International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Review Article

A Thematic Analysis on the Causes of Flood Disaster and Roles of Smart Tunnel in Flood Disaster Management in Kuala Lumpur Malaysia

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Received: 02/09/2015 *Revised: 16/10/2015* *Accepted: 17/10/2015*

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 of tunnels' technology in managing environmental disaster with a specific focus 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 is undertaken as a joint venture projects between the government and the private sector corporation. This study therefore, makes an effort to investigate the causes of flood disaster as well as the roles SMART Tunnel plays in the city centre of Kuala Lumpur Malaysia. Nevertheless, the study adopted a qualitative approach, six respondent were targeted which form the sample size. However, five of them were met and interviewed. Similarly, interviews was undertaking with the five people three of which are from Drainage and Irrigation Department while two are from the Malaysian Highway Authority. However, thematic network analysis and chi-square were used for data analysis. The study has discovered that urbanization, weather condition, poor drainage system, number of rivers are the causes of flood disaster in Kuala Lumpur, whereas, SMART Tunnel plays a very vital role in Flood disaster management and traffic congestion management in the city centre of Kuala Lumpur Malaysia.

Keywords: Tunnel, SMART, Flood, Kuala Lumpur, Malaysia.

INTRODUCTION

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 become solutions to many problems. Tunnels are constructed all over the world to solve certain problems. This paper focuses on SMART Tunnel in Kuala Lumpur Malaysia. This tunnel is very unique because it is the type 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 storm water diversion from Klang valley. SMART tunnel was used over

80 times to divert flood water from the Klang valley. The entire paper is about the SMART tunnel roles as well as causes of flooding in Kuala Lumpur Malaysia.

Tunnels as Stormwater Sewers

Stormwater sewers are defined as storm drains[1]. Most major cities around the world are using sewer system to transport rainwater to nearby outlet such as stream or rivers. Storm sewers are large structure or pipes that transport water runoff from streets to natural water source such as stream and rivers. Commonly catch basins are provided in order to store the water before gradually releasing it into natural source. The catch basin also functions as the trap for water floating debris such as rubbish, sands and other unwanted materials that not supposed to be in the natural rivers. [1]

Some storm sewers are treated and some are not treated. This depends on area and jurisdiction. Treatment of water helps to clean and purify the water in order to release in the natural rivers. This is very important as every engineering structures or planning have to consider the environmental issues as one of the priority status. [1]

History of Storm Sewers

The earliest sewer that was found was in the Indus Valley civilization. [2] In ancient Rome, the Cloaca Maxima was considered a marvelous engineering design and construction.

The Cloaca Maxima (also called the Maxima Cloaca) is one of the world's earliest sewage systems. [3] Constructed in Ancient Rome in order to drain local marshes and remove the waste of one of the world's most populous cities, it carried effluent to the River Tiber, which ran beside the city. [3]

The name literally means Greatest Sewer. According to tradition it may have been initially constructed around 600 BC under the orders of the king of Rome, Tarquinius Priscus.

This public work was largely achieved through the use of Etruscan engineers and large amounts of semi-forced labor from the poorer classes of Roman citizens. [3] Underground work is said to have been carried out on the sewer by Tarquinius Superbus, Rome's seventh and last king.

Although Livy describes it as being tunneled out beneath Rome, he was writing centuries after the event. From other writings and from the path that it takes, it seems more likely that it was originally an open drain, formed from streams from three of the neighboring hills, that were channeled through the main forum and then on to the Tiber. This open drain would then have been gradually built over, as building space within the city became more valuable. It is possible that both theories are correct, and certainly some of the main lower parts of the system suggest that they would have been below ground level even at the time of the supposed construction. [2]

The eleven aqueducts which supplied water to Rome by the 1st century AD were finally channeled into the sewers after having supplied the many public baths such as the Baths of Diocletian and the Baths of Trajan, the public fountains, imperial palaces and private houses. The continuous supply of running water helped to remove wastes and keep the sewers clear of obstructions. The best waters were reserved for potable drinking supplies, and the second quality waters would be used by the baths, the outfalls of which connected to the sewer network under the streets of the city. [3]

In the medieval European cities, small natural waterways are built to channel wastewater and as time passes this were upgraded to covered channel that is known today as sewer systems. [4]

Tunnels vs. Bridges

The advance in construction technologies have resulted in the

development of major structures such as skyscrapers, roads, highways, airports, ports, tunnels, bridges, etc. The main reason bridges are more preferable is because of the cost and the simplicity of the design and construction. Simplicity doesn't mean that bridges are easy to build than tunnel, but in certain circumstances it does look easier. There are advantages and disadvantages of using bridges compare to tunnels.

