JOURNAL OF TECHNO-SOCIAL
ISSN: 2229-8940 e-ISSN: 2600-7940

JTS

Vol. 16 No. 1 (2024) 81-94
https://publisher.uthm.edu.my/ojs/index.php/jts

Managing Road Risk: The Development of Road Infrastructure Toward Liveable City

Farhan Hakimi Mohd Zuhori[1], Mohd Hilmi Izwan Abd Rahim[1]*, Rozlin Zainal[1]

[1] *Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, Johor, MALAYSIA*

*Corresponding Author: hilmiizwan@uthm.edu.my
DOI: https://doi.org/10.30880/jts.2024.16.01.007

Article Info

Received: 6 March 2024
Accepted: 25 June 2024
Available online: 30 June 2024

Keywords

Road infrastructure, road management, road risk, potential road infrastructure

Abstract

A country's economic development and prosperity depend on its cities. This study is conducted due to an effectiveness of road infrastructure are still a key issue that affecting quality of life in urban areas. Traffic jams, accidents and delays not only cause driver frustration and inconvenience, but also have serious economic and environmental impacts. This study attempts to identify the type of road infrastructure, to investigate the risk classification of road infrastructure and to suggest the potential development of road infrastructure in development of rural area. The study focused on the rural development area and this research includes data collection from primary and secondary sources such as interviews. Stakeholders and expert players have been interviewed for this research. The data that we found has been analysis using content analysis which is matrix table. The results of this study have found that there are several issues that exist in implementing of good road infrastructure concept and initiatives and development in rural development area. In conclusion, all respondents gave a positive review on the study and the research shows that good road infrastructure is needed to create our country safer and our cities towards liveable city.

1. Introduction

In the pursuit of creating cities that are not only sustainable but also liveable, the focus often gravitates towards urban centres and their immediate surroundings. However, an integral aspect that is sometimes overlooked is the role of development road infrastructure in shaping the overall liveability of a city. The development and enhancement of road networks in development areas play a pivotal role in fostering connectivity, economic growth, and social cohesion, all of which are essential ingredients in the recipe for a truly liveable city. development road infrastructure serves as the arteries that connect the urban core with its development hinterland. As cities continue to expand and populations grow, the pressure on these development roads intensifies.

Neglecting their development not only hampers access to essential services and opportunities for development residents but also undermines the potential of cities to thrive in a holistic sense. In this discourse, we delve into the critical nexus between the development of road infrastructure in development areas and the aspiration for liveable cities. We examine how strategic investments in development roads can catalyse sustainable urbanization, enhance the quality of life for both urban and development dwellers, and contribute to the creation of inclusive, resilient, and thriving urban landscapes. Through an exploration of best practices, challenges, and opportunities, we aim to shed light on the transformative power of prioritizing development road infrastructure in the journey towards building cities that are not just habitable, but truly liveable for all.

1.1 Research Background

A country's economic development and prosperity depend on its cities. As the increase in the number of populations is directly proportional to the rise in the number of populations, mass transportation occurs when the number of cars exceeds the capacity of the traffic system (Roopa, 2020). This creates traffic jams, especially in metropolitan areas, and even more so during pick hour. Malaysia's transport system is developing rapidly, leading to an increase in travel demand. The Malaysian economy also developed so quickly that most people could afford to buy their own car. Currently, very congested roads with all types of vehicles and passengers traveling at various speeds is the current state of roads in Malaysia. Lack of transportation and parking spaces also exacerbate traffic congestion in Malaysia.

The last source is the transportation infrastructure, which represents the traffic control devices and physical bottlenecks. Moreover, these bottlenecks are responsible for 40% of the overall traffic congestion, followed by traffic incidents, such as vehicles accidents with 25%, bad weather conditions with 15%, work zones with 10%, and poor traffic signal timing and special events with 5% each one. Another explanation for the incidence of traffic jams in Malaysia is the rise in disposable income and weak maintenance of the public transport infrastructure, the increase in the volume of cars and the funding for various conflicting policy steps (Kasipillai & Chan, 2008). This research aims to identify the proportion of the main factors contributing to traffic congestion and to identify the significance of the impact of traffic congestion in development road users, society and the economy, the roads of development area towards liveable city.

1.2 Problem Statements

Despite ongoing efforts to enhance traffic management, numerous cities are grappling with the challenges posed by population growth and the escalating use of vehicles. The rapid economic and population expansion in the development area, has given rise to various urban transport issues, including a surge in private car ownership, heavy traffic volumes, user dissatisfaction with public transport services, and limited parking spaces (Mukhtarah, 2009). Between 2015 and 2020, a total of 405 traffic accidents were recorded along the FT050 route (Batu Pahat-Ayer Hitam-Kluang), with 227 of them being fatal. This route, connecting Parit Raja to the Ayer Hitam toll station, is identified as the busiest road, especially during festive periods (Fadillah Yusof, 2021). A traffic survey in 2020 revealed a substantial volume of 28,298 registered vehicles within 16 hours, with 2,279 vehicles recorded during peak hours (5pm to 6pm) in Batu Pahat.

This data underscores a pressing concern regarding the maximum traffic capacity on this route. To address the traffic challenges in the development area, a comprehensive set of solutions is needed. Firstly, a focus on enhancing public transport services, including new routes and modes, can provide residents with viable alternatives to private car ownership. Intelligent traffic management systems and the optimization of traffic flow through technologies like smart traffic lights can alleviate congestion along key routes. Developing additional parking infrastructure and promoting sustainable transportation options, such as bicycles and electric scooters, can contribute to reducing reliance on private vehicles. Integrating advanced technologies for traffic management and prioritizing safety measures along accident-prone areas can contribute to a comprehensive solution. The implementation of these strategies requires a coordinated effort from local authorities, transportation agencies, and the community to create a more efficient and sustainable urban transport system in the region.

1.3 Research Questions

This section includes research questions of the study.

i. What is type road infrastructure in rural development area?
ii. What are the risk classifications of road infrastructure in rural development area?
iii. What is the improvement of road infrastructure in rural development area?

1.4 Research Objective

This section includes research objectives of the study.

i. To identify the type of road infrastructure in rural development area.
ii. To investigate the risk classifications of road infrastructure in rural development area towards liveable city.
iii. To suggest the potential development of road infrastructure in rural development area towards liveable city.

