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Direct Impact of Flash Floods in Kuala Lumpur City: Secondary Data-Based Analysis

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Flash floods are the most common and disruptive hydro-meteorological phenomena that Malaysian cities experience most often. The capital city of the country, especially, is experiencing more incidences of flash floods than the past. Although flash flood does not always confine to monsoon seasons, the city experiences flash flood more frequently in this period of time of the years. While several mitigative and adaptive initiatives have been implemented, flash floods are still a major concern in the city. Therefore, it is important to revisit the matters for achieving the sustainability of Kuala Lumpur, bringing balance in the urban development and flood management. Understanding flash flood impact is also important for proper set-up and implementation of land use regulations, implementing stricter laws about socio-economic development of catchment areas. This paper quantitively analyses the direct impact of flash flood based on loss and damage perspectives. It focuses on the direct tangible and intangible impact of the flash flood in the city. That is to delineate what direct consequences are being actually experienced when the flash flood take place in the city. Flash floods are handled by these two separate departments in the city: Kuala Lumpur City Hall (DBKL) deals with drainage and street related flash flood while Drainage and Irrigation Department (DID) deals with river-related flash floods. This paper focuses on both stakeholders at the same time. The results show that the roads and highways, houses and vehicles are directly affected, damaged and disrupted by flash floods.

Keywords: flash floods, direct impact

I. INTRODUCTION

Flash floods are common phenomena in the capital city of Malaysia. Every year, the city experiences several flash floods. The location of the city is in the river basin of two major rivers (i.e. Klang River and Gombak River) which is also in the middle of a valley. As a result, floods are inevitable event in the city. Flash floods are mostly caused by the seasonal monsoon rain when inadequate drainage systems are unable to channel the water flow properly. The overflow of the rivers also a major reason for occurring flash floods in the city.

Various structural and non-structural measures were taken in the city after the first massive flash flood in the city in 1971 (Abdullah,

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2004) which include improvement of the river channels, construction of levees, construction of flood by-passes, construction of sediment traps and improvement of hydrological data recording (Hong and Hong, 2016). However, looking at the recent past, it seems the problem has worsened instead of resolving. For coping with the massive thrive of population growth, urban development, and expansion, it was much needed for bringing balance and efficiency in the performance of the city. In this flood management, several issues were given higher priority such as the proper set-up and implementation of land use regulations, more strict laws on socio-economic development of catchment areas. However, as a capital city, the pressure of multi-dimensional activities and changes in the landscape had never been eased rather increased day by day. The entry and exit of the extensive population every day in the city, migration from the rural side, massive urbanization and development were and still a nonstop process in the city. As a result, flash floods remain as one of the most serious environmental problems (Mahmoud and Alazba, 2016) of the city, which affected the efforts of Kuala Lumpur to achieve the goals of the sustainable city. That is why the flash flood risk and its impact, should be thoroughly understood by the professionals and planners involved in city management, designing, and monitoring development and changes in a city to build a flood resilient city (Hammond *et al.*, 2015).

Loss and Damage (L&D) concept pertaining to flash flood is very relevant because the climate change variability has a close association with them. Rainfall variability as a stressor of climate change plays one of the major roles to cause flash floods. L&D is a great concern in the climate change research community now. This concept has been discussed by many influential and international organisations and scientists. Yet, there is no universally agreed definition. However, there are enough studies that had been done by setting a working definition in the research community. This paper considers the working definitions of Warner *et al.*, (2012) that conceptualises L&D as "the negative effect of climate variability and climate change" to which people could not be able to cope or adapt with. Considering the frequency of flash floods in this dynamically important city, the very significant issue to be discussed is the socio-economic impact from both direct and indirect perspectives. It is because the increase in the frequency of hazardous events has a severe impact on urban areas through disruption in various important and critical aspects of city life (IPCC, 2014). L&D can be a more understandable and easy approach to identify the impact of the flash flood in the city. This paper focuses on only direct loss and damage for its investigation including tangible and intangible dimensions into the consideration.

