

# A Thematic Analysis On The Roles And Functions Of Smart Tunnel In Flood Disaster And Traffic Flow Management In Kuala Lumpur Malaysia

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## ABSTRACT

Managing environmental disaster requires the use of technology into how technology is used to minimize the casualties and loss incurred when disaster strikes. This research is based on the roles SMART tunnel plays as the tool in flood prone areas. SMART is an acronym for “Stormwater Management and Road Tunnel”. This project is located in Kuala Lumpur the capital metropolitan city of Malaysia. The SMART Tunnel project was initiated by the Former Prime Minister Tun Dr. Mahathir Mohammad under the Malaysian Development Plan. The project was undertaken as a joint venture projects between the government and the private sector corporation. This study therefore, makes an effort to investigate the roles SMART Tunnel plays in the city center of Kuala Lumpur Malaysia. Nevertheless, the study adopted a qualitative approach, ten respondent were targeted which form the sample size to answer two of the research objectives. Similarly, interviews was undertaking with the ten people eight of which are from Drainage and Irrigation Department while two are from the Malaysian Highway Authority. However, thematic network analysis and narration, photographs and observations were used for data analysis. The study has discovered that SMART Tunnel plays a very vital role in Flood disaster management and traffic congestion management. The research contribute in providing valuable frontier and offer means to improve the demand of another SMART Tunnel or ponds to accommodate flood water in the other area where SMART does not covered. It also updates people about the roles of SMART Tunnel in the city center of Kuala Lumpur Malaysia.

**Key words:** Disaster, Management, SMART Tunnel, Kuala Lumpur, Malaysia.

## INTRODUCTION

A tunnel is a passage way that carries people or vehicle across a destination that have obstruction or to shorten the travelling time. Tunnels in the olden days are used for mainly mining works. In the recent years as technology evolves with time, tunnels construction had become more

commonly used as transport routes in places that has alternative solutions such as roads or bridges impossible to be built or the costing is higher, since there are obstruction to be accounted for in order to build the necessary routes. Tunnels are also used as rails links, vehicles and also as canals for water diversion. Most tunnels are built

through a hill or mountain and underground below cities, roads, ocean or rivers. The constructions of tunnels are very complex because it involves precise and accurate planning. [1] Tunnel construction depends mainly on geological study of the sub-surface before determining the type of construction method and costing involves. This is because the type of soil formation will determine the structural needs, types of machineries suitability for that particular location to construct the tunnel, and also the environmental impact on the society and the natural surrounding especially the sub-surface of the soils (e.g. underground streams and the stability of the soil). Tunnels are constructed all over the world and the method of construction is getting more advanced and this allows the tunnels that are impossible to build are now done. Although tunnels have their own advantages and uses, the effectiveness of tunnel may not outweigh the costs associated with building and maintaining such tunnel. This is especially true as tunnels get older due to wear and tear. To understand the effectiveness of tunnels towards their intended purpose, this research will focus on one such tunnel i.e the SMART underground tunnel in Kuala Lumpur Malaysia. This tunnel is very unique because this is the only one kind of tunnel in the world that combines the wet and dry system. The tunnel is used as a pathway to transport vehicle and also a channel for stormwater diversion from the city centre of Kuala Lumpur. [1] The SMART tunnel is built using two Slurry Shield TBM machines that allows the drilling and tunnel lining work to be done continuously without setbacks. The machine also eliminates the hazard of tunnel stability during construction and also the ground water drawdown that cause sink holes. The focus therefore is on the effectiveness of SMART tunnel in both traffic and flood diversions of the Kuala Lumpur city center.

## LITERATURE REVIEW

This chapter comprise of a comprehensive review of literature relating to the SMART tunnel and its performance, natural disasters around the world as well as the technologies used to manage natural disasters around the world. Emphasis is given to the tunneling technology, its construction, roles as well as performance.