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

1.5 Significant of The Research

This research aims to benefit and provide references to the parties such as contractor. This study helps contractors find the potential and possible risks that come with road development systems. By knowing how people act, how they move around, and what risks are involved, contractor can put in place the right safety measures and protocols to keep accidents and injuries to a minimum. This study can be used to make sure that road management system can be maintain in order towards liveable city. Additionally, this research will be able to contribute to the existing body of knowledge in disciplines such as transportation engineering, human factors, psychology, and ergonomics because of this study. Researchers can generate new insights, theories, and empirical evidence by investigating escalator usage patterns, passenger behaviour, and safety considerations. This adds to the academic discourse and advances our understanding of escalator dynamics.

2. Development of Road Infrastructure Towards Liveable City

The development of road infrastructure towards creating a livable city involves a comprehensive approach to planning, designing, constructing, and maintaining road networks with the goal of enhancing the quality of urban life. Here's a breakdown of the key components and considerations involved city related discussed in this section.

2.1 The Definition of Road Infrastructure

According to Choy Peng Ng (2019), road infrastructure plays a crucial role by providing mobility for the efficient movements of people, goods and services as well as providing accessibility to land and a wide variety of commercial and social activities. It refers to a system of roads, highways, bridges, tunnels, and related structures that facilitate the movement of people, goods, and services within and between regions. The quality and efficiency of road infrastructure has a significant impact on transportation, economic growth, social connectivity, and overall quality of life. The goal of any development of road infrastructure is to ensure that roads are well maintained, operated efficiently, and safe for all users.

2.2 Type of Road

There is an increasing focus on integrating advanced technologies such as geographic information systems (GIS), global positioning systems (GPS), remote sensing, and data analytics. These technologies provide enhanced capabilities in data collection, asset management, condition assessment and maintenance decisions. These enable real-time monitoring, spatial analysis, and predictive modelling to improve efficiency, cost-effectiveness, and enable informed decision-making.

2.2.1 Geographic Information System (GIS)

GIS integrates various data sources such as maps, satellite imagery, aerial photographs, and tabular data to create a comprehensive, interactive representation of the earth's surface. Mansourian (2006) proposes a Geographic Information System tool which is web-based system in an SDI (Spatial Data Infrastructure) framework for reliable information collection and sharing. GIS technology enables structured storage and organization of geospatial data, enabling efficient data retrieval and manipulation. It provides a platform for spatial analysis, allowing users to perform tasks such as proximity analysis, overlaying multiple layers of data, and modelling spatial relationships. This capability is particularly valuable in areas such as urban planning, environmental management, transportation, and emergency response.

2.2.2 Global Positioning System (PSS)

The Global Positioning System, or (GPS), is a satellite-based navigation system that provides position and time information anywhere on Earth. GPS technology uses a network of satellites orbiting the earth to determine the precise location of a GPS receiver. A GPS receiver receives signals from multiple satellites in a GPS constellation. According to Maria Castro (2006) the usage of GPS for obtaining geographic information of highways has been carried out with different aims. By calculating the duration that it takes the signal to reach the receiver and the known positions of the satellites, a GPS receiver can accurately determine its own position in terms of latitude, longitude, and altitude. According to Elumalai, (2014) the use of GPS in the transport sector is used to collect data for making maps for highway navigation systems. GPS is also used for emergency response and disaster management. This enables fast and accurate location determination, facilitating route planning for search and rescue operations, disaster relief operations and emergency vehicles.

2.2.3 Road Maintenance

Road management systems use various maintenance strategies such as corrective maintenance, preventive maintenance, and predictive maintenance. According to Richard Wong from the Institution of Engineers Malaysia said road maintenance is essential because it can preserve road, protect adjacent resources and user, and provide convenient travel along the route.

2.2.3 Traffic Management

Traffic management plays a vital role in road management systems as it involves strategies, techniques, and technologies aimed at optimizing traffic flow, improving safety, and enhancing the overall efficiency of road networks. According to Code of Practice (2008) it encompasses a range of activities and measures to monitor, control, and manage traffic conditions. During road development, traffic engineers analyse traffic patterns, conduct traffic impact studies, and consider future growth projections to design roads and intersections that can efficiently handle expected traffic volumes.

2.3 Liveable City

According to United Nations, nearly 60 per cent of the world's population will live in city by 2030. Today, half of the world's population of 3.5 billion people are living in cities. To date, there are 21 megacities in the world with population size of over 10 million in each". "In Asia alone, there are currently 12 megacities." (United Nations, 2012). A liveable city is one that offers its residents a high quality of life and has a variety of factors that contribute to their overall well-being and well-being. These cities put the needs and desires of their residents first and strive to create a sustainable, inclusive, and welcoming environment. Achieving quality of life requires a holistic approach that considers multiple dimensions, including infrastructure, social services, environmental commitment, and cultural opportunities.

A liveable city depends first on good infrastructure. Liveability owns these characteristics of amenity and the other features of the built environment such as the arrangement, design and construction of dwellings and other buildings, public transport systems, road networks and public spaces, walkability and accessibility to goods and services, and high qualities communication technology (Major Cities Unit, 2012). These include efficient transportation systems, well-developed roads, and reliable public services. A city with good public transport reduces congestion, air pollution and commuting times, resulting in a better quality of life for its residents. Additionally, access to quality medical facilities, schools, and recreational spaces is essential for a liveable city.

2.3.1 Liveable City in Malaysia

Malaysia has made great strides in creating liveable cities that prioritize the well-being and quality of life of its residents. Several cities like Malaysia's capital, Kuala Lumpur, is a mix of modern infrastructure and cultural heritage. Public transportation such as LRT, MRT, and monorail is well□equipped, and commuting is smooth. The city has green spaces such as his KLCC Park and Lake Gardens that provide recreational opportunities. With diverse housing options, first-class medical facilities, and a vibrant arts and cultural scene, Kuala Lumpur offers a high quality of life. According to the Malaysian Physical Plan (2002), the highest energy consumption in Malaysia comes from transportation and industrial sectors (which is 40%) while the other sectors remain stagnant between 0 to 10 %.