L&D assessment has tangible vs. intangible dimensions; both of them are further divided into direct vs. indirect dimension (Asaduzzaman, M. *et al.*, 2013; Birkmann and Welle, 2015; Nafari *et al.*, 2016). It includes the avoidable adverse impact from the residual impact that has not been cope with and adapt to yet. Determining whether an L&D indicator will be categorised as direct or indirect and tangible or intangible will differ in studies to studies based on approaches. Some consider a particular L&D element as tangible if it can be bought or sold (Hochrainer-Stigler, 2012), some are of the position to consider an L&D element in the same category if it has or can be represented by a monetary value (EMA, 2002; Hochrainer-Stigler, 2012). Therefore, the element that cannot be bought or sold in the market or cannot be represented by a monetary value are the intangible L&D. The direct L&D, on the other hand, is considered by some when they are caused during the actual hazard event (UN General Assembly, 2016). Whereas, some studies are of the position that if L&D is caused due to the direct contact of the hazard event, they are to include as a direct L&D (EMA, 2002; Mechler *et al.*, 2010; Hochrainer-Stigler, 2012). Therefore, the indirect L&D elements are of those which are caused neither due to the direct contact nor during the time of the hazard.

Most of the flash floods occurred without any warning. That is why such floods are expected to be more damaging as affected people are not often prepared. There are various dimensions of flood impact in a city. In a comparatively small area, an urban place is usually congested with crucial and critical service and activity centres. A halt in such places could also cause significant communication interruption which ultimately hampers the networking systems pertaining to everyday mobilisation. All these, including the rapid urbanisation, have multiple consequential responses which can lead to massive socio-economic L&D too (Douglas *et al.*, 2008). These consequences can, directly and indirectly, affect the society. However, the direct impacts are crucial for finding validated clues for indirect and flow impacts. Therefore, by referring to secondary data, this study aims to evidentially examine the direct tangible and direct intangible impact of flash floods so that the consequential impacts can be tracked easily. This will put a remark on how progress has been achieved along the time to manage flash flood problems in the city and what ought to be done in future.

Urban areas are vulnerable to small but frequent climatic and hazardous events. A sudden hit of a flash flood in an urban place may impose various problems in the daily routine of the city and its dwellers. Multiple aspects of the productive sector can be shut down or interrupted, and a comparatively large number of assets can be at risk as well. A flash flood event can also cause severe destruction and damage to the relatively more vulnerable segment of people and assets. Therefore, the study on urban flash floods is very important and significant for a resilient and efficient city building goal.

A. Understanding flash flood scenario in Kuala Lumpur

Kuala Lumpur city experiences two kinds of flash flood around the year such as fluvial flash floods and drainage system induced flash floods. For each type of the flash floods, separate stakeholders are liable to handle and monitor the situation. The fluvial flash floods are dealt by DID, while drainage and street related flash floods are dealt by DBKL. For both types of flash floods, rainfall is playing a major role. However, clogged drains, narrowing water channelling ways and littering behaviour of the people and urbanisation are also contributing the flash flood hazard occurrences.

The flash flood of 1970, the most talked and referred flash flood of Kuala Lumpur, happened due to 2 to 3 hours of non-stop heavy rain. However, since the 2000s, the frequency of flash floods started to increase and become a major headache for the city dwellers (Abdullah, 2006). It is during this is time that the massive urban development also speeded up. This development process shrunk the open spaces, water passing passages, reduced vegetative cover and increased the build-up areas. These are also to be blamed for increasing flash floods in the city.

B. The consequences of flash floods in Kuala Lumpur

Flash floods have some unique characteristics such as they are sudden, unexpected and most of the time violent in nature. They last from few hours to a day-long in a relatively small area which may have occurred due to extensive rain, dam failure, ice jam and inadequate drainage systems (Esper Angillieri, 2008; Mohit and Sellu, 2013; Mouratidis and Sarti, 2013; Shrestha and Pradhan, 2015). Despite the comparatively short temporal and spatial size, they considerably cause a great economic loss, tangibly and intangibly. There are many high-rise office buildings, hotels, shopping complexes in Kuala Lumpur with a network of wide roads and commuter train system. There are many other facilities as well as utility control centre that are subject to be affected and thus cause costs by dislocation, disruption, and physical damages. Altogether, the losses become too high for a city like KL when the frequency is increasing over the time. The direct losses i.e. property damage and injury; the indirect impact i.e. interruption to public services; and economic activities can be affected which may lead more consequential adversity to a city (Mejía and Moglen, 2010; Smith *et al.*, 2012; Wright *et al.*, 2012). These may have further consequences by hampering office goers, school children, and college students' delay or absence in their daily works.

