Improving Flood Management, Prediction and Monitoring

Facts and Trends of Urban Exposure to Flash Flood: A Case of Kuala Lumpur City

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ABSTRACT

Kuala Lumpur, the capital of Malaysia, is exposed to several natural hazards, among which flash floods are most common and frequent. Expanding development and higher intensity of rainfall are the primary causes of flash floods. As the urbanisation is growing, the number of exposed properties, people and business premises are also increasing. This may have a detrimental impact on the socio-economic state of the city. Therefore, the purpose of this chapter is to investigate the frequency and intensity of flash flood occurrences between 2011 and 2016 and to delineate how it is impacting the urban livelihood. For this study, several news reports of flash flood events, previously published and reports were reviewed to elicit information so that the frequency and intensity of flash floods can be analysed for identifying flash flood risk areas. Along with the information from newspapers, Google map was used to identify the spatial locations of flash flood events, thus identifying the risk zones. This study found the City Centre as the most risk prone to flash floods. It was noted that 39% of flash floods occurred in this place. The Damansara-Penchala area comes in the second position with 20% of flash floods occurring in this place. Most of the people of these zones are exposed to flash flood and the affected people suffer from road blocking and heavy traffic jam. This study will help researchers and policymakers to

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understand the impact of flash floods in the city. This will also help to identify the most flood-prone areas of the city.

Keywords: Economic exposure; loss and damage; urban disaster loss; disaster risk reduction; flash flood; natural hazard

INTRODUCTION

Flash flood events are common phenomena in the capital city of Malaysia. Every year, the city experiences several flash flood events, especially during the monsoon period. This city is located in the floodplain area of the river Klang. The confluence of two major rivers Gombak and Klang is situated right in the centre of the city. As a result, flood experience in the city is inevitable and common. The most widespread flood in the city was the 1971 flood. After this flood, both structural and non-structural measures were taken (Abdullah, 2004) which included improvement of the river channel, construction of levees, construction of flood by-passes, construction of sediment traps and improved hydrological data (Hong & Hong, 2016). However, the scenario of the recent years reveals that the problem has worsened instead of getting resolved.

Most of the flash flood events in urban areas are due to anthropogenic causes. It is because, due to urbanisation, the surface condition changes a lot, especially the amount of vegetation, type of soil, land use and many other factors are altered due to the development process. As a result, the water runoff, distribution and infiltration get affected (Scholz, 2004). The inevitable consequence of such changes is reflected through flooding most of the time. The biggest sufferers of urban flooding are not only the people living in the city but also those who come to the city every day for various purposes. Consequently, the anthropogenic attempts at resolving the crisis are also formidable. For example, in Kuala Lumpur, a project called Stormwater Management and Road Tunnel (SMART) has been carried out to resolve the flash flood problems at an estimated cost of RM 1.8 billion. SMART is a multi-purpose project which at the same time mitigate flood, manage traffic and improve safety by managing stormwater (SMART, n.d.). However, despite the successful implementation of the project from 2007, the city still suffers from a significant number of flash flood events.

The population in the city is increasing every year. As a result, not only do people exposed to flash floods increase but also properties, infrastructures and many businesses and economic activities are exposed to these frequent floods. Flash floods are small in nature and have a shorter duration. However, the impact is never negligible in urban areas. As the city is the centre of economic, business and administrative activities, even a small-scale hazard may result in a considerably wider impact. That is why flash flood events are not to be neglected because of their undersized and short periodical nature. The purpose of this chapter is to investigate the frequency and intensity of flash flood occurrence from 2011 to 2016. The study aims to answer what places are more flash flood

prone and how many people and properties are exposed to them. This will help researchers and policymakers to understand the impact of flash floods in the city and help to identify the flash flood-prone risk areas of the city.