This clearly shows that Malaysian cities are far away from having a sustainable environment as both transportation and industries are the biggest contributors towards low quality environment in the urban area. According to the Malaysian Automotive Association (2010), the total number of registered vehicles had increased by 63% from year 2000 until 2009. Besides, according to Shuhana Shamsuddin (2012), "Kuala Lumpur is best known for its tourist attractions, and it is a vital to enhance its appearance and image as a liveable city (suitable place to live)". Kuala Lumpur underwent a major urban transformation in the 1990s and early 2000s, with a focus on infrastructure improvements such as the construction of highways, public transport, and famous landmarks such as the Petronas Twin Towers.

2.4 Current Road Risk in Development Area

According to Analysis of Road Infrastructural development area in Malaysia stated that road design standards made about five main aspects namely functionality, economy, safety, comfort, and aesthetic. Road infrastructure standard and elements in development area can be define such as geometry of road, traffic signs, pavement parking, street lighting, width and road shoulder, road barriers and traffic signal is the current road conditions. Road risk in road infrastructure refers to potential hazards and challenges arising from the construction, maintenance, and use of roads. According to Khairul Amri (2018), the road accident usually caused by combination of five factors which is behaviour of driver, infrastructure of road quality, traffic volume and the environment. These risks can affect the safety of drivers, passengers, pedestrians, and worker.

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

2.4.1 Safety Risk

Safety risk can come from inadequate road design, intersection and junction safety or poor visible lighting. Improper road design can cause safety problems. These include inadequate lane widths, inadequate hard shoulders, lack of clear line of sight, inadequate curve radii, inadequate signs and lane markings. Such design flaws can increase the chances of accidents and make it difficult for drivers to drive safely. According to Tsui (2009), Malaysian system needs improvement in the circumstances of injuries must be addressed. According to Nantulya and Reich (2004), road injury and fatality rates demonstrate significant variations with different level. Safety hazards in road infrastructure refer to potential hazards and risks that may threaten the safety of road users, including motorists, pedestrians, cyclists, and other vulnerable populations.

According to example of analysis of road infrastructural along area of rural development area in Malaysia case study in year of 2016 stated that road design standards made about five main aspects namely functionality, economy, safety, comfort, and aesthetic." Road infrastructure standard and elements in area of study are geometry of road, traffic signs, pavement parking, street lighting, width and road shoulder, road barriers and traffic signal is the type of road conditions in rural development area. However, the risk analysis found that around example of case study area have multiple of risk priority. Figure shows the classification level of risk priority in example of case study area as in Figure 1.

No.	Location	Risk classification		
		Low	Medium	High
1	KM17			
2	KM 10, 13-16,18-20,23,24			
3	KM11,12,21,23			

Fig. 1 *Classification level of risk priority based on location in example preliminary study rural development area*

2.5 Proper Road Infrastructure

According to Shuhana Shamsuddin (2012), urban centres operate as vital hubs for economic activities and employment prospects, drawing citizens in search of new opportunities and a better life. Nevertheless, a city's allure extends beyond professional pursuits. It necessitates the provision of appealing residential areas, as well as vibrant entertainment options, to enhance its attractiveness and stimulate economic growth. Some measures have been taken so the condition road to be maintain at good condition to make development area towards liveable city. To assess the proper road management in development area, evaluation is needed to find out the effectiveness of traffic management measures such as traffic signal synchronization, intelligent transportation systems (ITS), and incident management protocols. This method to analyse data on traffic accidents, response times and signal performance to identify opportunities for improvement.

2.6 The Potential of Road Infrastructure in Development Area

Road upgrades improve accessibility, safety, and sustainability and play an important role in making cities liveable. According to Anastasios (2010) include prediction of pavement performance and maintenance, road improvement effects, user costs and benefits, estimates of environmental effects, standard economic indicator. The development of road management systems has the potential to improve the efficiency, safety, and sustainability of transportation systems. By collecting and organizing data, road management systems can identify areas that need improvement and make decisions that help reduce congestion, improve air quality, and make roads safer for everyone.

2.6.1 Integrated Transportation Network

An integrated transportation network enables seamless movement of people and goods between different modes of transportation. This can be achieved through various methods such as coordinated schedules. Different modes of transportation must be coordinated so that passengers can easily transfer without long waiting times. According Toward an Asian Integrated Transport Network (2007), Integrated intermodal transport has been a major policy issue of concern to the governments in Europe and North America for the past

two decades. A unified transport network emphasizes seamless connectivity between different transport modes. This includes ensuring convenient travel between buses, trains, trams, and other forms of public transport, and integrating pedestrian and bicycles infrastructure into transportation hubs. According to Othman and Ali (2020) by facilitating smooth travel, residents are encouraged to use multiple modes of transportation for their trips.

2.6.2 Pedestrian and Cyclist Friendly

Pedestrian and bicycle friendly infrastructure is a key building block for making cities worth living in. By prioritizing the needs and safety of pedestrians and cyclists, cities can foster active traffic, improve accessibility, and create a more sustainable and vibrant urban environment. According to Mohd (2019), "The cycling-friendly environment in residential neighbourhood area in Malaysia needs to investigate for the future betterment of living". When creating a complete roadway, the roadway should be designed with all users in mind, including pedestrians, cyclists, and motorists. Additionally, improving safety at intersections is crucial for pedestrian and bicycle friendly infrastructure. According to MIROS research report (2021), The use of this facility has been controversial as proven in many studies worldwide were depending on the design, the risk of crashes can be lower or higher. Introducing features such as signalized intersections, pedestrian countdown timers, bike boxes and elevated intersections improve visibility, provide clear concessions, and reduce the risk of collisions.

2.6.3 Smart Integration Technology

Smart technology integration can play a vital role in creating a liveable city. A liveable city is one that provides a high quality of life to its residents. According to Musa (2020), "Dynamic Traffic Signal Control System (DTSC) employs sensors and cameras to observe and track vehicles along the road that approaches the intersection". According to Harun Sazali Ismail (2019), "these technologies are already revolutionizing the way we live, and work and they can equally well revolutionize the way that we travel". Many such technologies have been developed to enhance vehicle safety, to prevent crashes, reduce trauma during a crash or to reduce trauma following a crash and used in mitigating traffic congestion. Overall, the integration of smart technology into a city can have a significant impact on the quality of life for its residents. By reducing traffic congestion, improving public safety and security, and improving access to public services, smart technology can help to create a more liveable city.