Therefore, the consequential impact and indirect losses are often higher than the direct losses in terms of flash floods; these indirect losses mostly come into being through traffic disturbance, water ponding on sidewalks and parking spaces (ten Veldhuis and Clemens, 2010). The residential and commercial sectors also bear a considerable damage through repair cost, cleaning cost, damage to the gardens and house contents. Another type of loss and damage that may also incur are such as the loss of value added in commerce and business due to interruption by flash floods, some small shops need to be closed after the disaster as damages to shop fittings, goods, raw material and machinery (Gasim, M.B. *et al.*, 2014). The loss and damage list can pile up by including increased fuel costs due to use of alternative transportation routes, time wastage due to traffic delays, and health costs in the purpose of treating illness for the people who get exposed to water bared and communicable diseases especially for children and the elderly people.

The social consequences of flash floods are also worthy of paying attention too. Despite the short duration of flash floods, the social impact is expected to be significant because of their sudden and unpredictable occurrences which leave the people unprepared. As a result, the disruption of living, dislocation and physical injury may cause a relatively severe impact on the affected people. These impacts are usually be reflected by the emotional and psychological condition of the people (Petersen, 2001; Mureithi *et al.*, 2015). The people in the squatter settlements and the urban suburbs, including who are relatively poor, are impacted by flash floods in different magnitude and manner. Several other factors such as evacuation, loss of personal property, fear of theft, and unwilling to move, losing irreplaceable times, disconnected from the community and home may also result due to flash floods (Yusoff and Chin, 2010).

The reason for the frequent flash flood is that large portion of forest and agricultural areas have been cleared up. These places are replaced by many types of development works such as concrete buildings, roads, and drainage system (Jamaluddin, 1985). As a result, the capacity of the soil to infiltrate rain water has been reduced. Additionally, it also results in the destruction of flora and fauna.

II. STUDY AREA

Kuala Lumpur, the capital city of Malaysia, is located in a valley named after the river Klang. The city covers an area of 243km^2 and has an estimated population of 1.79 million as of 2015 (Department of Statistics Malaysia, 2015). Kuala Lumpur is one of the fastest growing metropolitan regions in South-East Asia, in terms of population and economy. There are two major rivers in Kuala Lumpur named as Sungai Klang and Sungai Gombak. These two rivers are flowing through the urban areas that have already been choked up with sediment because of soil erosion from previous mining activities, housing, and rapid developments in the upstream. Due to the rapid development that cause clogged drain and overtopping of rivers, high rainfall often lead to flash floods in low-lying areas (Hong and Hong, 2016).

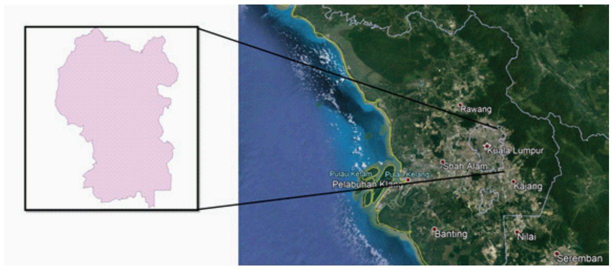


Figure 1. Kuala Lumpur, the study area

III. MATERIALS AND METHODS

This study is conducted based on secondary data. The data collected were for two different time periods and from two different sources. Flash floods in Kuala Lumpur are dealt by two separate stakeholders, DID and DBKL. These two departments have asymmetric data recording and management policy. DID upgrade their data set once every 10 years, and as a result, fluvial flash flood data could only be retrieved from 2000 to 2010 and the recent flash flood data could not be collected due to no data update has been done yet. On the other hand, DBKL started recording flash flood data from the year 2010 only. Therefore, drainage related flash flood data could only be retrieved from 2010 to 2016.

The data were analysed in the spreadsheet of Microsoft Excel. This study used a simple graphical approach to analyse and present the data. Since the data sets represent two different time frames, the analysation does not present a comparative scenario. However, this study demonstrates how the direct impact looks like in terms of both types of flash flood. Organising data, calculating the averages, totals, and percentages were done in the Excel Spreadsheet. The graphics such as bar chart and pie charts were also constructed using the Excel Spreadsheet.