Literature review is very important in a research to get a deeper understanding of issues relating to the previous research by using the appropriate framework to achieve the research objectives. According to, [2] literature review is an integral part of the whole research process, helping to get the comprehensive and extremely valuable input in preparing the research measures. Thus, literature review helps researchers to identify the gap area which is still not explored by the previous researches.

The review of the literature is considered a systematic and critical review of the most important published scholarly literature on a particular topic. Scholarly literature refers to published and unpublished data based literature and conceptual literature materials found in print and non-print forms. [3] This chapter looks at a review of relevant literatures that give a background of the SMART tunnel, which are related to the improving its performance in flood disaster management.

### *Types of Technology Used in Disaster Management*

The development of technological tools makes the world of today safer and gives the opportunity to take righteous action against a given phenomenon. The technological tools commonly used in disaster management in the world today are: **Geographic information system (GIS)**

The first known use of the term "Geographic Information System" was

by Roger Tomlinson in the year 1968 in his paper "A Geographic Information System for Regional Planning". Tomlinson is also acknowledged as the "father of GIS". It is a collection of hardware, software, geographic data, and personnel designed to capture, maintain, store, organize, update, manipulate, analyze, and display geographically referenced information. [6] GIS can also maintain and retrieve large quantities of data, manipulate spatial and related tabular data, perform complex spatial analysis, rescale data for analysis. GIS is suitable in doing things such as Map production, allowing the user to design map, tables, graph, charts and images. Searching and selecting geographic features of interest based queries, logical queries, arithmetic queries, and spatial relationships. Selecting and displaying map features based on location.

Analyzing spatial data based on conditions of proximity, containment and adjacency. Measuring distances between mapped locations as well as calculating summary statistics such as count, sum, average, and variance. GIS can also edit spatial layers and their attribute tables, importing spatial layers from a variety of other sources as well as creating new spatial layers through digitizing from the screen or digitizing tablet, intersecting and "clipping" of vector spatial layers. The acronym GIS is sometimes used for geographical information science or geospatial information studies. In the simplest terms, GIS is the composite of cartography, statistical analysis, and computer science technology. GIS is used in so many countries in the world for disaster management.

### **Space Technology**

Space technologies are becoming gingery to modern day disaster management. Earth observation (EO) satellites provide images at various wavelengths that assist

rapid-mapping in all phases of the disaster management cycle, mitigation of potential risks in a given area, preparedness for eventual disasters, immediate response to a disaster event, and the recovery/reconstruction efforts following it. [7] Global navigation satellite systems (GNSS) such as the Global Positioning System (GPS) help all the levels by providing accurate location and navigation data, helping manage land and infrastructures, and aiding rescue crews coordinate their search efforts. Communications through satellites allow the transfer of information (voice, images/maps, video) when usual communications cadre are disabled by the disaster event. [7] The emergency communications carried out using semi-mobile terminals and handheld satellite phones are particularly useful during immediate response activities, including damage assessment, search and rescue efforts, news reporting, aid coordination, and telemedicine activities. [7]



Figure 1. Space Technology  
(Source: Space Generation, 2012)

It should be noted that the UN Office for Outer Space Affairs<sup>6</sup> has established the UN Platform for Space-based Information for Disaster Management and Emergency Response<sup>[7]</sup> which oversees and assists nations affected by disasters to obtain various kinds of space-based information,

regardless of whether or not they have their own space capabilities. UN-SPIDER is being implemented as an open network of providers of space-based solutions to support disaster management activities. Besides Vienna (where UNOOSA is located), the program also has an office in Bonn, Germany and will have an office in Beijing, China. Additionally, a network of Regional Support Offices multiplies the work of UN-SPIDER in the respective regions. Space technology plays a tremendous role in disaster management due to its accuracy in generating information.

### ***Tunneling Technology***

A tunnel is an underground passageway, completely enclosed except for openings for entrance and exit, commonly at each end. A tunnel is a passage way that carries people or vehicle across a destination that shortens the travelling time. Tunnels in the olden days are used for mainly mining works. As a result of technological development with time, tunnels construction had become more commonly used as transport routes that links places, rails links, vehicles and also as canals for water diversion.