The city is the busiest and economically most productive centre of the country. Therefore, almost anything disrupting happens in it will have an impact on the entire country in one way or another, especially from the economic perspective. The forest fragmentation and its correlation to human land use as well as changes in landscape spatial pattern in the state of Selangor were studied and researchers argued that the state socio-economic development is mainly influenced by the Federal Territory of Kuala Lumpur (KL) (Abdullah & Nakagoshi, 2006, 2007). In the state where KL is situated, land use change is largely contributed by the increase of urban and build up area. This indicates that the impact of urbanisation and its rapidity is reflecting significantly in this area (Abdullah & Nakagoshi, 2007). Currently, flash flood events are one of the major issues in the KL's urban life. Therefore, the socio-economic disruptions, physical destructions and their impact due to flash flood may affect the population in various forms. Boori, Netzband, Choudhary, and Voženílek (2015) studied the urban growth of KL in last three decades and found that the urban built-up land cover is a significantly increasing class in terms of land use. As more and more people are heading to the capital and consequently the demand for urban land use is increasing, the urbanisation is not only one of the major causes of flash flood but also results in increasing the number of people and properties exposed to flash flood risks. In addition, the city is not only getting populated and congested due to massive infrastructural development but also expanding its surroundings outwardly (Boori et al., 2015). This may make more places prone to flash floods and more properties and peoples exposed to their impact. Yusof, Ismail, Chan and Ibrahim (2004) found that squatter settling is one of the major causes of urban flood hazards. Chan Ngai Weng (2011) further discussed the issue showing many research reviews about how squatter settling contributed to make places flood prone in KL. Some other major causes of flash flooding are blocking of the drainage channel, surface runoff increase, poor drainage maintenance and uncontrolled urbanisation (Nasir & Othman, 2015).

In KL, expanding development coupled with the higher intensity of rainfall is the primary reason of flash floods (Fugura, Billa, Pradhan, Mohamed, & Rawashdeh, 2011). The results of flash floods are usually reflected in road blocking, moving or damaging of large objects, interruption business and damaging of properties. Since flash floods in KL usually take place due to heavy rainfall and windstorms, falling of trees and destruction of electric posts also occurs. Therefore, in a busy city like KL, this leads to negative economic impact. However, the significance of economic impacts are a matter of separate focus and investigation. The immediate results of flash flood events in the city are traffic jam, damage to property and business premises, road damage, interruption to utility services and transportation systems (Nasir & Othman, 2015).

Study Area

KL, the capital city of Malaysia, is 143 km^2 large with an estimated population of 1.73 million (Department of Statistics Malaysia, 2018). The Greater KL area, also known as Klang Valley, and which covers the entire boundaries of the metropolitan area, covers 2,793.27 km^2. The city is basically located at the confluence of Klang and Gombak River. A valley named after the Klang River called Klang Valley embodies the unique features of the city. It is located at the middle-upper reaches of the Klang River and the headwaters of this river comprise of thick tropical jungle-covered mountains and steep terrain. The city is a tropical rainforest climate area where it is usually warm and sunny, and the rainfall is abundant during the year of October to March, the northeast monsoon season. The temperature of the city is steady at the range of maximum 32−33°C and minimum of 23−24°C (Elsayed & Che, 2006; McGinley, 2011). The city is one of the fastest growing cities in the country. The urbanisation progress of the city may result in a complex environmental situation as it usually does in other cases (Al-shalabi, Billa, Pradhan, Mansor, & Al-Shari, 2013; Al-sharif, Pradhan, Mohd Shafri, & Mansor, 2013; Alsharif & Pradhan, 2014; Jebur, Mohd Shafri, Pradhan, & Tehrany, 2013; Mahmoud, Elbialy, Pradhan, & Buchroithner, 2011; Tehrany, Pradhan, & Jebuv, 2013). The city is exposed to natural hazards like flash floods, heat Island, Landslides and haze. Due to the unique geographical characteristics of the Klang Valley and the relatively congested constructions in the city, KL is exposed to flash floods.

MATERIALS AND METHODS

Review and Content Analysis

This study is fully based on secondary data. The data sources of this study are mainly online news reports by several mainstream news portals. Previous peer-reviewed publications and reports were also reviewed to collect data.

Identifying Flash Flood Risk Areas

Flash flood occurrences were first collected from news reports. The affected places were identified from the same sources as well. The number of occurrences within the stipulated time period were then analysed to find out which places are more prone to flash flood. The places in which flash floods occurred were then marked on the map to highlight the areas. We used the graphical method to analyse the trend and fact analysis.

Locating the Flash Flood Areas

KL is a federal territory which has six strategic location. This study identified the distribution of the flash flood occurrences in six strategic locations using google earth.

Methods of Analysing

The methods of analysing flash flood facts and trends are through simple graphs and table presentation. The graphs and tables were used to compare and analyse the flash flood scenario in the city.

Classifying as Flash Flood

The water department of Malaysia classifies water inundations as flash floods depending on the area and inundation level. In our study, we focus on public perception. Our focus is to go beyond the boundary of classification framework so that the real effect of the flash flood can be accommodated in the analysis. This is because some inundations may not be classified as flash floods according to the water department of Malaysia but the affected people may see them as such. The reason for choosing newspapers reports is to identify those flash floods that affected the people around. This also shows that these flash flood can appear again on a larger scale. Therefore, we selected flash floods that had been reported by several newspapers to maintain the quality of information and to avoid mixing insignificant inundations with flash floods.