IV. RESULTS AND DISCUSSION

As mentioned in the earlier section, flash floods are dealt by DBKL and DID. The state and policy of data recording are different in these two departments. DBKL begins to record flash flood cases from 2010 whereas DID records flash flood cases since 2000. As DID updates their data once in every 10 years, they can only provide flash flood data until 2010. As a result, the data from the two departments are in the different time frame. As no other option available, this study analyses two sets of data to understand the flash flood scenario in terms of both types of flood. Figure 2a and 2b represent flash flood scenario in terms of the days of flooding against the number of locations they hit on.

Although in a separate time frame, the numbers of fluvial flash flood days are much lower compared to the drainage related flash flood days. As both kinds of flash floods usually hit several parts of the city within a particular day, the numbers of affected locations are much bigger than the flash flood affected days. According to fluvial flash flood scenario, in a flash flood affected day, almost 8.5 (8.47 to be exact) locations/places can be affected on average. Whereas, in terms of drainage-related flash floods, in a flash flood affected day, 2 (1.83 to be exact) locations/places can be affected. As it can be seen in the next section that, mostly roads are affected when flash floods occur which means if a flash flood affects multiple locations in the same day, it will result in a number of roads and railways to be affected as well. In a busy city like KL, this may cause a standstill in the traffic flow which may have more additional adverse consequences to the affected peoples, pedestrians and motorists as well.

Another general conclusion can be made from the existing data is that the fluvial flash floods are more intense than the drainage related flash floods. Fluvial flash floods cover a significantly larger area and a greater number of locations/places per flash flood affected day. This indicates the fact that fluvial flash floods are characteristically different than the drainage related flash floods. Therefore, a more in-depth investigation is necessary to understand more reliable and accurate loss and damage of flash flood in KL. To do so, a more comprehensive and detail data recording is one of the major areas to improve. In that case, the duration, size of affected area and time would be very fundamental information to be recorded.

A. Direct Tangible Impact

As in the city, both kinds of flash flood directly affect some common elements such as roads, houses, vehicles, train stations and so on. Considering the lack of detail data available, this could be a lower bound calculation. Figure 3(a) and 3(b) describe the directly affected elements of flash floods in the city.

The most common and highly affected elements by both types of flash floods are roads and highways, houses, and vehicles. The number of affected vehicles is difficult to express in an exact figure in terms of fluvial flash flood. It is because, there are several incidents where the data set mentioned phrases like 'several cars affected', 'several cars involved' and 'cars affected'.