### ***Tunnels***

Tunnels in early days are used especially in mining. Tunnelling and mining are together since beginning of the industry. Before mining, tunnels in an ancient history were used for water carriage. In cities such as ancient Rome, tunnels are designed to carry water supply from aqueduct nearby. [1] The technology of tunneling advanced from ancient days until now. Sometimes tunneling becomes most soluble solution, but constructing tunnels are still under major studies because we need to upgrade the design according to time and needs. [8]

When the scientist from China invented the gun powder, it gave way to new methods for tunneling work to presume. Gunpowder since then has advanced into more severe

usage in the tunneling industry. Gunpowder gave way to much more powerful nitroglycerin, quickly followed by dynamite, introduced by Nobel in 1967. [8] In rock drilling, compressed air became the accepted motive power, although the usage of the hydraulic powered machines was preferred for a time period commonly in Europe.

The use of explosive in hard layer is common in order to blast through the hard surface. Blasting is one of the easiest methods in tunnel construction, but there are weakness such as the safety and problems of excessive caving in of the layer. There are different types of tunnels constructed from different soil layer or location, such as:

- (i) Soft ground
- (ii) Hard Rock
- (iii) Underwater

Tunnels also are the major solution for the purpose of pedestrian crossing, general road traffic, for the usage of the vehicles, railway links and also for canals. Most of the tunnels are designed and constructed specifically for carrying water for daily consumption, for the purpose of generating electricity such as the hydroelectric or as sewers for major cities to ease the flooding problems and for telecommunication cables. Brunel's great Thames Tunnel is the first tunnel that was ever built to cross under a tidal river and the first shield driven tunnel. [9]

Tunnels are usually constructed in different type of ground soil layers that varies from soft clay to hard rock layer. In soft clay layer, the tunnel digging is done using New Austrian Tunnelling Method (NATM) and in hard layers Tunnel Boring Machine (TBM) is used widely.

### ***Underground Road Tunnels***

Development of countries had brought new technologies particularly on engineering design. Innovation in engineering also plays a vital role in

upgrading existing services and invention of infrastructures such as long bridges, tunnels, skyscrapers, etc. Road tunnels development are actually very famous in Europe compared to Asia. But currently it is getting more attention in Asia as there are numerous advantages from this type of development. There are different types of road tunnels development in the world such as:

**Table 1. Tunnels around the world**

Country	Tunnel Name	Length (m)
Norway	Laerdal	24510
Norway	Gudvanga	11428
France	Le Tunnel Est	10000
France-Italy	Freju	12895
China	Zhongnanshan	18040
Switzerland	St Gothard/San Gottardo	16918
Austria	Alberg	13972

Source: The World's Longest Tunnel, (2009)

### ***Purpose of Using Technology in Disaster Management***

The main rationale behind using technology in disaster management in the world today is the accuracy of data collection, analysis and presentation of technological tools. Today the ambiguous nature of disasters in the world results in the employment of technology in its management. GIS, Space technology, Tunneling Technology as well as Tsunami early warning system play a vital role in disaster forecasting, dissemination of information about the occurrence of disaster as well as providing room for disaster preparedness. These tremendously help in disaster preparedness, mitigation and recovery. There are so many traditional methods of flood disaster management for example such as sanitation of drainage etc. But these methods are insufficient due to the technological advancement and accuracy of technology in disaster management.

In the disaster prevention phase, GIS is used to manage the large volume of data needed for the hazard and risk assessment. In the disaster preparedness phase, it is a tool for the planning of evacuation routes,

for the design of centers for emergency operations, and for the integration of satellite data with other relevant data in the design of disaster warning systems. In the disaster relief phase, GIS is extremely useful in combination with Global Positioning System in search and rescue operations in areas that have been devastated and where it is difficult to find ones bearings. In the disaster rehabilitation phase, GIS is used to organize the damage information and the post-disaster census information, and in the evaluation of sites for reconstruction. Hence, GIS is a useful tool in disaster management if it is employed effectively and efficiently.