The advantages are it is cheaper compared to tunnel that needs expensive budgets. The disadvantages are navigational consideration may limit the use of high bridges or draw bridges spans when intersecting with shipping channels such as the Penang Bridge that intersects the Penang Straits from the island to the mainland Butterworth with the length at 13.5km as shown below. [5]

Figure 1: The Penang Bridge, Malaysia
Source: DID (2004)

Whereas the tunnel construction are more expansive compared to the bridges, but the advantages are for navigational crossing will be easier and more convenient to build as it does not interrupt the movement of busy channel such as the Lincoln Tunnel (Between New Jersey and Manhattan Island in New York City. There are also combination of bridge and tunnels such as the Hampton Road Bridge-Tunnel that connects City of Norfolk and Hampton as shown below. [6]

Figure 2: Lincoln Tunnel, New York
Source: Lincoln Tunnel (2010)

Figure 3: Hampton Road Bridge-Tunnel, Norfolk
Source: Scott N. Kozel (2011)

Tunneling Methods

Tunnels are constructed according to types of soil formation. This is a major criterion for choosing tunneling methods. Tunneling project also depends on schedule, cost allocation and location. There are several methods or ways in selecting proper tunneling method, such as:

(i) Selection of proper tunneling system.
(ii) Cost and Risk Analysis
(iii)Tunnel designs

In urban tunneling such as the SMART Tunnel, the design, selection, cost and safety of the tunnel will be very important. [7] This is because the tunnel is built in the busy metropolitan city of Kuala Lumpur which is full of high rise structures and dense with high population. Proper care must be taken in order to avoid disaster or accidents from happening. In SMART Tunnel, the usage of Tunnel Boring Machine was employed because of the efficiency and the simplicity of construction process. [7] There are several types of TBM that are available for special construction purposes. In this project, the Slurry Shield TBM was chosen because of the existing groundwater condition that is a major setback to the construction. The slurry shield TBM machine is shown below.

Figure 4: The Slurry Shield TBM at SMART Project
Source: DID (2004)

Selection of Tunnelling Methods

In most tunnel construction works, the most important criterion is the tunneling

method. This is because proper tunneling method will make the construction process run smoothly without any delays and problems. In SMART Tunneling project, the usage of Tunnel Boring Machine was chosen because this is the new method that has numerous advantages. There are different types of TBM that are used currently in most tunnel projects worldwide. Different country with different soil and ground properties has different aspects to tackle in order to complete the tunnels. TBMs are used to excavate or deep tunneling works in urban or remote areas. [8]

The TBM is usually circular with a rotary cutter in front of the machine. The machine is jacked using hydraulic jacks sideways and a force is applied to push the machine forward in the cutting location. The machine moves on a track and tunneling and lining works can commence immediately after drilling. Horizontal directional drilling will be used to core tunnel that are less than one meter rather than using the TBM. Tunnel boring machine is new inventive machine that will solve the problems that are caused by normal drilling and blasting. Showing below is the progress made by the TBM. [8]

Figure 5: TBM break through at South Junction Box
Source: DID (2004)

However, road header machine is also one form of tunneling machine that is commonly used. Road header machine is limited in the operation of cutting hard rock surfaces. It is limited by the system stiffness, the inability of radial and point attached cutting tools to withstand high normal forces and premature carbide insert failure. Road headers are traditionally used in rocks with unconfined compressive strength. Road headers are widely used in tunneling where the formation of soft to medium strength rock formation. [9]

The advantages of road header are the high mobility, versatility and low capital cost of system operation. Road header was not used in the SMART Tunnel Project because of the size and formation of the tunnel and rock. [10] Below is a picture of the road header machine.

Natural Disaster Investigation

Natural disaster investigation is very important in order to gather all the information regarding the targeted area of SMART project in the city centre of Kuala Lumpur Malaysia. The type of disaster that is very common in Malaysia is flooding, as it occurs almost every year. Flooding is very common in Malaysia because of the tropical weather that cause rain most of the days in a

year. Earthquake is very unlikely as Malaysia is actually outside the South- East Asia's earthquake plate. [9] Below is the major Tectonic Plate around the world.

Figure 6: Road Header Machine
Source: Mining Techonology.Com (2010)

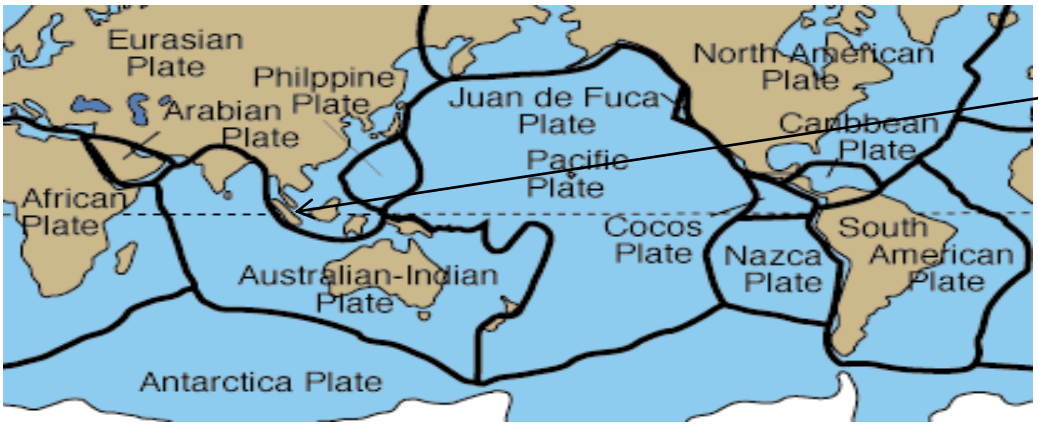

Figure 7: Major Tectonic Plates around the world
Source: Shirashi Corporation (2011)

Even though Malaysia is outside the region, studies are been conducted to avoid structural damages in all major project such as the SMART Project. The Indonesian region of Acheh that is very close to East Malaysia is one of the critical epic-region. This can be seen during the Tsunami that was caused by the tectonic plate in Acheh. [8] This caused an earthquake with a magnitude of 9.0 on the Richter scale that caused major devastation from Asia to the coastal of Africa. This was an awakening call to Malaysia that was very certain that it is safe from this natural disaster.