RESULTS AND DISCUSSION

In KL city, the roads are mostly affected by flash floods. That means motorists and business premises are more exposed to flash floods. Among flash flood-prone areas, Jalan Duta (Jalan Tuanku Abdul Halim), Jalan Tun Razak and Jalan Pudu are the top in the list. Our analysis does not only include KL federal territory but also the outer periphery of the city, since most of the flash floods occur on the motorways, due to which the exposures and impact can also be carried out beyond federal territory. Another reason for including places from the outer periphery of KL federal territory is that those places are also urban areas. Therefore, for getting a more comprehensive picture, we decided to include the outer periphery as well.

In the greater KL area, about 80 places were found affected by flash floods according to several news reports published in the news portals. Among those, 64 places are very close to KL federal territory. Since people move in and out of the city for economic, business and other purposes every day, many roads being affected indicate that many economically important facilities and major means of connectivity are exposed to flash floods. That means that, although some places are out of KL federal territory, they may have economical interruption through road blocking, traffic jam and working hour loss. For example, the number of daily vehicles crossing the MRR I is 1.305 million and the MRR II is 2.125 million (DBKL, 2008). This means a flash flood in these two expressways may lead to a huge amount of time loss in the street, loss in working hours and communication disruptions, all of which have an economic impact as the dependency of productivity depends a lot on functioning transportation and communication systems. In the same way, all roads that are affected by flash floods may result in a large number of cars, business peripheries and working

Table 1. Ranking of the Streets and Strategic Zones According to Flash Floods Occurrences.

		2011	2012	2013	2014	2015	2016 (June)	Total	Rank
Strategic zones	City Centre	6	2	6	4	1	6	25	1
	Damansara-Penchala	2		4	2		5	13	2
	Wangsa Maju-Maluri	2		1	3	6		12	3
	Bdr. Tun Razak-Sg.Besi	1	1	1	4	2	1	10	4
	Sentul-Menjalara	1			1	1	1	4	5
	Bukit Jalil-Seputeh			1				1	6
		Number of Flash Floods							
Name of the streets	Jalan Duta (Jalan Tuanku Abdul Halim), Jalan Pudu, New Pantai Expressway and Jalan Tun Razak	4						20	1
	Jalan Cheras Lama, Jalan Chan Sow Lin, MRR2 and Jalan Raja Chulan	3						12	2
	Jalan Mahameru, Jalan Parlimen, Jalan Sultan Ismail and Jalan Ampang	2						8	3

Source: Newspapers.

hours, as well as people being exposed to flash floods. Table 1 shows flash flood frequency and the ranking of the six strategic zones and affected roads.

From the outcome of the current analysis, we can rank the strategic zones and streets according to the number of flood occurrences (see Table 1). This will give an idea of which areas are riskier in terms of flash floods. While looking at the six strategic zones of KL, it shows which zones are more flash flood prone in the city. The City Centre is the most prone to flash floods. From 2001 to June 2016, there were 25 flash flood incidents in the City Centre area. This area is very active and busy for economic and business purposes and includes thousands of working centres and offices. Flash floods in these areas can also affect more business premises as business units are very congested in this area. Table 1 also shows the ranking of the streets. For example, Jalan Duta (Jalan Tuanku Abdul Halim), Jalan Pudu, New Pantai Expressway and Jalan Tun Razak can be ranked as most flash flood risk-prone streets as all equally have four occurrences in the given time period. In the same way, Jalan Cheras Lama, Jalan Chan Sow

Lin, MRR2 and Jalan Raja Chulan can be ranked as second most prone. Jalan Mahameru, Jalan Parlimen, Jalan Sultan Ismail and Jalan Ampang can be ranked as third most prone in the list.

As shown, Table 1 expresses the frequency of flash flood in the particular streets. This also indicates that many motorists and motor vehicles are exposed to flash flood. Those motor vehicles pass through the listed streets are certainly exposed to flash floods. It can easily be found out exactly how many people and motor vehicles are exposed to such occurances if the relevant data are available. In this case, the number of motor vehicles moving through the flash flood affected streets may provide a clearer picture.

Altogether, about 65 incidents of flash floods have been reported by newspapers in the stipulated time period. In 2014, the highest number of flash flood events occurred, which is about 14. The years 2013 and 2016 were the second most flash flood occurring years, when 13 events occurred. However, in 2016, where the data of the entire year have still not been assessed, it stands as the second most flash flood occurring year. Fig. 1 shows how each strategic zone was affected by flash flood (Fig. 1(a)) and in total what is the percentage of flash flood occurrences for each zone (Fig. 1(b)).