### ***Effectiveness of Tunnels in Managing Disaster and Traffic Movement***

Tunnels in early days are used especially in mining. Tunneling and mining are together since beginning of the industry. Before mining, tunnels in ancient history were used for water carriage. In cities such as ancient Rome, tunnels were designed to carry water supply from aqueduct nearby. Tunneling becomes solutions to so many challenges, but constructing tunnels are still under major studies because we need to upgrade the design according to time and needs. <sup>[1]</sup>

However, tunnels are solutions to problems of road crossing, road traffic for the usage of vehicles, railway links and also for canals. Most of the tunnels are designed and constructed specifically to provide routes for motorists, for the purpose of generating electricity such as the hydroelectric or as sewers for major cities to ease the flooding problems and for telecommunication cables. Brunel's great Thames Tunnel is the first tunnel that was ever built to cross under a tidal river and the first shield driven tunnel. <sup>[10]</sup> Tunnels are usually constructed in different nations and are effectively used for their purposes. Laerdal tunnel of Norway with the length of 24510m (24.5km) is effectively used to

traffic management. It provides routes for approximately 25,000 motorists a day. However, Gotthard tunnel in Switzerland with 16.942km is efficiently and effectively used to manage traffic of approximately 9,000 motorists a day. This tunnel runs between goschenen in the canton of uri at its northern portal to airola in Ticino to the south. [11] Penchala tunnel in Malaysia with the 710m was the first breakthrough tunnel in Malaysia that provides routes for motorists.

However, different technologies are used to manage different disaster in different countries around the world. In Algeria, Remote Sensing and Geographical Information System (GIS) technologies has been the point of significant interest to all core concerned with space and in particular emergency services and disaster management. [12] Among the most frequent are the forest fires that destroy thousands of hectares every year, earthquakes that have a devastating effect every time. GIS is used in Algeria effectively for searching and selecting geographic features based queries, logical queries, arithmetic queries, and spatial relationships. Selecting and displaying map features based on location. Analyzing spatial data based on conditions of proximity, containment and adjacency. [6]

Similarly, the Indian subcontinent is vulnerable to Drought, Floods, Cyclones and Earthquakes. Though Landslides, Avalanche and Bush fire too frequently occur in the Himalayan region of northern India. [13] Flooding is the most frequent and often the most devastating disaster among all the disasters that occur in India. The cause for floods is basically the curiosities of rainfall in the country. Out of the total annual rainfall in the country 75% is concentrated over a short monsoon season of three to four months. [13] However, satellite data is effectively and efficiently employed for mapping and monitoring the flood inundated

areas, flood detriment assessment, flood risk region, and post-flood canvass of river cadre and protection works in India. [4]

Along with other countries in the region, the Philippines is increasingly relying on technology in its preparedness and response as a key programmatic tool in reducing the impact of disasters while saving as many lives as possible. The National Telecommunications Company reported a total of 94.2 million cellular mobile phone subscribers in Philippines out of the estimated population of 105 million in 2011. [14] It is, therefore, an effective means of text messages as an essential aspect of its nation-wide early warning system. [14]

The effectiveness of tunnel and technology in disaster management and traffic decongestion is not overemphasized. Both play a very vital role in making lives of people free from negative impact of disaster. [15]

## **METHODOLOGY**

### ***Research Design***

Research design is the conceptual structure within which research would be conducted. [7] Similarly, [16] defined research design as a logical plan, not the logistics plans often reference by others (the logical plans are still needed but over the management of your research, such as scheduling, and coordination of the work). However, according to, [14] the preparation of research design appropriate for a particular research problem, involves the consideration of the following:

- (i) Objectives of research study
- (ii) Method of data collection to be adopted
- (iii) Source of information
- (iv) Tool for data collection
- (v) Data analysis