3. Research Methodology

The methodology delves into the comprehensive framework guiding the study from its inception to its culmination. The methodology serves as the research design meticulously implemented throughout the entirety of this study. Bolch's Other Methodology is elucidated as a guiding and accurate framework employed consistently during the research process (Mohamed, 2006). Furthermore, this section outlines the methodology employed for data and information collection in this study. It expounds on the data compilation process, with a subsequent discussion on data analysis reserved for the following chapter. The focal points in this methodology chapter encompass the study design, study area, study method, and the instruments employed in the study.

According to Creswell and Poth (2017), qualitative methods strive to understand and evaluate subjective thoughts, behaviours, attitudes, and ways of making decisions. They try to get at the meanings and experiences that people give to their own thoughts and deeds. This method lets researchers include a lot of different thoughts and points of view, not just facts about what, where, and when. It tries to find out why and how people make decisions in order to learn more about the basic reasons and processes. This study uses a qualitative methodology to collect information from stakeholders involves in an infrastructure maintenance. This methodology is used by maintenance companies to analyse and identify problems encountered to ensure that all equipment is functioning optimally. Interviews were chosen as the data collection method in this study based on their ability to comprehensively explore and understand participants' perspectives, encounters, and perceptions. Interviews provide an opportunity to ask open-ended questions, address more detailed answers, and clarify uncertainties and discrepancies. In addition, interviews have the potential to adapt research strategies to respondent responses, allowing for a more flexible and dynamic exchange of information. Interviews are generally chosen as a means of thoroughly examining the research topic from the participant's perspective.

The research utilizes interviews as the primary method for data collection. Interviews, characterized by face-to-face communication between the researcher and the participant, serve as an inquiry strategy aimed at achieving a thorough exploration and understanding of the participant's perspectives, experiences, and perceptions. This method enables the researcher to gather comprehensive and nuanced data by posing open-ended questions and engaging in interactive discussions. Through the interview process, researchers can accumulate detailed and rich information by encouraging participants to express themselves openly. The use of open-ended questions facilitates a more profound exploration, allowing the researcher to pursue clarification, uncover essential motivations, and delve into underlying meanings. Interviews offer a unique avenue for

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

capturing subtle details, emotional responses, and personal interpretations, aspects that may prove challenging to elicit through alternative methods of data collection. The interactive nature of interviews fosters a dynamic exchange of information, providing a deeper insight into the participant's perspective and contributing to a more comprehensive understanding of the research topic.

Finally, the method of efficiently changing natural information into important experiences is known as information investigation. The method involves scrutinizing, categorizing, organizing, and deducing bits of knowledge from the amassed data. Through the utilization of differing explanatory strategies and strategies, researchers are competent of identifying designs, relationships, and inclinations inside the accumulated information. In this study, the data analysis is using content analysis which is matrix table. The essential objective of information examination is to infer critical and dependable deductions that cater to the inquire about targets or theories. The details of research methodology process discussed in Figure 2.

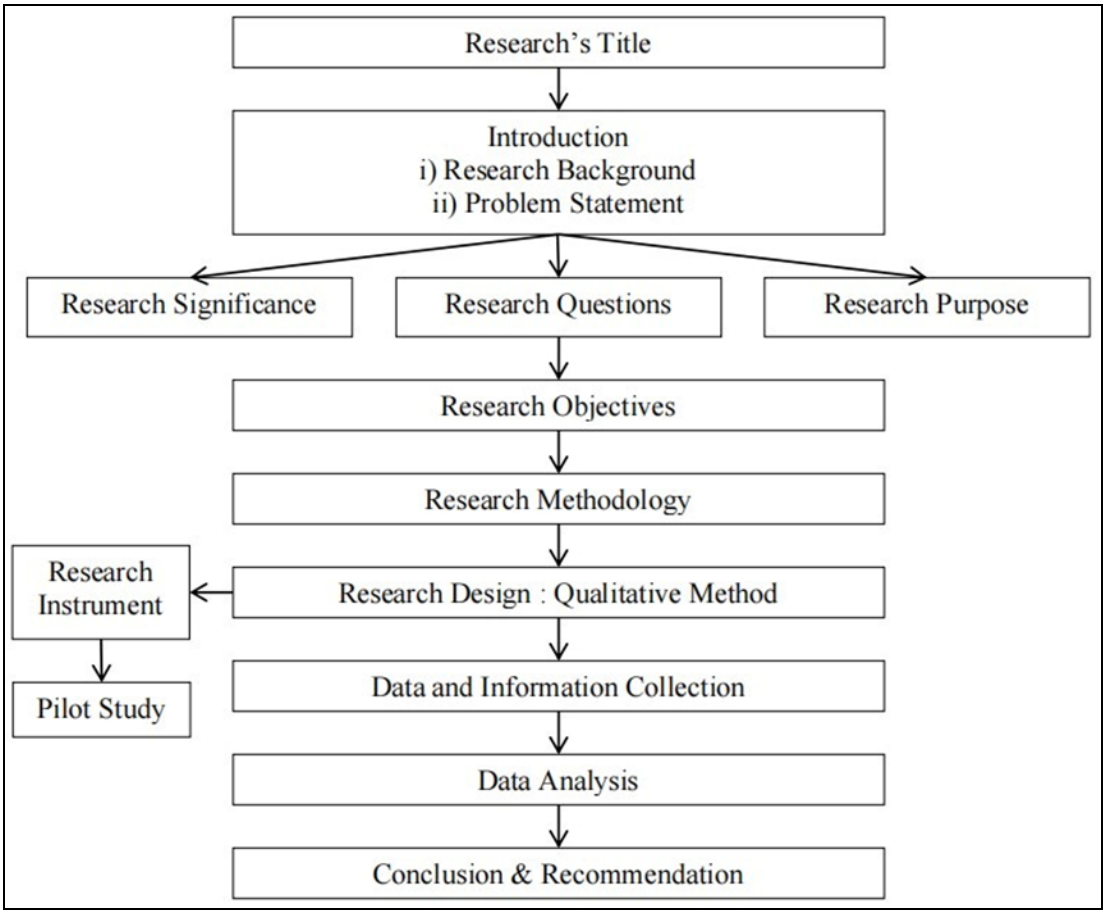

Fig. 2 *Process research methodology*

4. Data Analysis and Discussion

This section explains the data analysis and the results obtained based on the research methods used to achieve the three objectives of the study. This study was conducted using a semi-structured interview method to collect relevant data and information based on selected respondents. Each interview question answered by the respondent will be used as data, the information obtained will be analysed by content analysis using matrix table to get the expected analysis results. The answers to the questions obtained from the respondents were used as data for this study and analysed using appropriate analytical methods.