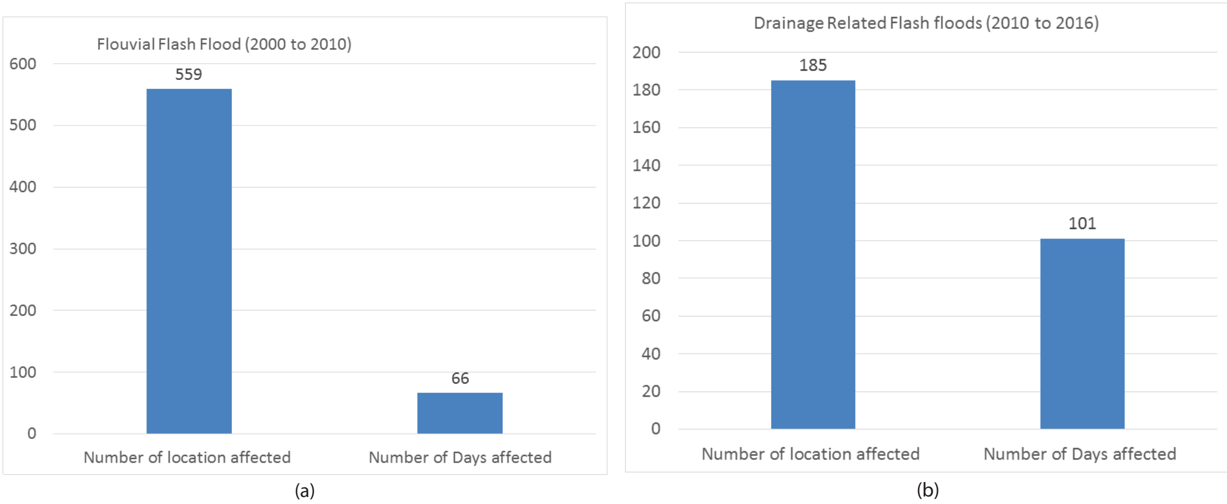


Figure 2. (a) Fluvial Flash Flood (b) Drainage Related Flash floods

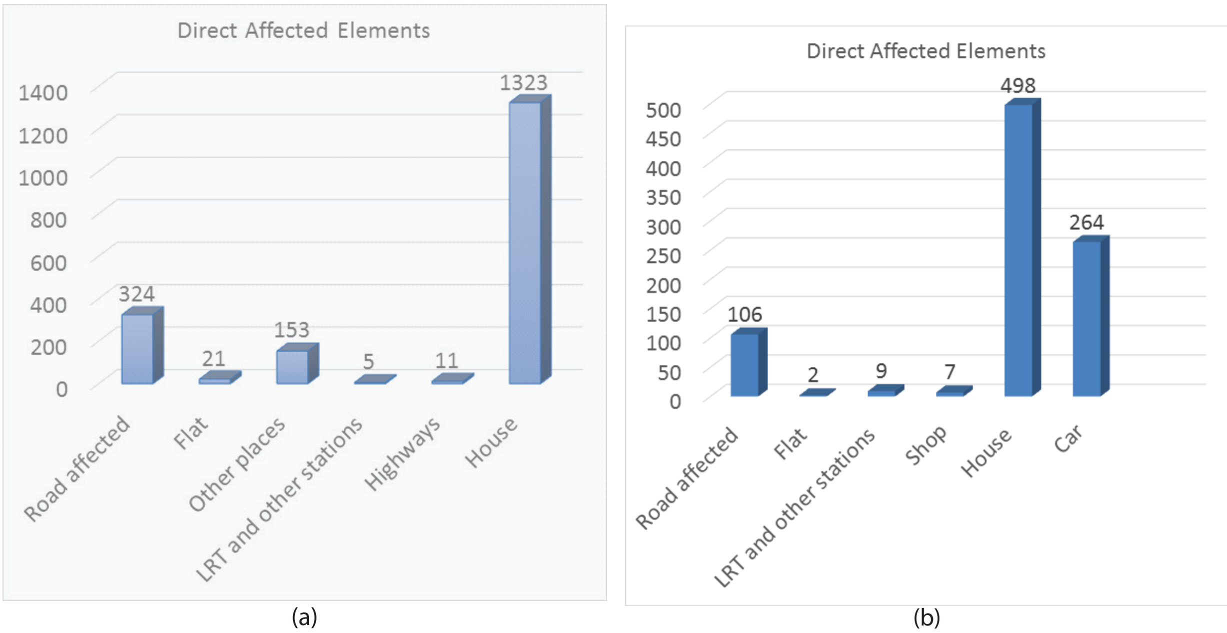


Figure 3. (a) Fluvial flash floods (b) Drainage Related flash floods

An exact number could be calculated in terms of drainage-related flash floods which reveal that 264 vehicles were affected. There can be secondary impact due to vehicles being affected. It can be easily guessed that, as a secondary impact, people will have to repair their cars due to any damage caused to their vehicles by flash floods. This may have a psychological impact as being caught in a flash flood while in the car may cause fear of death, damage to the car and unable to meet scheduled task on time (Shu *et al.*, 2011; Xia *et al.*, 2011; Sharif *et al.*, 2012; Teo *et al.*, 2012). In addition, as shown in Figure 3(a) and 3(b), roads were affected 324 times by fluvial flash floods and 106 times by drainage related flash floods. This indicates what could be the consequential impact upon the people using the affected roads and highways. The immediate consequence would be traffic congestion which may further cause chaos and frustration among the travellers.

The extra time on the road may also cause extra fuel burning in the cars which involve cost and environmental pollution. The delay in work and returning home from work may have a different impact on the affected people. About 1323 houses were affected by fluvial flash floods and 498 houses were affected by drainage related flash floods. This also means a good number of households are affected which may have different types of cost involved due to being affected, such as damage to household contents, clean-up cost, repair and replacement cost, losing recreation opportunities and so on. These are all subject to further investigations whereas this study shows the possible consequences of direct impacts. By knowing the direct impacts, one can get a clue on what are the secondary impact could be.