### **Qualitative research**

Qualitative research involves the use of interview survey, observation and

document review. However, [17] qualitative research should be specifically aligned with action research and critical hermeneutics traditions and those qualitative researchers should form a community around this specific concern. Qualitative research enables you to conduct in-depth studies about a broad array of topics, including your favorites, in plain and everyday terms. Qualitative researchers aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour. Qualitative research has the advantage of flexibility in data analysis such that data can be analyzed manually or using computer. [9]

The researcher used qualitative research tools for gathering information which include: Participant observation, semi-structured interview and analysis of documents and materials. The nature of the research objectives are qualitative in nature, the study tries to find out the roles SMART Tunnel plays in the city centre of Kuala Lumpur Malaysia. Therefore, interview, observation and document review is more suitable in this case. The interview is analyzed using thematic network analysis, while observation and document review serves as means of triangulation to the data obtained. Qualitative [18] method describes the characteristics of people and event. However, there is a need of visiting SMART Tunnel in the city centre of Kuala Lumpur by the researcher; this contributes immensely in figuring out the real picture of SMART Tunnel to the researcher. Following the buttressing points mentioned above, it clearly shows that qualitative research method is the appropriate method in finding out the roles of SMART Tunnel in the city center of Kuala Lumpur Malaysia.

#### **Data Collection**

This study is qualitative in nature and thus, adopted three methods of qualitative data collection:

- (i) Observation

- (ii) Interview
- (iii) Document review

#### **Observation**

Observation can yield information which people are normally unwilling or unable to provide. Observation involves recording the behavioural pattern of people, objects and event in a systematic manner. The areas of observation of this study are listed below:

- (i) Technology used in SMART Tunnel
- (ii) Operation of SMART Tunnel
- (iii) Capacity of SMART Tunnel (Cubic metres)

The observation is carried out by the observer not disclosing to the subjects that they are under study. Observation is the most complete form of sociological datum, in which the participant observes some social event, the events which precede and follow it and explanation of its meaning by participant and spectators, before, during and after its occurrence. Such a datum gives more information about the event under study than data gathered by any other sociological method.

The contextual meaning signifies that through observation data is generated with it interpretation and further explanation is recorded to ratify the action of the people under study. The kind of observation carried out is a systematically done in order to detect a particular role. The role under study is to know the functions of SMART Tunnel in flood disaster and traffic management in the city center of Kuala Lumpur Malaysia. The observation is carried out in a covert manner without the subjects of the study knowing that they are under observation, (structured observation).

#### **Interview**

The interview is typically structured conversations that researchers have with individual. It can be understood that interviewing is a technique that is primarily

used to gain an understanding of the underlying reasons and motivations of people's attitudes, preferences or behavior. Interviews can be undertaken on a personal one-to-one basis, or some other agreed location. It can be structured, unstructured, or semi structured interview, but for the purpose of this research structured interview is adopted.

The research involves interviewing the staff of 2 organizations, i.e. Drainage and Irrigation Department and Malaysian Highway Authority in Kuala Lumpur Malaysia. The researcher interviewed 2 people of the Flood Water Management Division, 1 person of the Stormwater Management Division, 5 people of the SMART tunnel flood control unit from the Drainage and Irrigation Department. Similarly, the researcher also interviewed 2 people from the Malaysian Highway Authority with the aim of figuring out the types of maintenance work of SMART tunnel in flood disaster management in Kuala Lumpur as well as the roles SMART Tunnel plays in diverting traffic to and from the city center of Kuala Lumpur Malaysia. The researcher use 40 minutes per session for the interviews.

The number of interviewees was 10 staff, 8 of which are from Drainage and Irrigation Department while 2 are from the Malaysian Highway Authority.

#### ***Document Review***

Document review involves the use of numerous forms of existing document which can be analyzed as assessment data public record. It can be generalized as the official, ongoing records of an organization's activities.

Similarly, document review process is a systematic procedure for identifying, analyzing and driving useful information from these existing documents. Review a variety of existing sources such as documents, reports, data files, and other

written artifacts, with the intention of collecting independently verifiable data and information. However, critical study of document under review was made by the researcher to derive inferences on events or to make an assessment on a certain subject or object. Official reports from various organizations are used in this research study.