4.1 Respondent Details

The researcher discovered that the respondent's history is crucial to the study while using the interview method to conduct an interview. It is regarded as significant while doing research through interviews since its goal is to guarantee that all information collected by the researcher comes from participants who can provide insightful replies to each question posed. The degree of knowledge and experience possessed by the responders determines how successful this is. Through this interview, 5 respondents have been identified to collect data and achieved the objectives of this study. The information about the respondent's background is obtained as shown in Table 1.

Table 1 *Respondent details*

Number of Respondent	Position	Experience
Respondent 1 (R1)	Civil Engineer J44	16 Years
Respondent 2 (R2)	Engineer	10 Years
Respondent 3 (R3)	Assistant Engineer	20 Years
Respondent 4 (R4)	Engineer	5 Years
Respondent 5 (R5)	Engineer	5 Years

It is evident from this data that every respondent has over five years of experience working in the construction industry, particularly in the road sector. Respondents extensive job experience allows them to respond to questions clearly and concisely. The respondents also described the expertise and understanding they had acquired while working on road construction projects.

4.2 Data Analysis

Based on the results of the interviews conducted by the researcher, the interview participants developed a few questions and information related to the research topic. The information obtained is to determine the objectives of the study which are to identify the current road infrastructure in development area, investigate the infrastructure risks in development od rural area and propose the potential for infrastructure development of road level in development rural area towards a liveable city.

4.3 Type of Road Infrastructure

Table 2 *Project planning and design*

No	N =5	Type	Respondent
1	5	Rural 5	R1, R2, R3, R4, R5
2	3	Widen Road	R1, R2, R3
3	**2**	Regular Maintenance	R4, R5

4.3.1 Rural Type 5

There are few types of roads that follow the specifications that JKR has adopted. According to all respondents, which is R1to R5. All respondents mentioned that as.

… "*The rural highway standards that the Malaysian Public Works Department (JKR) adopted apply to federal roads in Malaysia. These standards range from Rural 1 with no access control and low speed limits, to Rural 5, which are federal roads or highways with limited access control and speed limits up to 90 km/h. Only high-speed (up to 110 km/h) motorways with complete access control are permitted to use the Rural 6 standard*" …(R2)

Additionally, respondents specified that some of the area of in progress development is still in Rural 5. R1-R5 said that:

… "*Road width, median and shoulders varies according to Rural 1-Rural 5 types and KM10-KM24 is still in Rural 5 level*" … (R4)

Table 3 *Types of rural road*

Standard	Max Design Speed Limit (Km/h)	Minimum Lane Width (m)	Access Control	Application
JKR R6	110	3.5	Full	Expressways under the administration ofMalaysian Highway Authority (MHA)

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

JKR R5	100	3.5	Partial	Roads and partial access highways for the Federal JKR
JKR R4	90	3.25	Partial	Main / secondary roads
JKR R3	70	3.0	None	Secondary roads
JKR R2	60	2.75	None	Minor roads
JKR R1	40	5.0/4.5*	None	Single-lane minor roads (country lane)

4.3.2 Widen Road

Findings from the interview revealed that current methods applied in current infrastructure are maintain the roads. Maintain the road, which scored the highest frequency of 2, are most applied in current infrastructure in development area. Respondents 4 and 5 said that:

"… *Rural development has been maintaining according to the reports regarding potholes or pavements or any emergency maintenances that has been made from the publics. Besides, as we received the instructions or order from Jabatan Kerja Raya or local authority, we will act as fast as we could to make sure the road is safe and can be used for the publics…" (*R5)

4.3.3 Regular Maintenance

However, R1 to R3 say that:

… "*Area of development roads has been widened due to high loading of traffic to prevent further fatal accidents on the federal road".* But R4 and R5 said that *"the road is especially from development infrastructure has been maintain to avoid poor rod conditions during any rainy seasons, traffic congestions and road accidents like potholes or cracks" …* (R5)

Strong, smooth, rough, affordable, and adhering to hygienic and sanitary standards are all required of road pavement. These attributes are contingent upon the nature and composition of the pavement, traffic density and velocity, the importance of the road, and the building materials employed. Pavement's strength, smoothness, and roughness are its three most crucial qualities. Insufficient pavement strength leads to rutting or even breaching and a significant increase in rolling resistance.

4.3.4 Discussion Type of Road Infrastructure

The road's characteristics is that it is planned to widen the road and add a road divider. The plan calls for expanding routes, installing bike and pedestrian lanes, upgrading the traffic network management system, and maintaining roads that are overseen by stake holders. Next, the completion time for road infrastructure projects depends on the type of land ownership. Projects on government land are expected to take 3-4 years, while those on public-owned land may take 5 years or more. This highlights the importance of considering land ownership in project planning and execution According to the study, lane and shoulder widths are important elements that contribute to safer roads. It is emphasised that appropriate road classification is necessary to guarantee that roads are built to accommodate traffic volumes and speeds, which helps to promote effective traffic flow.

Different Rural 1-Rural 5 types have different considerations for road width, and budgetary restrictions demand cost-effective design, construction, and maintenance solutions. Furthermore, different road types require different approaches to road maintenance, such as those with flexible or rigid pavement. The research highlights rural development road infrastructure's conformity to Malaysian Public Works Department (JKR) standards. In particular, roads in development are classified as being in the Rural 5 standard's application area. Road maintenance is currently in progress area of development primary means of maintaining its infrastructure. It handles problems like potholes, pavements, and emergency maintenance in accordance with stakeholders reports and directives.

4.4 The Risk Classifications of Road Infrastructure

This section discusses related to risk classification of Road infrastructure for development in rural area.

Table 4 *Risk of road infrastructure*

No	N=5	Risk	Respondent
1	5	Climate Change	R1, R2, R3, R4, R5

2	5	Traffic Congestion	R1, R2, R3, R4, R5
3	5	Cybersecurity Threats	R1, R2, R3, R4, R5

4.4.1 Climate Change

Based on the interviews conducted, all five respondents stated that environmental factors like rainy days can lead to road infrastructure risks.