B. Direct Intangible impact

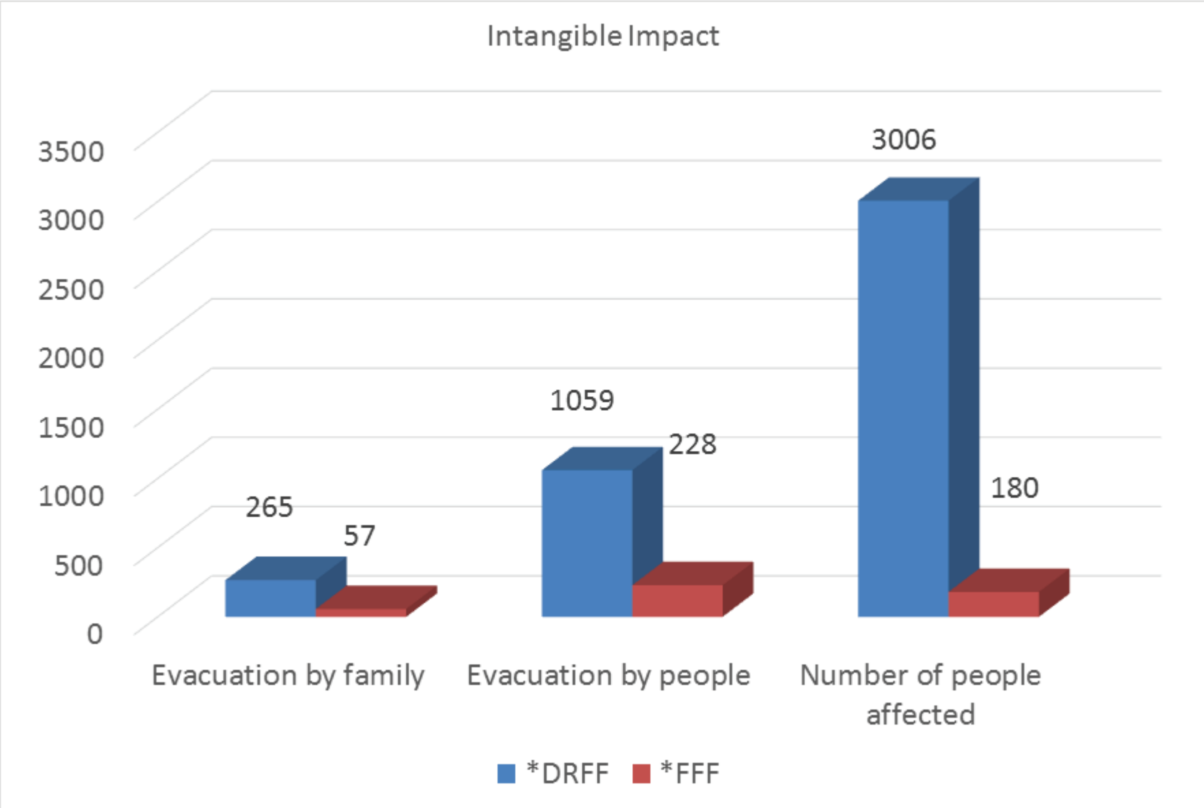
There are many direct intangible impacts of flash floods. However, this study only focuses on the available information. This certainly limits this study to a smaller scope which can only reveal the scenario from affected people and evacuation perspectives. The direct intangible impact of flash floods is depicted in Figure 4 below.

Figure 4 combines the scenario of fluvial flash flood and drainage related flash floods in terms of the number of affected people and evacuation. However, the evacuation is demonstrated by two measurement units, people and family. It is because the dataset sometimes mentions the evacuation number by family and sometimes by people. To get a clearer picture, one needs to use a uniform measurement unit to represent the total evacuation number. Therefore, the number of the family was converted to a number of people and vice versa by using average household size (4 per household) in Kuala Lumpur, sourced from Kuala Lumpur City Plan (DBKL, 2008). The results show that drainage related flash floods affect a significantly high number of people than the fluvial flash floods. Same follows in terms of evacuation as well. The number of affected people by fluvial flash flood (180) is lesser than the number of evacuations (228) by the same type of flash flood. This seems illogical because total affected people cannot be less than evacuated people. However, due to inaccurate data recording, the number of affected people could not be traced out in many cases making the exact total number of affected people is unknown. This reconfirms that the relevant stakeholders should improve their data recording quality and standard. Otherwise, the actual evaluation and assessment will provide an inaccurate conclusion. Looking at the number of affected family indicate that a household level investigation will reveal what socioeconomic impact flash flood may have in the city.