According to Fig. 1(a), 2012 is the least flash flood occurring year. The City Centre is the most prone to flash flood, then Damansara-Penchala zone is the second and Wangsa Maju-Malurizone is the third in position in terms of flash flood occurrences. A study by Nasir and Othman (2015) also found the City Centre as the most prone area to flash floods based on the report of the Department of Irrigation and Drainage (DID).

In Fig. 1(b), it can clearly be identified that the City Centre is the most flash flood risk area where 39% of the total flash floods took place in last five years. The second most flash flood risk area is Damansara-Penchala zone with 20% of a total flash flood occurring followed by Wangsa Maju-Maluri zone with 18%, Bdr. Tun Razak-Sg.Besi zone with 15%, Sentul-Menjalara zone with 6% and Bukit Jalil-Seputeh zone with 2%.

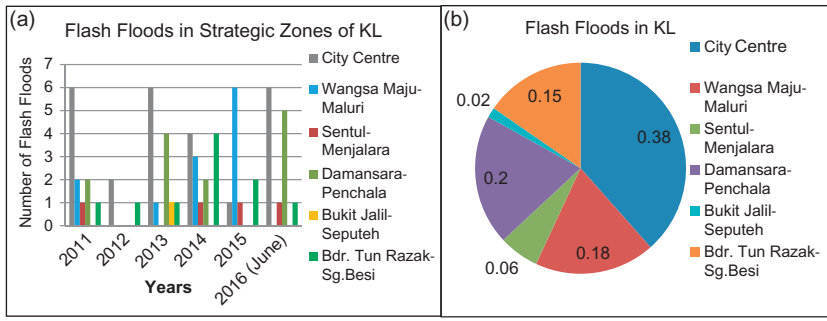

Fig. 1. Graphical Depiction of Six Strategic Zones in Terms of Flash Flood Occurrences. *Source*: Newspapers.

In a very general assumption, the more the people live in a particular flood-prone area, the more people will be exposed to flood at the place. Fig. 2 compares the population, density and flood occurrence trend to understand how the exposure to flash flood is changing over time. Fig. 2(a) shows the population and Fig. 2(b) shows the population density of the six strategic zones of KL. They also show the projected population and density of 2020.

In the City Centre, the most flash flood-prone area, almost 143,000 people are exposed to flash flood according to the 2005 density estimation (Fig. 2(a) & (b)). This number is likely to increase as a huge number of people move in and out of this part of the city every day for various purposes. In the long run, the population is expected to increase, which means that the population exposure will also increase according to the 2020 projection. As the most populous area of the city, as well as experiencing the highest number flash flood occurrences in a given time, this area holds the largest number of population, properties, business premises and land exposed to flash flood. As a highly congested area, even a small flood can affect more people, properties and business premises as compared to other places.

The Damansara-Penchala zone, which is second highest flash flood occurring zone of the city, contains 167,100 people with 3,521 people living per square

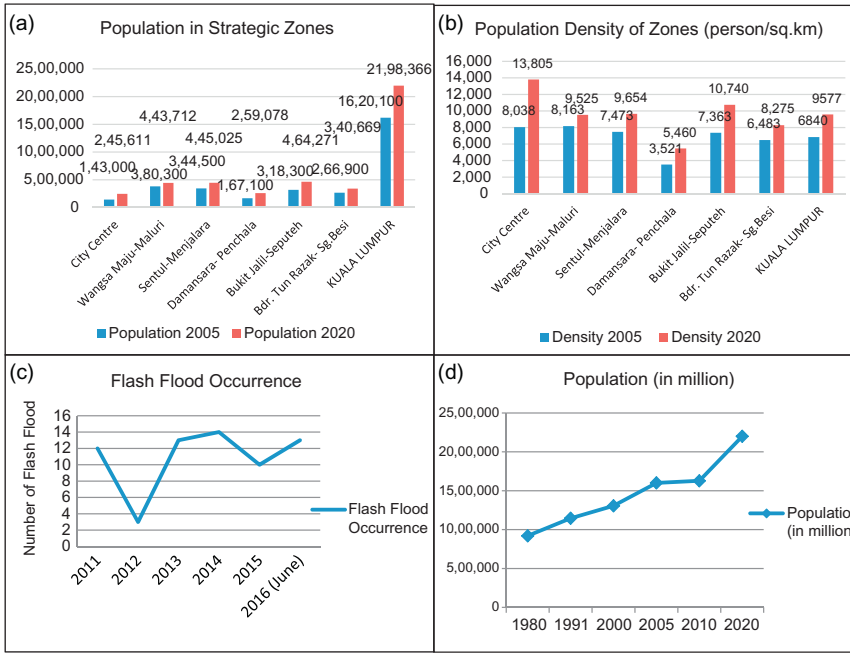

Fig. 2. Flash Flood Trend and the Exposure in KL. *Source*: KL Development Control Plan 2008 – Vol. 2, Part 1, KL City Plan 2020.