… "Persistently rainy weather can harm roads and increase the danger of road infrastructure." … (R4)

… "This area has a tropical climate, which is characteristic of its climate. Even in the driest month, there is a lot of rain in this area, so it contributes to risk of accident and damage of road infrastructure…". (R2)

… "Climate change and rising temperatures are currently having a major impact on urban areas and are becoming more serious as 10 tonnes of CO2 is produced per 0.4 hectares of built-up area" … (R1)

4.4.2 Traffic Congestion

Every respondent R1, R2, R3, R4, and R5 agreed that:

.. "Stop-and-go traffic is a common consequence of traffic congestion, which exacerbates deterioration of the road surface. The lifespan of the road may be shortened as a result of potholes, cracks, and other types of pavement deterioration.". (R5)

Besides, the efficient operation of traffic management systems can be hampered by congestion, which makes it more challenging for law enforcement to react quickly to emergencies or incidents. This decreased operational effectiveness may have an effect on the general road infrastructure's safety and functionality. Traffic congestion also raises the risk of accidents, which can lead to infrastructure damage on the roads. Parts of the road may need to be rebuilt or repaired after a collision, especially if heavy machinery is involved. The volume of traffics that exceed the capacity of road infrastructure, it can lead to overloading the load thus will put additional stress on the road potentially caused the need for more frequent of maintenance.

4.4.3 Cybersecurity Threats

All respondent R1, R2, R3, R4, R5 said that that:

… "ITS technology not fully implemented in this area, so the risk of road infrastructure get from this technology are not discover yet" … (R3)

Only the camera is installed at traffic light that use to monitor the traffic flow and determine traffic light timing. But the respondent R1 said that:

… "The incorporation of cutting-edge technologies, including control systems, communication networks, and sensors, exposes road infrastructure to cybersecurity risks" … (R1).

Cybercriminals might be able to take advantage of weaknesses in ITS components, which could cause problems with data integrity, vehicle control systems, or traffic management. Besides, road infrastructure will be more susceptible to system malfunctions or failures as it becomes more dependent on ITS technologies. The management of transportation, signal control, and traffic flow could all be impacted if these technologies failed.

4.4.1 Discussion on Risk Classification

The study aims to identify and comprehend the risks related to road infrastructure through a thorough examination of environmental factors, urbanisation, population growth, technology-related risks. Regarding environmental factors, the respondents draw attention to how vulnerable road infrastructure is to variations in climate patterns, elevated temperatures, heavy precipitation, and exposure to both hot and cold weather. These components add to general instability, expansion and contraction of the pavement, and wear and tear. Tropical climate, which is marked by intense heat waves and constant rain, presents unique difficulties for the longevity of road infrastructure. Rapid urbanisation, an increase in the number of vehicles, and increased traffic congestion are all correlated, according to the study. The preference for private automobiles over public

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

transport exacerbates traffic problems, putting existing road networks under stress and raising the possibility of accidents and other safety hazards. Furthermore, population growth might surpass the rate at which road infrastructure develops, leaving roads with insufficient capacity.

There are new risks associated with the integration of modern technology into road infrastructure, especially in cybersecurity. Concerns raised by respondents include the possibility of traffic flow disruption, data leaks from inadequate encryption, traffic flow manipulation, and cybersecurity risks to intelligent transportation systems (ITS). According to the study, road infrastructure is becoming more and more dependent on technology, which puts data integrity at risk, interferes with traffic management systems, and endangers people's safety. There is a discussion of the difficulties road infrastructure faces, including poor maintenance, traffic congestion, and safety concerns. The increasing number of vehicles on the road, which exacerbates traffic, must be addressed. Additionally, the effects of increasing urbanisation must be managed, and frequent maintenance must be emphasised to stop road deterioration. In the future, the study found that the road infrastructure developing through the integration of multiple public transport modes, the application of smart technologies, and the design of roads that can accommodate a wide range of users. Intelligent Transport Systems (ITS) have the potential to improve road safety, facilitate smoother traffic flow, increase the effectiveness of transit services, and have a positive environmental impact. Notwithstanding, it is acknowledged that there are obstacles to be overcome in the implementation of smart road technology, including budgetary constraints and financial considerations.

4.5 The Potential of Road Infrastructure

Table 5 *The potential of road infrastructure*

No	N =5	Potential	Respondent
1	5	Careful Planning	R1, R2, R3, R4, R5
2	5	Smooth traffic	R1, R2, R3, R4, R5
3	5	Crosswalks, pedestrian walks, bikes lanes	R1, R2, R3, R4, R5

4.5.1 Planning

An efficient road network makes it easier to move goods throughout the nations and can improve a better mobility. A strong road network guarantees that people living in rural and urban areas have equal access to jobs, education, and other necessities. All respondent R1, R2, R3, R4, R5 stated that:

… "in order to successfully identify road infrastructure potential and implement intelligent transportation systems (ITS) and smart technology into any infrastructure, including road systems, careful planning is essential…" (R1)

It serves as the basis for resource allocation and includes budget planning to ensure funding for deployment, maintenance, and future upgrades. In addition, the plan addresses the complexity of technology integration by focusing on interoperability and standardization to enable seamless communication between different components. Robust security measures, including cybersecurity planning and data protection considerations, are an essential part of any effective plan to protect intelligent infrastructure. Respondent 1 said that:

… "proper planning requires a comprehensive approach that takes into account various aspects of development, ensuring harmonious and balanced progress" … (R1)

This includes judicious allocation of financial resources not only for immediate infrastructure projects, but also for long-term economic sustainability and the development of a skilled workforce through education and training initiatives. The road map for prospective development is careful planning.

4.5.2 Smooth Traffic

Respondent R1, R2, R3, R4, R5 supported by said that:

… "potential ITS and smart technology have become ground-breaking options that could greatly reduce traffic jams and improve traffic management in general" … (R1, R2, R3, R4, R5).

These systems make use of cutting-edge technologies like sensors, cameras, and communication networks to collect data in real-time. Traffic signal timings can be dynamically adjusted, and congestion hotspots can be quickly identified by authorities thanks to the continuous traffic condition monitoring provided by ITS. By optimising traffic flow at intersections, this adaptive approach reduces congestion. By integrating with navigation software, ITS gives drivers access to real-time data on traffic patterns and alternate routes. Furthermore, the establishment of centralised traffic management centres is greatly aided by smart technology. These facilities act as command centres from which operators can oversee and manage message signs, traffic signals, and incident response in real time. By discouraging needless travel during peak hours, this strategy efficiently manages demand and eases congestion. ITS and smart technology are beneficial because they can transform traffic monitoring, management, and navigation, leading to a more responsive and efficient transportation ecosystem that helps tackle urban congestion issues.