The government of Malaysia enforced laws that all skyscrapers and major infrastructure should be built with earthquake resistance capabilities. One of the methods that are incorporated into tunneling works is to earth-quake proof the piles as shown below. The method is by rolling steel plate around the piles by pressure fit. This method is very cost effective and the strength is very high.

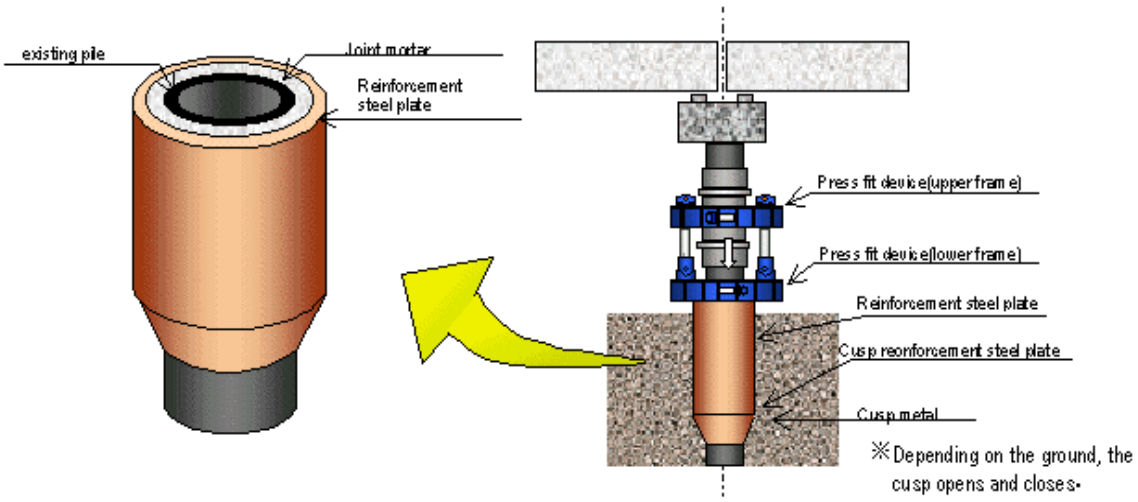

Figure 8: Method Protect the piles
Source: Shirashi Corporation (2010)

Other methods to structurally protect the tunnel is where the footing of the structure is also been protected. The footing method follows the ultimate lateral strength earthquake resistance design that required large scale of reinforcement at footing area. These are done after the pile of the foundation is rolled by the pressure fit plates. Then the footing will be heavily reinforced in order to reduce the vibration of the earthquake as shown below.

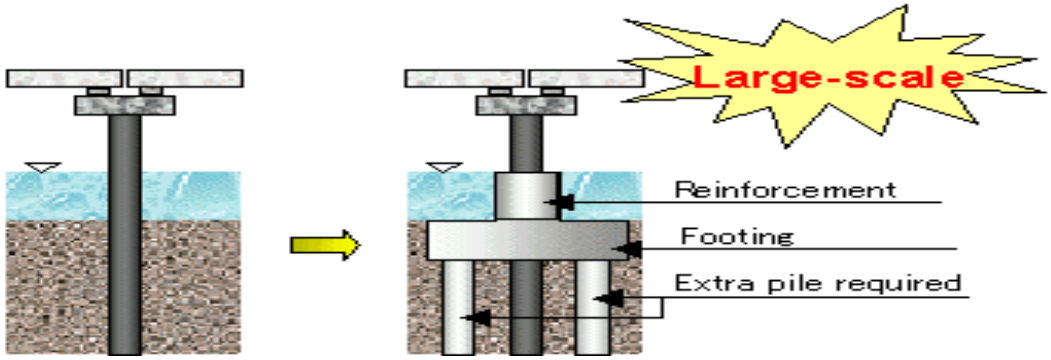

Figure 9: Footing Protection
Source: Shirashi Corporation (2010)

Earthquake can be classified into three categories: [11]

(i) Major Earthquake: This is considered as severe that is considered having 10% probabilities over the time period exceeded of 50years and the impact will be devastating and cause severe loss of lives and damages to properties.

(ii) Moderate Earthquake: In this part the probabilities are 50% over the time period exceeded 50 years

(iii) Minor Earthquake: This will produce light or moderate ground shaking over short duration time.

Site Investigation

The site investigation study for the SMART Tunnel Project was very beneficial as it gives the wide ideas of the site investigation undertaken in Malaysia. The

site investigation not only covers the geophysical investigation but also the surface layers.