kilometer (Fig. 2(a) & (b)). This zone is comparatively larger than other zones and is a less populated area than the others. However, one of the portions of this zone is located just beside the City Centre. As a result, several important business centres, workplaces and public places are in this area. This makes this zone very busy as well. Like in the City Centre, thousands of people move in and out every day. Therefore, flash floods in this zone may have several impacts as well. Moreover, most of the flood took place in this zone is close to the City Centre. A similar analysis can be carried out for the third most flash flood-prone zone, which is Wangsa Maju-Maluri zone. About 12 flash flood affected areas have been reported by various newspapers so far. This place has 380,300 people living with 8,163 people per square kilometer density (Fig. 2(a) & (b)). Most of the flash floods of this zone also took place in the areas close to the City Centre. This similarity is also found in terms of Bdr. Tun Razak-Sg.Besi zone.

Overall, the trend of flash floods in KL is increasing. Except in 2012, the numbers of flash floods in KL have always been above 10. As shown in Fig. 2(c), the flash flood scenario is getting worse year by year. The scenario of the year 2016 is expected to be alarming. It is because the number of flash flood events in this year has only been recorded until June and up to that, the number of flash flood event is already approaching towards the highest point. This can be enough to come to the conclusion that breaking the previous years' record is only a matter of time and the number can go higher. As a result, more people, business premises and properties will be exposed in coming days.

It is obvious that the population is also increasing in the city. The population is expected to increase in future as well. As shown in Fig. 2(d), the increase in population trend will continue and in 2020, the population is expected to grow up to 2.2 million. That means, given the fact that the number of flash flood is also increasing (Fig. 2(c)), more and more people will be exposed to flash flood not only due to increase in population but also by increase in the number of occurrences. Beyond increasing population, even more people would be exposed to the risk to flash flood as the number of jobs created increases. As a result, more people will tend to enter in and exit from the city every day. Since most of the flash floods occur in the roads transportation system, working class people will be more affected from flash flood events. This will probably have a significant impact on the economic and social status of the city and the state itself.

CONCLUSIONS

Although flash floods in KL have natural causes like geographical location and construction, heavy rainfall and windstorm, the anthropogenic causes such as uncontrolled urbanisation, poor drainage system, blockage in water pass ways and many other causes are vital behind flash floods events. As the number of people is increasing in the city, more and more people are moving in and out every day, and infrastructural development is happening, the exposures to flash floods are also increasing in terms of people, working hours, motor vehicles, properties and many more. As the City Centre is the most flash flood risk area in the city and the heart of the city, a significant number of business premises,

people and touristic spots will be exposed in this place. As a densely populated zone, the number of people is expected to be higher than any zone in the city. This study identifies the risky zones, the frequency of flash floods and ranks the streets based on the number of flash flood occurrences. This helps readers to gauge what sectors and factors are to be affected the most by flash floods in KL. As has already been shown, high frequencies of flash floods in important streets suggest that a huge number of working hours, motorists, vehicles as well as leisure time will be lost due to flash floods. This study indicates that some very important future research may be carried out to identify the amount of loss and damage incurred due to flash floods and the impact of the flash flood on the working hours.

This study will help researchers and policymakers to understand the impact of flash floods in the city. This will be beneficial in planning city structure and development. This will also help to plan solutions for the most flood-prone areas of the city. The researchers and practitioners will be able to find the focus points to dig out more on the issue and test different approaches for investigating more queries derived from the insights discussed in this study. This study has several limitations such as considering only news reports to identify flash flood occurrences, using simple statistical and trend methodologies and not focusing on any sort of relational analysis. However, the potential of this study is that it necessitates deeper study and would guide such a study.

The city planners, policymakers and law enforcement agencies may look upon the issue to resolve it. This study recommends initiating more a sustainable and environmentally friendly city plan. The planner should be more careful and creative as rapid development and urbanisation initiatives are taking place. The City Centre should be given first priority to resolve flash flood occurances. The thrust of people into the city should be lessened by implementing more sustainable working hub distribution in the outward areas of the city. We suggest the flash flood risk areas should be repaired in a way that flash flood problems can be resolved. The city planners can also think about technologies by which massive amount of water can be moved out in a short period of time. The drainage system can be improved if possible and blockages in the water passage should be resolved by controlling and changing dumping behaviour of the people.

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