4.5.3 The Implementation of Crosswalks, Pedestrian Walks and Bike Lanes

When evaluating the potential of road infrastructure, the presence of bike lanes, pedestrian walkways, and crosswalks is crucial as it plays a major role in creating a liveable city. Urban planning places a high priority on the safety and accessibility of all users of the roads, and these elements are essential to creating a more sustainable and inclusive urban environment. All respondent supported by stated that:

… "crosswalks offer spaces set aside for pedestrians to crossroads safely, reducing the chance of collisions and improving mobility" … (R1, R2, R3, R4, R5)

Sidewalks and pedestrian walks make a city more walkable, encourage physical activity, improve public health, and create lively urban areas. Next, adding bike lanes acknowledges the expanding significance of environmentally friendly and sustainable forms of transportation. Respondent 3 said that:

… "*bike lanes decrease dependency on conventional motorised transportation by encouraging healthier and alternative modes of transportation in addition to providing a designated area for cyclists" … (R3)*

This fits with environmentally and health-conscious urban planning strategies in addition to helping to lessen traffic congestion towards liveable city. An urban area can be considered liveable if it has well-planned bike lanes, pedestrian pathways, and crosswalks. Encouraging environments that put residents' health and quality of life first is key to making a city liveable. This vision is complemented by the creation of safe and convenient areas for bicyclists and pedestrians, which improve the urban environment overall and promote a feeling of community. However, all this potential need to clear the variety of obstacles that must be overcome for road infrastructure to reach its full potential. All respondent R1, R2, R3, R4, R5 said that:

"The problem of financial limitations is the most pressing of these difficulties" … (R1, R2, R3, R4, R5)

The substantial initial outlay needed to implement smart technology, along with continuous maintenance expenses, creates financial obstacles that could restrict the range and efficiency of the solutions that are put in place. As various agencies and regions adopt various smart systems, interoperability and standardization also become crucial obstacles that could cause problems with data sharing and integration. Moreover, strong security measures and privacy policies become more crucial as smart infrastructure becomes more susceptible to cybersecurity attacks.

4.5.4 Discussion on Potential of Road Infrastructure

The integration of intelligent transport systems (ITS) and smart technology, effective planning, and the development of a liveable urban environment are all critical components that are closely linked to the potential of road infrastructure. All respondents stressed the value of meticulous planning in Characteristic 1, acknowledging that it is the cornerstone of technology integration, budgetary planning, and resource allocation. In addition to addressing the urgent needs for infrastructure, this all-encompassing strategy guarantees long-term economic viability and workforce development. Respondent 1 emphasises the significance of wise financial management, not only for short-term projects but also for long-term programmes like training and education to develop a skilled labour force. Feature 2 explores the breakthrough potential of ITS and smart technologies to alleviate traffic congestion and improve traffic management.

Real-time data collection from sensors and cameras allows you to dynamically adjust traffic light times and quickly identify congestion hotspots. This adaptive approach reduces congestion by optimizing traffic flow and integrates with navigation software to provide drivers with real-time information and alternative routes. The establishment of a central traffic management centre will further improve real-time monitoring and incident response. The importance of bike lanes, pedestrian walkways, and crosswalks in creating a liveable city is

Journal of Techno-Social Vol. 16 No. 1 (2024) p. 81-94

explored in Characteristic 3. All the respondents stress the significance of improving safety, lowering collision rates, and encouraging alternate forms of transportation. Well-planned urban features that put residents' health and quality of life first and promote a sense of community are linked to liveability. However, as all respondents pointed out, there are obstacles in the way of realising this potential. Financial constraints become a critical issue, as the high expenses of deploying smart technology and continuous upkeep limit the effectiveness of remedies. Cybersecurity threats and problems with interoperability and standardisation among various smart systems provide more obstacles.

5. Conclusion and Recommendations

This section describes the conclusion of this study. In conclusion, the research has been success by doing the three objectives that have been made and the answer we get from the respondents. The result shows positive to the road infrastructure. So, important for the government, to take measures to control the risk that happens in road infrastructure in order to create safer and more comfortable road for citizens.

Based on the findings mentioned above in Chapter 4, suggestions are also made on several related issues to give due attention and consideration to the stakeholders. In order to complete this study, qualitative analysis was used, namely interviews and observations. Among the constraints faced by researchers to obtain information and data is the difficulty in giving respondents feedback. This is because the majority of data collection is conducted through interviews.

Acknowledgement

The author would like to thank the Research Management Centre (RMC) and Faculty of Technology and Business Management, Universiti Tun Hussein Onn Malaysia. These research works were supported by Tier 1 Grant Vot Q338 for their support.

References

Abdul L., Jaapar, A. & Mat I., (2021). Factors Influencing Governance Practices in Rural Development Projects: A Case Study of Rural Road Project in Malaysia. *Journal of Construction in Developing Countries*: 1–36.

Abdullah, J. (2012). Road Network System in Port Klang, Malaysia and Impacts to Travel Patterns. *Procedia - Social and Behavioral Sciences* 35: 629–636.

Adil H., Abderrahim M. & Larbi H. (2020). Automated Real-Time Intelligent Traffic Control System for Smart Cities Using Wireless Sensor Networks. *Wireless Communications and Mobile Computing* 2020: 1–28.

Ahmad R., & Abdul Hamid. (2014). Synchronization of Traffic Light Systems for Maximum Efficiency along Jalan Bukit Gambier, Penang, Malaysia. *SHS Web of Conferences* 11: 01006.

Ahmadi, M., Valinejadi, A., Goodarzi, A., Safari, A., Morteza Hemmat, Hesamedin Askari Majdabadi & Mohammadi, A. 2017. Geographic Information System (GIS) capabilities in traffic accident information management: a qualitative approach. *Electronic physician* 9(6): 4533–4540.

Aidil M. (2019) A Comparative Study Of Malaysian Expressway Traffic Management With Selected Countries. 2019.

Akomah, B. B., Ahinaquah, L. K., & Mustapha, Z. (2020). *Skilled labour shortage in the building construction industry within the central region*. Baltic Journal of Real Estate Economics and Construction Management, 0(8), pp. 83-92.