The study on the karstic limestone formation that is found surrounding the project site and also this is the main soil formation in Kuala Lumpur other than clay layers. The geophysical and surface studies are conducted in order to build the tunnel in a proper design. In order to plan for the construction and the design of the tunnel, first you have to conduct the site investigation to determine the type of structural design, financial aspect, type of construction machineries etc.

Flooding

Flash floods are defined as a rapid flooding in low lying areas, [12] rivers streams usually caused by the intense rainfall cause by thunderstorms. Most flash flood occurs because of the intense rainfall cause the ground location where the thunderstorm takes place becomes saturated and could not absorb or accommodate the heavy downpour. The rainfall runoffs are collected in the low level areas and will flow down to the downhill areas. Other than the intense downpour, flash flood also can be caused by cloaked drainage system, Shallow River and also bad sewer design.

Flash floods are dangerous because it can happen in a split of time and nobody will notice it. The water level especially in urban areas can rise into critical levels as there will be no warning. This is dangerous as the water can be a good conductivity for electrical cables, damages to property and lives. Flash flood water has the capacity or force to move boulders, bring down trees and properties and obliterate bridges. Below is the picture of flash flood occurrences in the Klang Valley.

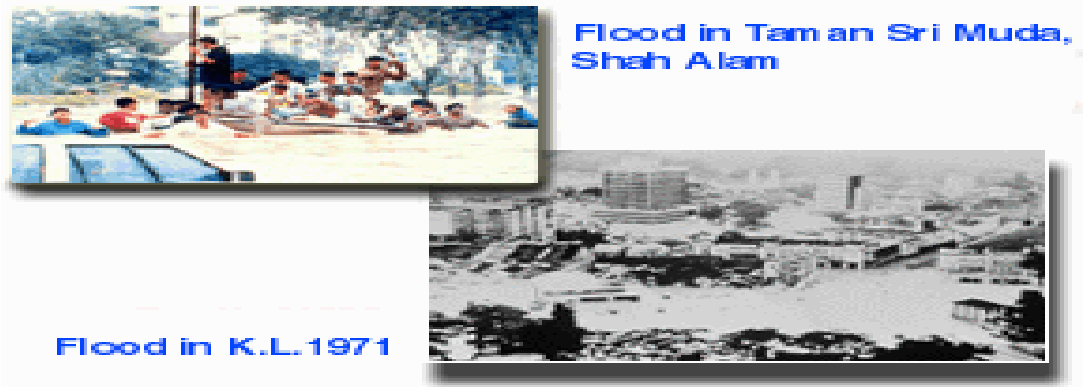

Figure 10: Flash Flood in Malaysia
Source: DID (2002)

Flood water is one of the common natural disasters that happen in almost every corner of the world. [13] The global warming that is melting the ice in the arctic region worsens the situation. This directly causes the sea water level to rise gradually. Most floods have enough capacity to change the direction of the river and also damage the properties and cause loss of thousands of lives yearly. Flash floods are one of the most dangerous flooding scenarios because this happens without warning.

A flash flood can be defined as a fastest moving flood that cause severe destructive along the pathway. Heavy downpour that is collected in a stream or gully turns the scene from calm to instant rushing force. This is the main cause of loss of lives and damage in properties as the flood will catch the people off guard as seen below.

Figure 11: Flash Flood in Klang Valley
Source: DID (2002)

Interaction between Flood and Weather in Malaysia

Flash flooding in Malaysia is becoming very common as more development and urbanization are taking place in a great velocity. Malaysia is one of the countries in Asia that has flood problems. This is as a result of the tropical weather that causes high rainfall intensity in the region. Most floods or flash flood occurs during the monsoon season from November till January (Flood Commission, 2010).The worst flood situation in Malaysia happened in 1926 and followed by 1931, 1947, 1954, 1957, 1967, 1971 and 1992. [14] It was estimated that almost 9% of the location in Malaysia (26000kmsq) are flood prone during monsoon season. [8]

Malaysia is one of the countries in South- East Asia that have very high rainfall intensity. The main states that have flood problems are Penang, Kula Lumpur, Terengganu, Kedah and Kelantan. The highest rainfalls in Malaysia are during the monsoon season from mid-November to March. In this season the east coast of peninsular Malaysia, east coast of Sabah and coastal area of Sarawak will experience heavy downpour. In November and early December, the monsoon weather will reach the west coast of peninsular Malaysia. [15]

This will result heavy thunderstorm in major parts of West of peninsular Malaysia. The monsoon season will begin in the coastal of Kelantan and Terengganu in November. This will spread to Pahang and east of Johor. The weather in Malaysia especially in peninsular Malaysia is monitored by the Meteorological Department. There are 18 numbers of stations scattered around all the potential rainfall areas in West Malaysia.

Flash Flood in Klang Valley (Kuala Lumpur)

Klang Valley Kuala Lumpur the capital city of Malaysia. The city's population is estimated to be about 1.8 million people. Kuala Lumpur is a major hub for financial, education, work, living and tourism. Previously, Kuala Lumpur was the administrative capital of Malaysia, but has moved to Putrajaya. Malaysia is one of the countries in the world that have high rainfall intensity with average of 3000mm annually and this makes the country rich in water resources. [7] The amount of water in Malaysia especially the rainfall is seasonal. This is because in some months of the year there will be high rainfall while some are not. Flooding and drought are the results of this situation. Flood is the most common problem in Malaysia. Excess rainfall cause frequent flash flood especially in cities like Kuala Lumpur.