#### ***Data Analysis***

Qualitative analysis can be differentiated from quantitative analysis according to the level of variables being analyzed. However, qualitative analyses follow some series of strategies which start by coding the data, coding is neither an automatic nor a prescriptive process it requires a great deal of skill and that skill can be developed only through practice. The three main direction for analyzing qualitative data, they are; Thematic analysis, meaning generation and confirmation, synthesis and illumination.

The data analysis in this research is based on thematic analysis which uses element of inductive approach (i.e. about reasoning to a probable conclusion technically from a logical standpoint), feedback and comparison (allows for refinement or change of emergent themes) and saturation technique (involve theoretical and observational issues for convergence of notion). The thematic analysis provided the avenue for carrying out analysis of the qualitative data. However, it is calls research display which is divided into two basic displays i.e. within-case display and cross-case display. Data analysis first step is exploring and describing of data, this is the process of organizing the data by creating analytic text which is the result of the research in process then the data display development then seek to explain, order and predicts. Causal modeling and causal networks are also part of this process.

#### ***Data Analysis***

All interviews that have been undertaken have been transcribed word for word, by using thematic network analysis as a means of analyzing data from the field as it is shown in the following page.

**Area of Investigation One: To examine the effectiveness of SMART Tunnel in flood disaster management in the city center of Kuala Lumpur Malaysia**

The interviews conducted at the Drainage and Irrigation Department, Malaysian Highway Authority as well as SMART tunnel control centers explored the effectiveness of SMART tunnel in flood disaster management in the city center of Kuala Lumpur Malaysia which are examined carefully and analyzed by thematic network analysis for the area of investigation as shown in figure 2 below.

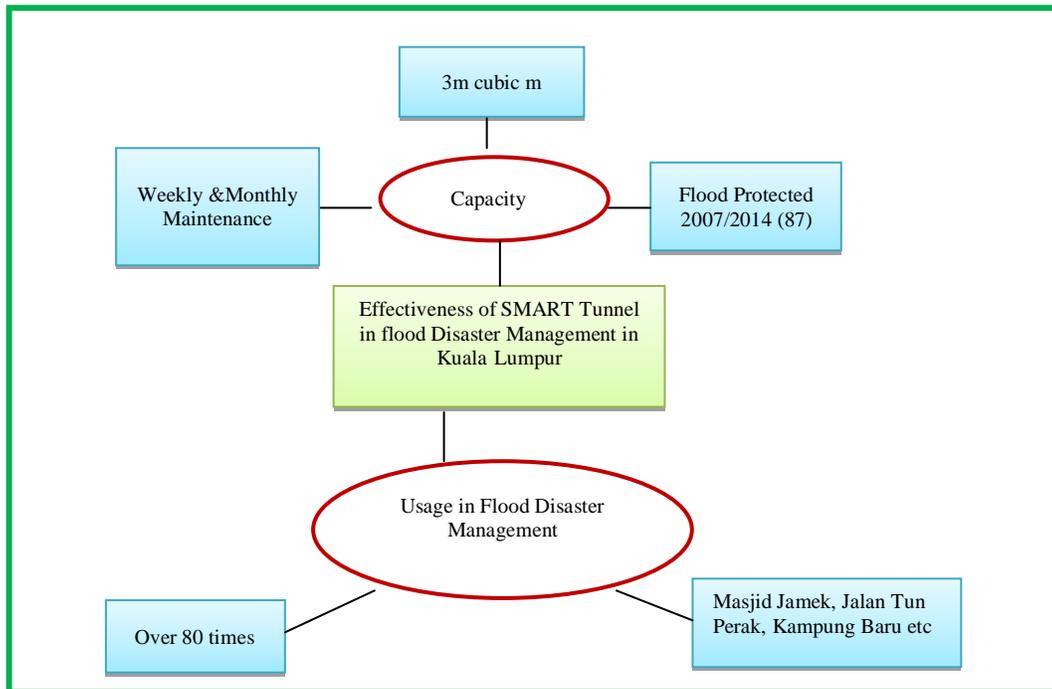


Figure 2: Effectiveness of SMART tunnel in Flood Disaster Management in Kuala Lumpur Malaysia Source: Interview Survey (2014)

