of-Things presents an exciting frontier for the city to integrate its existing mobility options. IoT refers to a network of physical objects that can access the internet. In transportation, IoT can be applied in traffic congestion control systems, the telematics systems in vehicles, and can be used in the reservation and booking systems of transport operators. In the city of Dubai, IoT solutions have been implemented in the form of smart surveillance through the use of intelligent street lights to help monitor traffic congestion along major roads in the city. In an integrated mobility system, IoT can be used to help transport operators create a better reservation system for commuters so that they can access all transport options easily. The technology can also be used by authorities to monitor traffic to reduce congestion and report accidents.

The proposed integrated mobility system in Dubai will also have to deal with Big Data. One of the biggest challenges for smart cities, such as the one Dubai seeks to become, is to process extremely large amounts of complex data from several distributed sources. Big data can be used to gain and process information in real time for solving common challenges (Torre-Bastida et al., 2018). The goal of integrating mobility systems in Dubai can be facilitated by big data. In the city, data can be shared between vehicles and the transport authorities in real time to implement smart traffic management systems to assist drivers reduce accidents and adopt efficient and safe mobility. The information from the buses, trams, ferries, and other forms of transport can be collected in real time and processed to allow authorities the opportunity to make decisions concerning how best to link up these modes and understand which options are best suited for its population.

4.2 Benefits of Integrating Mobility Systems

Reduced Traffic Accidents

Implementing an integrated mobility system in the city of Dubai will help tackle one of the biggest underlying causes of traffic congestion in the city, accidents. The city of Dubai is one of the fastest growing and most populous cities in the Middle East. The city has an extensive road network and a high car ownership rate with one in every two resident owning a personal vehicle. Like many other major cities, the issue of traffic congestion is also rampant in Dubai with major traffic snarl-ups witnessed on major roads during peak rush hours. This study showed that one of the major contributing factors for congestion in the city is the high number of road accidents witnessed on the roads. Road accidents have been reported by the RTA as a major point of concern for the city since it affects a wide section of the population. The traffic congestion caused after a road accident brings about tremendous economic loss to the city, negatively impacts the quality of life of residents, and is harmful to the environment. Having an integrated mobility systems is a smart solution in reducing the number of accidents on the road thereby reducing traffic congestion.