There are several other factors that may contribute in flash flood. As we know flood usually are not manmade but it is caused by natural phenomena. This can be over ruled as currently most flash flood is

caused because of the over development of the particular place. Kuala Lumpur is one of the cities that have the common problem. Even the metropolitan city with proper drainage system has the same common problem. This is because new developments and skyscrapers cause the total impervious area to rise and the drainage of water into ground are reduced.

Most development are done with most impervious areas are estimated around ten percent. Most developers usually go for maximum development or in other words make as much money as possible in that particular area. Concerns on this type of minor matters are usually disregarded. In previous years before urbanization takes place, the rainwater runoff will usually be intercepted by the vegetation, infiltrate into ground and then runoff to the rivers by underground stream line.

Modern urbanization had interrupted this process as now the rainfall are collected from the roofs and other paved ground such as roads and channeled into the sewer line that will be diverted into the nearby natural rivers.

This causes over flooding of water in that particular river when the river takes natural rainfall and also the water intake from the nearby township that channels the water to the river by drainage system. In Malaysia, it is found that there are estimated 29,000km2 of average nine percent of the total land area in this country that are flood prone and affecting 4.9 million people. [16] There are modern solution to this situation especially the frequent flash flood in Kuala Lumpur that caused the country to loose RM1billion to reinstate the situation every time flood happen. [16]

Figure 12: Flooding in the heart of Kuala Lumpur
Source: DID (2002)

Methodology

Research approach

The research design shows how the research is carried out using the objectives and related variables linking them with the method to be adopted in order to achieve the stated objectives. The research used in this study is a qualitative research approach.

Qualitative research

Qualitative research involves the use of interview survey, observation and document review. [17] However, qualitative research should be specifically aligned with action research and critical hermeneutics traditions and that qualitative researcher 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. Which correlates with qualitative research has become an acceptable, if not a mainstream form of research in many different academic and professional fields. [17] 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.

The researcher used qualitative research tools for gathering information which include: Participant observation, semi-structured interview and analysis of documents and materials. The summary of (data collection and data analysis) methods under the qualitative data analysis techniques illustrate the suitable research instruments adopted to answer each research objective.

Research Tool

Research strategy is a general approach to research determine by the kind of question that the research study hope to answer. This study adopted only one research strategy: i.e. Case Study Approach. [18]

Qualitative 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 opined that 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. There are three main direction for analyzing qualitative data, they are; Thematic analysis, meaning generation and confirmation, synthesis and illumination. [19]

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. 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.

Thematic Network Analysis

Thematic analysis seeks to unearth the themes salient in a text at different levels, and thematic networks aim to facilitate the structuring and depiction of these theme. It is not grounded in any particular theoretical and epistemological framework and can therefore be applied across a wide range of qualitative research approaches. Thematic analysis is a search for themes that emerge as being important to the description of phenomenon. The process involves the identification of themes through careful reading and re-reading of the data. It is a form of pattern recognition within the data, where emerging themes become the categories for analysis. In seeking to analyze data, thematic analysis can either identify the themes pertaining to a particular research question (deductive analysis) or it can identify themes that are observed across the entire data range (inductive analysis).

Inductive thematic analysis occurs when the researcher observes themes from the data without having had a particular preconception of the various themes that would emerge. Deductive thematic analysis on the other hand, is guided by the researcher's particular thematic interest and seeks to analyze a specific area of the data.

Data Analysis

All interviews that have been undertaking have been transcribed word for word, by using thematic network analysis as a means of analyzing data from the field.

Area of Investigation 1: To identify the causes of flood Disaster in the city centre of Kuala Lumpur Malaysia

The interview conducted at the Drainage and Irrigation Department as well as Malaysian Highway Authority explored the causes of flood disaster in the city centre of Kuala Lumpur Malaysia which are examine carefully and analyzed by thematic network analysis for the area of investigation as shown in figure 4.9 below.