**Theme 1: Capacity of SMART Tunnel**

Response from interviewee ‘A’ from the Drainage and Irrigation Department says that SMART Tunnel plays a very vital role in flood disaster management in the city center of Kuala Lumpur, he added that SMART has the capacity of accommodating 3m cubic metres of water from the Klang river. Similarly, respondent ‘B’ reaffirmed the statement of respondent ‘A’ and also added that SMART Tunnel was launched in 2007 to divert flood water from the Klang river, whereas respondent ‘C’ from the Drainage and Irrigation Department

confirmed that since SMART Tunnel was launched in 2007 there has been no any flood that hit its targeted area.

However, respondent ‘D’ from Malaysian Highway Authority confirmed that since the inception of SMART Tunnel it was used over several times to divert flood water from the Klang river and also plays a very vital role in protecting the targeted area against the flooding. Moreover, respondent ‘E’ from the Malaysian Highway Authority stated that SMART Tunnel keeps its promise in protecting the targeted areas against the negative impact of flooding since

it was launched. Similarly, respondent 'F' said that the maintenance work of SMART tunnel plays a very vital role and is on weekly and monthly basis. Moreover, respondent 'G' says that maintenance of SMART tunnel is very crucial and is being carried-out weekly and monthly and said the cleaning of the tunnel is weekly and very important for tunnel's performance.

Respondent 'H' from the SMART tunnel control unit says that SMART is being maintained weekly and the flood tight gate receives more emphasis because the primary function of the tunnel is to protect the targeted area against the flooding. Respondent 'I' reaffirm the statement of respondent 'A' and added that automated flood control gate is checked weekly. Moreover, respondent 'J' from the same organization with respondent 'I' says that cleaning the tunnel weekly is very important and also helps the tunnel to perform its task as expected.

### ***Theme 2: Usage in Flood Disaster Management***

According to respondent 'A' from the Drainage and Irrigation Department SMART Tunnel is used over 80 times to protect its targeted areas against the negative impact of flooding, motorway checks is being carried-out monthly and thus plays a very vital role in SMART's function, whereas respondent 'B' from the same organization with 'A' said that SMART was used several times to accommodate flood water from the Klang valley and the monthly maintenance works that involve the whole major system of the SMART tunnel, including software checks plays a very vital role for SMART to function as it is expected. Similarly, respondent 'C' says that water tight-doors are being checked monthly and it's very important for tunnel's performance in its targeted areas.

Respondent 'D' reaffirm the statement of respondent 'A' and respondent

'E' from the Malaysian Highway Authority says that software checks that is being carried-out monthly is very crucial for tunnel's performance and SMART was used over 80 times to solve the problem of flooding. Respondent 'F' from the same organization says that SMART plays a very vital role thus, it was used 83 times to protect its targeted areas, he further said motorway tunnel is being maintained monthly and it is important for SMART tunnel in flood disaster management. However, respondent 'G' from the SMART tunnel motorway control unit says that motorway tunnel is maintained the way it supposed to be and thus, it helps tremendously in SMART performance.

Respondent 'H' says that software and water tight gates checks plays very vital roles in helping SMART tunnel to perform its task and also it is unfailingly carried out monthly, whereas respondent 'I' reaffirm the statement of respondent 'H' and also said motorway tunnel is also being maintained monthly according to the SMART tunnel operations manual. According to respondent 'J' software checks is crucial in tunnel's performance and the tunnel is required to be closed from 11pm to 6am for the maintenance of the major system of the SMART tunnel that include software checks.