Alwi, N. & Tajudin, B. 2006. PERFORMANCE OF GPS FOR ROAD NETWORK MAPPING AND ANALYZING VEHICLE POSITION.

Amir K. (2006) "*Overview of Its Development in Malaysia"*

Amsori M. D. (2014). A Review of Strategeis to Implement Sustainable Urban Transportation Option in Malaysia.

Anastasios Mouratidis & Papageorgiou, G. 2010. A Rational Approach for Optimization of Road Upgrading. Canadian Science Publishing:

Anil M. (2016). Climate Change and Road Safety: A Review to Assess Impacts in Malaysia. *Jurnal Teknologi* 78(4).

Asmalia Che Ahmad, NIANTI, I., Mohamad Nasrin Rosli & mohd. 2016. Hazard and Risk of Highway Maintenance Works: Case Study of PLUS Expressways. EDP Sciences:

Batu Pahat climate: Weather Batu Pahat & temperature by month. 2021. https://en.climate-data.org/asia/malaysia/johor/batu-pahat-25992/ [11 Disember

Castro, M., Iglesias, L., Rodríguez-Solano, R. & Javier Solana Sánchez. 2006. Geometric modelling of highways using global positioning system (GPS) data and spline approximation. *Transportation Research Part C: Emerging Technologies* 14(4): 233–243.

Chew, B. (2018). Exploring the Factors and Strategies in Implementation of Sustainable Land Transport System inAyerKeroh

Chiguma, M. (2007.). KTH School of Architecture and the Built Environment Analysis Of Side Friction Impacts On Urban Road Links. Case study, Dar-es-salaam.

Choy P. N., Teik H. L., Fauzan M. J. & Subramaniam, K. (2019). *Road infrastructure development and economic growth*.
De Souza, Allan M., (2018) "*Traffic Management Systems: A Classification, Review, Challenges, and Future"*
Economic and Social Commission for Asia and the Pacific (ESCAP). (n.d.).
Elsom, D. (2001) Effectiveness of Traffic Management Measures in Improving Air Quality in European Cities.
Elumalai, G. & Bhaskar, G. 2014. Identification and Controll of Spark Ignition Type Vehicles using Intelligent Transportation Technologies.
Ershad A. (2020) *"Geographic Information System (GIS): Definition, Development, Applications & Components."* ResearchGate, unknown, 26 Mar. 2020,
Ershad A. (2020) "*Global Positioning System (GPS): Definition, Principles, Errors, Applications & DGPS*." ResearchGate, unknown, 8 Apr. 2020,
Guan, Tham, and Nur Khairiel Anuar. Urban Transportation Issues: A Case Study at Kuala Lumpur, Malaysia.
Hermans, E. (2015). The impact of weather conditions on road safety investigated on an hourly basis.
Holmes, B. (2016) Qualitative Methods of Road Traffic Crash Research in Low and Qualitative Methods of Road Traffic Crash Research in Low and Middle income Countries: *A Review Middle-Income Countries*
Humayun, M., Afsar, S., Almufareh, M.F., Jhanjhi, N.Z. & AlSuwailem, M. (2022). Smart Traffic Management System for Metropolitan Cities of Kingdom Using Cutting Edge Technologies. *Journal of Advanced Transportation* 2022: 1–13
Isip, M., Van Westen, C. & Mavrouli, O. (2019). Development of a road asset management database for quantitative landslide risk assessment along roads in Colombia
Lubieniecka K. K. (2018). Managing information in road traffic: best practices. *MATEC Web of Conferences* 231: 02006.
Mansourian A., Abbas R., Javad, M. & Ian Phillip Williamson. 2006. Using SDI and WebBased System to Facilitate Disaster Management. Elsevier BV:
Muhamad R. (2014). Urban Transport and Land Use Planning Toward The Sustainable Development (Case Study Of Bandung Metropolitan Area.
Muhammad A. Z. and Noorfaizah H. (2022) "*The Implementation of Intelligent Traffic Management System in Solving Traffic Congestion: A Survey of Federal Route 3214"*
Muhammad Ariff Zamri and Noorfaizah Hamzah. The Implementation of Intelligent Traffic Management System in Solving Traffic Congestion: A Survey of Federal Route 3214
N. Kapileswar & Hancke, G.P. (2016). A Survey on Urban Traffic Management System Using Wireless Sensor Networks. *Sensors* 16(2): 157–157
Norshakina S. & Mohd. (2016) Assessment of Road Infrastructures Pertaining to Malaysian Experience. EDP Sciences:
Nur, Sazali A. W., Abu S. Y. & Syed A. F. (2016). Measuring the Effectiveness of Road Transportation Logistics Performance in East Malaysia: A Conceptual Model. Canadian Center of Science and Education:
Onur K. (2017) The Relationship between Economic Growth and Road Infrastructure: Evidence from Turkey
Oon, C., Ee, K. & Leng, K. (n.d.). Issues and challenges of a liveable and creative city: The case of Penang, Malaysia.
Rahman, M.M., Khan, A. & Mohammad Mizanur Rahman. 2019. Road Management System (RMS) for a Neighbourhood.
Razuhanafi, M. (2018) Effectiveness of Traffic Management at Kajang SILK Highway.
Richard W. & Rizati H. (2018) Road Maintenance In Malaysia The Institution Of Engineers, Malaysia.
Sofi, Aijaz A., & Archana S. (2022) "*Challenges of Traffic Controlling and Urban Traffic Management in Srinagar City*." International Journal for Multidisciplinary Research, vol. 04, no. 05
Srivastava, J. & Sudarshan Tsb. (2013). Intelligent traffic management with wireless sensor networks. unknown:
Stefania C. R., Ioannis B. (2016*) Improve Road Asset Condition Monitoring*. August 16
Syahriah B. (2015). Apreliminary Study of Sustainable Transport Indicators in Malaysia: The Case Study of Klang ValleyPublicTransportation.
The Future of Traffic Management State of the Art, Current Trends and Perspectives for the Future
Traffic Management for Costruction and Maintenance Work. (2011). Workplace Health and Safety Queensland:
Yam, I. & Sian, T. (2017). An Overview of Major Transport Infrastructure Development in Malaysia.
Zulhaidi J. (2015). Weather as a Road Safety Hazard in Malaysia - An Overview.