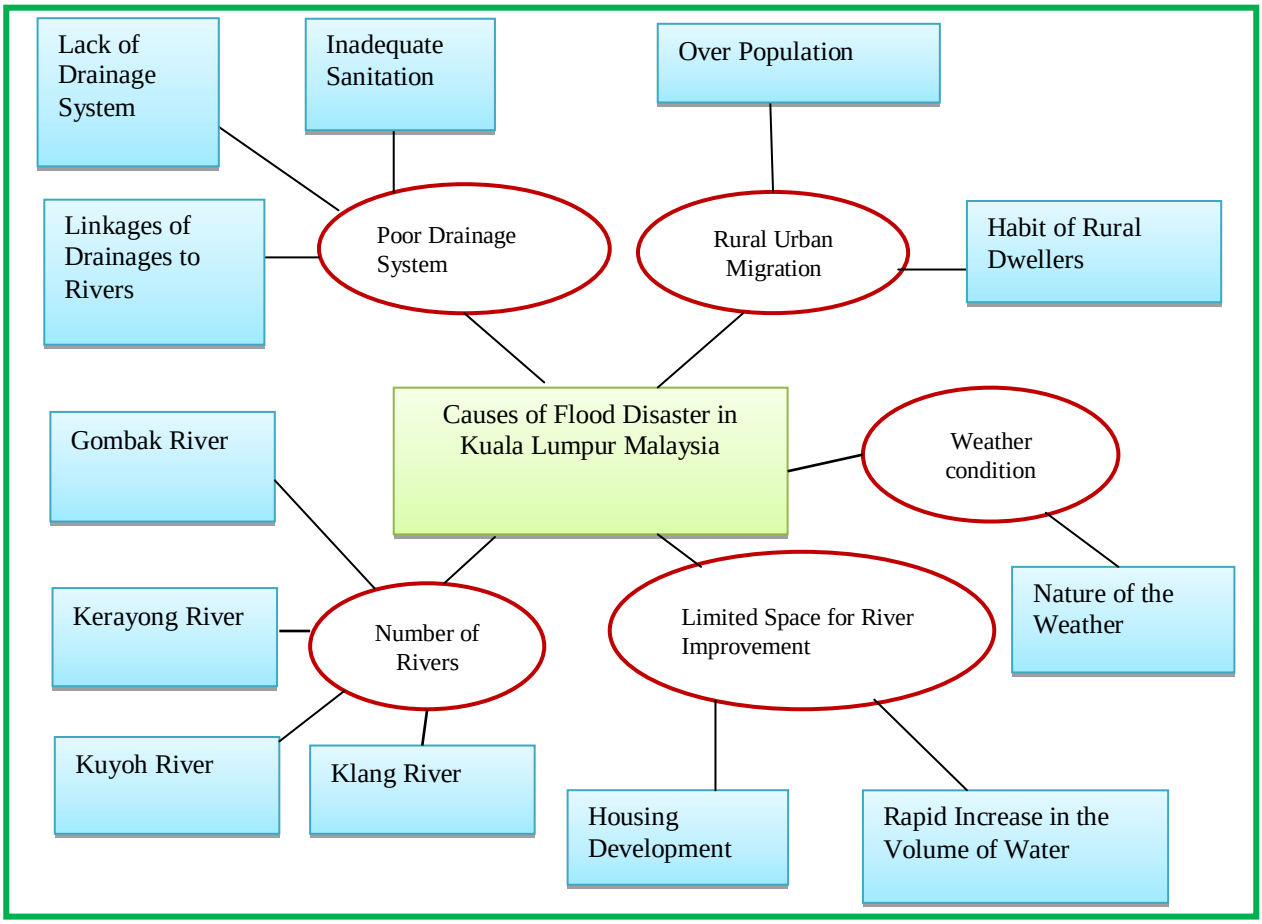

Figure 13: Causes of Flood Disaster in the City Centre of Kuala Lumpur Malaysia
Source: Interview Survey (2014)

Theme 1: Poor Drainage System

The response from interviewee 'A' from the Drainage and Irrigation Department confirmed that lack of drainage system in the city centre of Kuala Lumpur tremendously cause the flood disaster in the city center of Kuala Lumpur, whereas respondent 'B' in the same organization states that inadequate and infrequent sanitations of the existing drainages lead to the flood disaster in Kuala Lumpur. Similarly, respondent 'C' in the Drainage and Irrigation Department reaffirmed the statement made by respondent 'B' and also said if there is a constant sanitation of the drainage system in the city centre of Kuala

Lumpur the rate of flooding will be very minimal.

However, respondents 'D' in the Malaysian Highway Authority explained that direct linkages of drainage systems to the river contribute immensely to the rapid growth of the river level which leads to the overflow of the river banks in to the city centre of Kuala Lumpur, whereas respondent 'E' from the same organization with respondent 'D' confirmed that if there is available ponds that can be linked to the drainage system in the city centre of Kuala Lumpur for the absorption of water that came through the drainage system will help in protecting the city centre of Kuala Lumpur against the flood disaster.

Theme 2: Rural Urban Migration

According to the respondent 'A' from the Drainage and Irrigation Department rural-urban migration lead to the over population of the city centre of Kuala Lumpur which resulted in forcing people to be living in a flood prone areas in the city centre of Kuala Lumpur, whereas respondent 'B' also from Drainage and Irrigation Department reaffirmed the statement of respondent 'A'. Similarly, respondent 'C' from the same organization with respondent 'B' says that the opportunities that are in the Kuala Lumpur lead to the rural-urban migration which lead to the over population of the city centre of Kuala Lumpur and as well lead to the insufficient housing which force people to be living in the flood prone areas in the Kuala Lumpur Malaysia.

However, respondent 'D' from the Malaysian Highway Authority confirmed that the habit of rural dwellers contribute immensely in the flood disaster in the city centre of Kuala Lumpur in the sense that you will find an immigrant living in the flood prone areas not like those that are from the city centre of Kuala Lumpur. Respondent 'D' says that it is only the rural dwellers that you will found living in the flood prone areas, but those that are from the city prefer to be living in the far away areas despite the fact that their working place is in the city center of Kuala Lumpur Malaysia.