% of Death by Cause, Dubai 2013

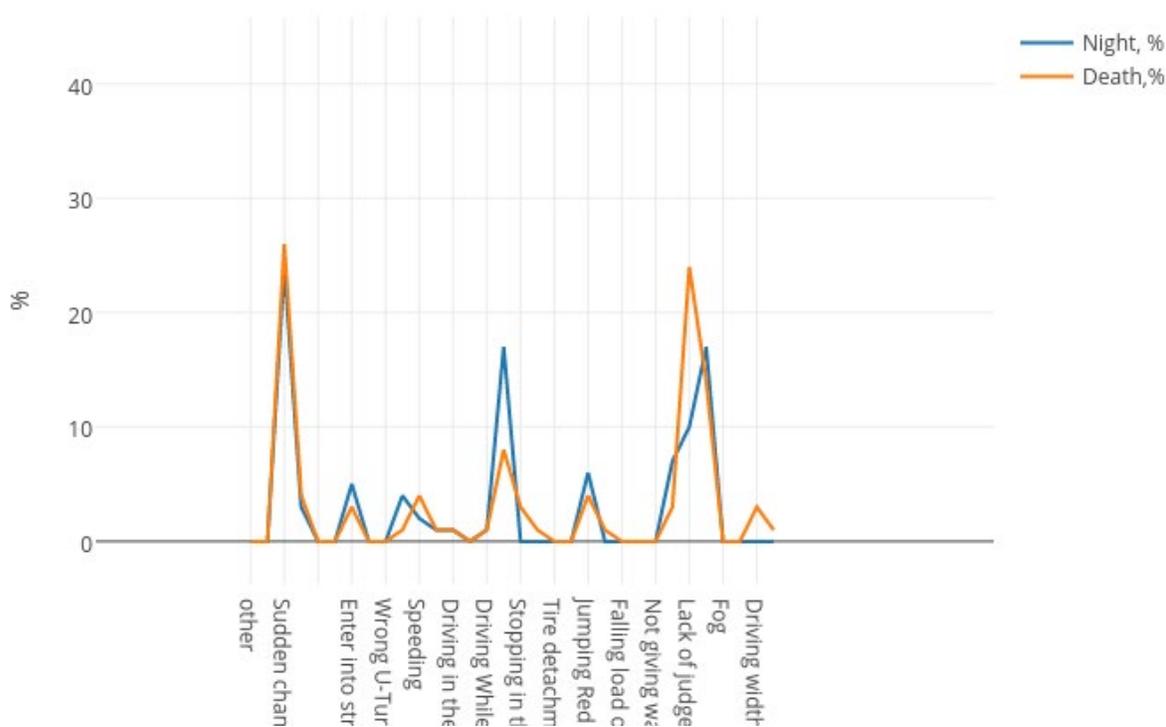


Figure 3: % Death by Cause in road traffic accidents in Dubai from 2013 (Fgill, 2015)

An integrated mobility system can help reduce accidents on Dubai roads by reducing the number of vehicles on the road, providing real-time traffic information, and incorporating smart street signs on the roads. Firstly, an integrated mobility system promotes the use of the interconnected and easily accessible public transport options that are available translating to lower numbers of personal vehicles on the roads. A majority of the accidents on Dubai roads involve private vehicles and so a reduction in their numbers will help reduce accidents. Public transport modes like trams and metro cars have a much lower accident incident rate and buses are driven by professionals who are less likely to get into an accident. Secondly, an integrated mobility solution will help provide commuters with real-time traffic information that informs road users on traffic conditions, roadwork, and accidents thereby helping improve navigation around these hurdles reducing congestion levels. Integrating the mobility system in Dubai will require that commuters can access traffic information via an approved portal or a phone application made available on all mobile platforms. Finally, the menace of accidents and traffic

congestion can be reduced in Dubai in an integrated mobility system that has smart road signs. Smart road signs and electronic boards give immediate traffic information to road users including the state of the road, any lurking dangers, and any accidents that might have occurred. The information not only reduces the chances of accidents occurring but also helps in improving navigation within the city.

Role of RTA

An important player in ensuring that an integrated mobility system is successfully implemented in Dubai is the RTA. The organization is in charge of coordinating the transport network and infrastructure in the city and is tasked with the responsibility of policy formulation and project oversight. RTA is currently in charge of several projects aimed at transforming the transport sector through the incorporation of smart solutions. One of its highlight projects is the expansion of the “Smart Traffic Systems” where the Authority has invested approximately AED 590 million to improve monitoring of accidents, congestions, and give road users real-time information through smart boards on the street. Integrating the mobility system in Dubai, therefore, requires that the RTA continuously invests in smart technology that would ensure that residents receive real-time traffic data, avoid traffic jams, and avail public transport options on a single platform.

Chapter 5 - Conclusion

5.1 Conclusion

The city of Dubai is growing exponentially as a major tourist and commercial hub in the region. Like many other major cities, residents are faced with the issue of traffic congestions that have a negative impact on the social, economic, and ecological well-being of the city. A review of the literature showed that accidents are a major cause of the problem. One possible solution is integrating all mobility systems in a bid to encourage more people to use public transportation. Integrating mobility systems is an extensive process that involves connecting multiple modes of transport and offering them to commuters from a single point. To determine smart solutions that would lead to the integration of mobility systems in Dubai and its effect on reducing traffic, the study thematically analyzed secondary data on the subject matter. The results of the study showed that Dubai had all the factors needed to integrate mobility system. The integration would also offer smart solutions for reducing road accidents that are a major cause of congestion. The process would be facilitated by the RTA and supported by current smart initiatives like ITS that have been initiated under the supports of Smart Dubai. Some of the smart initiatives required to make an integrated mobility system a possibility in the city include IoT, Big data, and Smart Mobility apps.

5.2 Recommendations

The idea of an integrated mobility system holds great potential for the city of Dubai. In collaboration with the RTA, the city should embrace the concept and promote to its wide population. Further research into the economic, social, and environmental impact of an integrated mobility system will shed further light on the topic.

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