The limitation of the study is the inadequate information and data access for analysing the direct and indirect impact of the flash flood events in KL. That is why a deeper analysis than graphical methods was not possible.

V. CONCLUSION

This study identifies the direct impact of the flash flood events in Kuala Lumpur city from



*DRFF: Drainage Related Flash Floods
*FFF: Fluvial Flash Floods

Figure 4. Direct intangible impact

both tangible and intangible dimension. The direct tangible and intangible impacts indicate some possible consequential impact in the city. The results indicate that several socioeconomic perspectives need to be considered in terms of flash flood scenario. For example, the number of people, roads, houses, and cars affected directly by flash flood indicates that a greater number of people would be affected indirectly by road block, traffic congestion and so on. As a result, people may have to spend more time in traffic, spend money and time for evacuation, clean-up and repair works for damaged items. This may have further socioeconomic factors to be affected. Affected houses may encounter loss of household contents as well. Affected cars may have to undergo through minor, medium or even sometimes major repair cost as well. Due to road and traffic affected by the flash flood, workers may face several problems such as delay or absent in work. People, especially the elders and the disabled, may have to cancel their outdoor activities routine. Students may face some difficulties to go to school. There are many more socioeconomic impacts that could possibly be affected due to flash flood directly and indirectly.

From this study, lack of data maintaining and recording in the current practice is realised. This confirms that the severity and diverseness of flash flood direct impact are unable to be realised with proper and efficient scale until a standard and more detail information recording is ensured. Therefore, the policymaker may consider a proper and standard data recording practice is implemented. Otherwise, a seriously underestimated result may create problem to make a proper and effective decision. The flash flood events are not recorded with fundamentally important information such as depth, duration, affected area, affected people, and so on. Had there been a more complete data, the severity and diverseness of flash floods' direct and indirect impacts would have been more accurately analysed.

Despite the limitations, the study unveils a few important facts that flash flood, though occur in relatively small temporal and spatial manner, puts a larger number of locations at risk. There are locations that repeatedly affected by flash flood too. Both cases indicate that there are a lot of improvements to be made structurally and non-structurally, which means that the random flash flood affected locations alone are enough to demand concern of the policy makers, planners, and practitioners. It is because, as population and development activities are increasing, the randomly flash flood affected places may turn into a repeated flash flood location in future. In addition, the location with repeated flash floods, which are mostly roads and streets are of given priority to be mitigated.

Flash floods directly affect several important factors that are socio-economically important for a city. Although flash floods in many parts of the world are liable for a large number of death (Schroeder, A.J. *et al.*, 2016), the case of Kuala Lumpur is seeming to be much better pertaining to death toll. However, other direct tangible and intangible loss and damages are much higher which may have a secondary or indirect impact on the city's welfare significantly. Therefore, the authority should look at why actually the flash flood events are increasing to find out a way out. The increasing number of impervious areas and construction of paved roads and inefficient drainage system are the reason for increasing flash flood incidents (Samsuri, Abu Bakar and Unjah, 2018). As the roadways are mostly affected by flash flood in Kuala Lumpur, a proper drainage system should be developed so that water recedes within the shortest period of time. The frequently affected roadways are to give special treatment to recede the water especially in the peak hours of the traffic.

The flash flood risk should be understood thoroughly by the urban planners. The drainage systems and water passages should be improved. Non-structural approaches should be given priority as they bring long-term benefit to the society (Samsuri, Abu Bakar and Unjah, 2018). There should be a comprehensive programme of action to change the littering behaviour of the city dwellers. In this case, social awareness campaigns addressing flash flood problems can be an effective option to change and improve the behaviour of the city dwellers. The social advertisements can be an effective tool for raising awareness among wider ordinances. The school children should be taught on what aspects of peoples' behaviour are liable for causing flash flood and how to avoid them. Flash flood-prone areas should be immediately identified, and proper mitigation and adaptation strategy should be implemented. For example, houses should be introduced by basic adaptation and mitigation techniques. The community involvements to treat flash flood problem should be examined at different levels to find and implement appropriate community action. For ensuring a sustainable development, engineers should implement eco-friendly construction that can enhance the infiltration rate of impervious surfaces of built areas to solve the urban run-off problems.

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