Theme 3: Limited Space for River Development

Respondent 'A' stated that limited space for river development cause the flood disaster in the city center of Kuala Lumpur Malaysia. He also said that rapid increase in the volume of water from houses lead to the limited space for river development which leads to flood disaster in the city centre of Kuala Lumpur. Respondent 'B' reaffirmed what respondent 'A' said so as respondent 'C'.

However, respondent 'D' disclosed that housing development in the city center of Kula Lumpur resulted in the limited space for river development. Similarly, respondent 'E' reaffirmed the statement of respondent 'D' and also said in any flood disaster management there is a need of river development and widening for it to accommodate as many cubic meters of water as possible, but housing development in the city centre of Kuala Lumpur resulted in inadequate river development.

Theme 4: Number of Rivers

Respondent 'A' stated that the number of rivers in the city centre of Kuala resulted in flood disaster where he said there are four rivers in the Kuala Lumpur. Similarly, respondent 'B' said that the number of rivers contribute in flood disaster in the city centre of Kuala Lumpur Malaysia. Respondent 'C' reaffirmed the statement of respondent 'A' and said the rivers are Gobmak, Kerayong, Kuyoh and Klang rivers.

Respondent 'D' from Malaysian Highway Authority said that due to the

number of rivers in the city centre of Kuala Lumpur SMART Tunnel is able to cover only the target area in the heart of Kuala Lumpur around Masjid Jamek, Jalan Tun Perak, Dataran Merdeka, Kampung Baru, Jalan Munshi Abdullah, the Old Court Complex, Jalan Melaka, Jalan Tunku Abdul Rahman and low-lying areas in the surrounding area has no longer experienced flash floods due to overflow of the Klang River. Respondent 'E' reaffirmed the statement of respondent 'D' where he confirmed that due to the number of rivers in the city centre of Kuala Lumpur SMART Tunnel is able to cover a flash flood from Klang River.

Theme 5: Weather Condition

Respondent 'A' stated that the weather condition especially the rainfall distribution in the city centre of Kuala Lumpur is among the causes of flood disaster in the city center of Kuala Lumpur. Respondent 'B' states that the rainfall distribution is even in the city centre of Kuala Lumpur which resulted in flood disaster. Similarly, respondent 'C' reaffirmed the statement of respondent 'A' and said that the rainfall distribution tremendously contribute to the flood disaster in the city centre of Kuala Lumpur Malaysia.

However, respondent 'D' said that the annual rainfall distribution of Kuala Lumpur is 2,600mm which contribute to flood disaster in the city centre of Kuala Lumpur. Moreover, respondent 'E' reaffirmed the statement of respondent 'D' and said that the minimum rainfall distribution in Kuala Lumpur id 2,600mm.

Area of Investigation 2: To identify the role SMART Tunnel plays in the city centre of Kuala Lumpur Malaysia.

The interview conducted at the Drainage and Irrigation Department as well as Malaysian Highway Authority explored the causes of flood disaster in the city centre of Kuala Lumpur Malaysia which are examine carefully and analyzed by thematic network analysis for the area of investigation as shown below.