### ***Area of Investigation Two: To investigate the effectiveness of SMART Tunnel in Traffic Diversion in the city center of the Kuala Lumpur Malaysia***

The interviews conducted at the Drainage and Irrigation Department, Malaysian Highway Authority as well as SMART tunnel control centers explored the positive impact of SMART tunnel in traffic management in and from the city center of Kuala Lumpur Malaysia which is examine carefully and analyzed by thematic network analysis for the area of investigation as shown in figure 3 below.

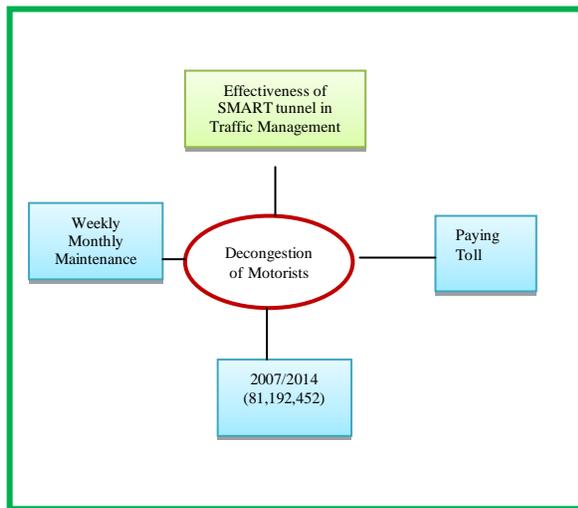


Figure 3: Effectiveness of SMART Tunnel in Traffic Management in Kuala Lumpur Malaysia. Source: Interview Survey (2014)

### ***Theme 2: Decongestion of Motorist***

Based on the interviews conducted from the Drainage and Irrigation Department and SMART tunnel control centers, Respondent 'A' says that between 2007 to 2014 monthly maintenance was carried out 84 times. In 2007 it was carried out 7 times, 11 times in 2008, 11 times in 2009, 12 times in 2010, 12 times in 2011, 10 times in 2012, 12 times in 2013 and 9 times in 2014. This helps SMART tunnel tremendously in performing its task as expected. Respondent 'B' from the same organization with 'A' reaffirms the statement of respondent 'A' and respondent 'C' says that between 2007 to 2014 weekly maintenance was carried out 382 times. In 2007 it was carried out 30 times, 52 times in 2008, 50 times in 2009, 52 times in 2010, 52 times in 2011, 51 times in 2012, 52 times in 2013 and 43 times in 2014. This helps SMART tunnel tremendously in performing its task as expected.

Similarly, respondent 'D' from the same organization with 'A' says that the number of motorist that passed through SMART Tunnel between 2007 to 2014 is

81,192,452 and confirmed that SMART tunnel is effective in providing routes for motorist. Respondent 'E' says that SMART Tunnel is used as a concessions to the private partners and thus, toll is been paid for. This serves as a source of income to government and also the private companies. Respondent 'F' from the same organization says that SMART plays a very vital role and thus, it was used many times as routes for motorist, he further said motorway tunnel is being maintained weekly and it is important for SMART tunnel in traffic management. However, respondent 'G' from the SMART tunnel motorway control unit says that motorway tunnel is maintained the way it supposed to be and thus, it helps tremendously in SMART performance.

Respondent 'H' says that software and water tight gates checks plays very vital roles in helping SMART tunnel to perform its task, whereas respondent 'I' reaffirm the statement of respondent 'H' and also said motorway tunnel is also being maintained weekly according to the SMART tunnel operations manual. According to respondent 'J' hardware checks is very important in tunnel's performance and its maintenance is carried out weekly.

### **CONCLUSION**

Encapsulation, SMART as an acronym for stormwater management and road tunnel has been noted to be effective in managing flood disaster as well as traffic decongestion in the city center of Kuala Lumpur Malaysia. During the course of this research, it was figured out that SMART tunnel was used more than 80 times to accommodate flood water from the Klang valley and also provide motorway for approximately 30,000 motorists a day to and from the Kuala Lumpur city center. This shows that SMART tunnel tremendously contribute in both flood disaster

management and traffic decongestion in the city center of Kuala Lumpur Malaysia.

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