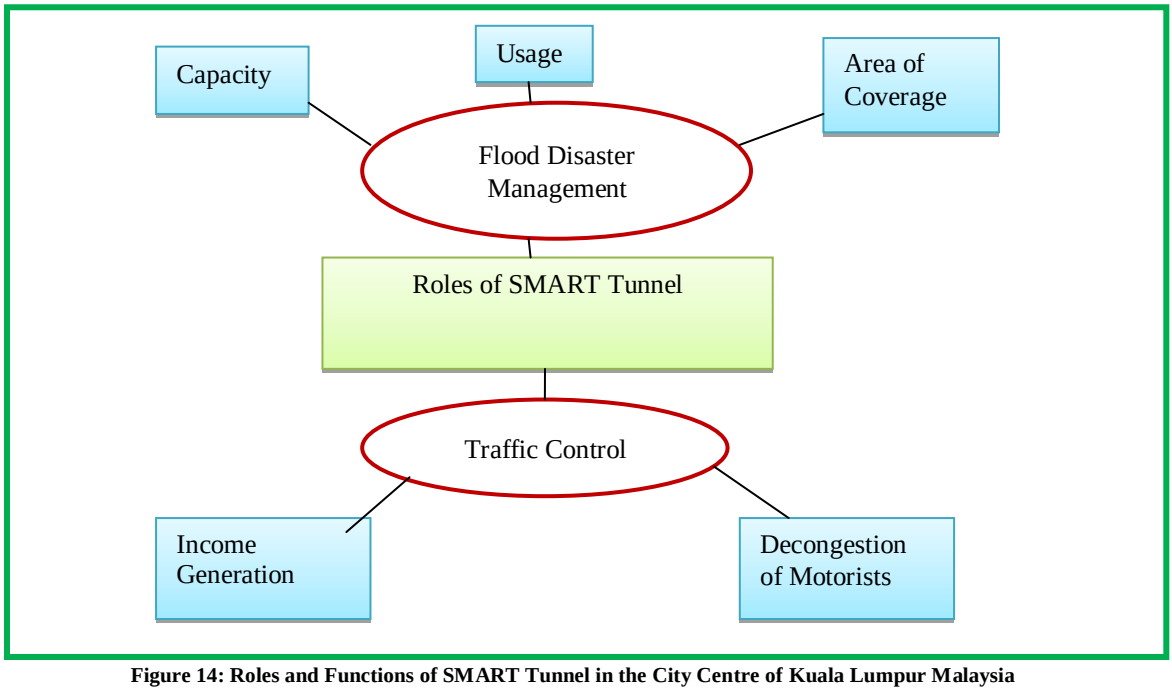

Figure 14: Roles and Functions of SMART Tunnel in the City Centre of Kuala Lumpur Malaysia
Source: Interview Survey (2014)

Theme 1: Flood Disaster Management

The response from interviewee 'A' from the Drainage and Irrigation Department confirmed that SMART Tunnel plays a very vital role in flood disaster management in the city centre 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 used over 80 times 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 80 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, he further listed the targeted area of SMART Tunnel as (around Masjid Jamek, JalanTun Perak, DataranMerdeka, KampungBaru, JalanMunshi Abdullah, the Old Court Complex, Jalan Melaka, JalanTunku Abdul Rahman and low-lying areas in the surrounding area). He confirmed that since the SMART Tunnel was launched these places had never experience flash flood.

Theme 2: Traffic Control

According to the respondent 'A' from the Drainage and Irrigation Department he said that the secondary function of SMART Tunnel is to minimized the traffic congestion during rush hour in the city centre of Kuala Lumpur, whereas respondent 'B' reaffirmed the statement of respondent 'A' and added that over 30,000 motorist are using SMART Tunnel every day. Similarly, respondent 'C' reaffirmed the statement of respondent 'B' concerning the roles and function of SMART Tunnel in the city centre of Kuala Lumpur Malaysia.

However, respondent 'D' from the Malaysian Highway Authority stated that SMART Tunnel has been the means of income generation to the Malaysian Government whereby Malaysian Government gave the SMART Tunnel as a 40 years concession to the contractors that invested RM621million in the construction of SMART Tunnel, whereas Malaysian Government invested RM1.31billion, he further added that SMART Tunnel costs RM1.93billion in its construction. However, respondent 'E' stated that it is used as an alternative solution to traffic congestion in the city centre of Kuala Lumpur.

Area of Investigation 3: To evaluate the impact of the SMART Tunnel in flood Disaster Management in Kuala Lumpur Malaysia.

The interview conducted at the Drainage and Irrigation Department as well as Malaysian Highway Authority explored the roles that SMART Tunnel plays in flood disaster management. Among the 5 respondents none of them said SMART Tunnel did not protect the people at the targeted area against the negative impact of flood disaster in the city centre of Kuala Lumpur Malaysia.

However, the hypothesis that the researcher is going to test are:

(i) **Null hypothesis (Ho):** There is no significant impact of SMART Tunnel in flood disaster management in Kuala Lumpur Malaysia.

(ii) **Alternative hypothesis (H1):** There is significant impact of SMART

Tunnel in flood disaster management in Kuala Lumpur Malaysia.

The 5 respondents of this research will be used to test the hypothesis at 0.05 level of significance. If the calculated value of chi-square is greater than the critical value, the null hypothesis should be rejected; otherwise the null hypothesis should be accepted.

Table 1: Chi-Square

Response	fo	fe	Fo-fe	$(Fo-fe)^2$	$\frac{(Fo-fe)^2}{fe}$
Yes	5	2.5	2.5	6.25	2.5
No	0	2.5	-2.5	6.25	2.5
Total					5

$\frac{(fo-fe)2}{fe}=5$

However, the critical value at 0.05 level of significance at one degree of freedom is 3.84.Since the calculated value of chi-square is 5 that is greater than critical value at one degree of freedom at 0.05 level of significance (3.84), the null hypothesis should be rejected, and the alternative hypothesis should be accepted. This implies that SMART Tunnel plays a very vital role in flood disaster management in the city centre of Kuala Lumpur Malaysia.

SUMMARY

Tunnels play a vital role in our way of life as it ease the method of transportation in urban cities in the world. Tunneling works came in to being in eighteen century, the technology and the construction method had developed over time. The current technologies used in tunnels construction around the world are becoming greatly develop and very efficient. In recent years technology has introduced new sets of tunneling technologies such as the tunnel boring machine (TBM). In this paper, SMART Tunnel in Malaysia had shown the new steps taken by the Malaysian Government to upgrade the national's urban transportation system in the capital city of Kuala Lumpur. This tunnel is a recipient of so many accolades; it is the only kind in the world that introduces the wet and dry system. This tunnel is used to drain out the flood water from the Kuala Lumpur city center and also to reduce the traffic congestion in the Southern Gateway (Sg. Besi Highway).

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How to cite this article: Isah N, Ali MB. A thematic analysis on the causes of flood disaster and roles of smart tunnel in flood disaster management in Kuala Lumpur Malaysia. Int J Res Rev. 2015; 2(10):624-640.

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