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Assessment of Flood Events in Selangor, Malaysia

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Abstract - Selangor has been experiencing floods, especially in the urban area, causing property damages and economic losses. The increase of population in the state has resulted in people and development luring in floodplains. This study investigated the frequency of flooding in a local municipality within Selangor to understand its trend in promoting disaster risk reduction for community resilience. The study performed a content analysis to gather and assess event data from open sources. The search of these data was broadened to the whole Selangor before being narrowed down to recent December 2021 events in Kajang Town. This is followed by trend and spatial analysis using the Kernel Density method using the Geographical Information System (GIS) to develop a flood concentration area. This study revealed that almost 150 flood occurrences had happened in Selangor from 2012 until 2021. In December 2021 during the Selangor Great Flood, Kajang Town has also been severely affected, with a total record of about 20 events in Kajang Municipality and four (4) were reported to be in Kajang Town, all are within high flood potential area. An area of flood concentration was developed from the Kernel Density with very high, high and moderate concentrations accounting for almost 40% of the investigated area. Two flood clusters have been identified that are Kg. Sungai Serai Hulu Langat and Kajang Town. This study has illustrated localised evidence-based information that offers the best options for informed decisions.

Keywords - Disaster Risk Reduction (DRR), Geographic Information System (GIS), Urban flood, Kajang, Spatial analysis

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1. Introduction

The recent report from the Intergovernmental Panel on Climate Change (IPCC) released in 2022 highlighted that global surface temperature will continue to increase. The annual mean rainfall and floods are projected to rise in Southeast Asia. Due to this, Malaysia can anticipate an increased frequency of extreme events such as heavy rainfall, floods, flash floods, mudflows, and landslides, all of which have already occurred in our country (Tang, 2019; Ehsan et al. 2022). Flood has been categorised as the common hazard in Malaysia with the highest likelihood of happening and extreme impacts that may directly or indirectly affect the country over the next five years (NADMA, 2021). The flood has caused physical infrastructure loss and damage, livelihood disruption and fatalities. Several states in Malaysia have experienced numerous episodes of major floods that have left state functions almost paralysed (Rahman, 2022). Previously, the 2014 Kelantan flood was the largest recorded flooding event in the century (Yahaya et al. 2015; Baharuddin et al. 2015) and recently, in December 2021, the country has witnessed a heartbreaking episode of floods across eight states, including Selangor, left almost 50 people dead and displaced about 40,000 people. The occurrence of floods and other hazards associated with extreme weather is projected to become more pronounced with climate change (IPCC, 2022). Malaysia is frequently affected by the annual flooding caused by the seasonal monsoon, which accounts for significant losses. These events have taken a toll on the socio-economy regarding flood damages (Yusmah et al. 2020). A better understanding of floods at the local level is essential to be better prepared for climate change.

As urbanisation trends continue around the globe, attention to urban disaster assessment and related hazard management has increased in the research domain (Etinay et al., 2018; Nazif et al., 2021). Flood occurrences in cities and urban areas severely interrupt society's normal functioning (Hammond et al., 2015). Such a flood will cause the surcharge of the sewer network to exceed its drainage capacity, creating an urban surge or pluvial flooding (Yang et al., 2022). Urban flood problems are generally related to land use change, geomorphology, failure of urban drainage facilities and poor urban planning (Dawson et al., 2008; Adeloye and Rustum, 2011; Nkwunonwo et al., 2020). In Malaysia, cities like Kuala Lumpur, Shah Alam, Kajang, Iskandar Puteri, Georgetown and many others often experience flooding. The scale of this flood is typically small with a shorter duration. However, the impact can never be ignored. As the city is the centre of economic, business and administrative activities, even a small-scale hazard may have a

considerably wider impact (Bhuiyan et al., 2018). This flood is often not considered as disaster by national standards, but they pose an inconvenience, causing traffic jams and disrupting the socio-economic activities of the affected population (Muhamad et al., 2021).

Selangor has been leading the other states in Malaysia's economy, making it one of the most preferred places to stay for its economic flourishing, employment prospect, great infrastructure, and excellent facilities (Husin et al. 2020). Selangor has become the most developed and progressive state with an increase in population, resulting in people and development luring in low-lying areas, including floodplains and coastal plains (Nor Ain Kandari et al., 2018; Yahaya et al., 2022). Selangor has been experiencing floods, especially in the urban area, causing property damages and economic losses. The extreme floods that occurred rapidly and simultaneously at many places in Selangor had left the local authorities struggling to manage the crisis (Yahaya et al., 2022). Numerous remarkable studies conducted on floods in Selangor can be found in the literatures (Salleh & Sidek, 2016; Khuzaimah et al., 2019; Siti Hafsah et al., 2020; Wardah et al., 2021; Ehsan et al., 2022; Liu et al., 2022). Findings obtained from this literature have well-served its purposes in facilitating decision-making processes. However, very few studies showcase the actual view of the flood phenomenon in Selangor.

Understanding the spatial flood distribution can be seen as a fundamental step prior decision makings related to emergency planning, mitigation strategies, prioritisation of preparedness and funding strategies and many others. This is because areas already exposed to floods may need to always prepare for more severe and frequent floods. New places that will be susceptible to flooding must be identified using new approaches, considering the impacts of climate change. This concern has served the purpose of the flood assessment in this study. Therefore, this study aims to investigate the frequency of flooding in local municipality within Selangor to understand its trend to promote disaster risk reduction for community resilience.

2. Materials and Method

2.1 Methodology

The workflow of this study includes (i) data collection and preparation through content analysis, (ii) trend analysis and (iii) spatial analysis (Figure 1). Content analysis was used to gather and assess data from multiple sources such as media internet, newspaper reports, peer-reviewed literature, open-source government reports and various unpublished documents. Different

keywords were used in determining the events data through these multiple open sources. The search for these data was broadened to the whole state of Selangor before being narrowed down to selected local municipalities recently hit by the flood. The recent December 2021 flood events within this municipality were included in the data acquisition. The findings from this analysis were used to generate information from a database and ArcGIS map to conduct trend and spatial analysis for the municipality. The trend analysis was then instructed to a decade set of events data (2012-2021) developed from content analysis to observe its spatial distribution within the Selangor state. Using a statistical application on Microsoft Excel, the pattern of flood events can be identified and visualised through ArcGIS tool mapping.

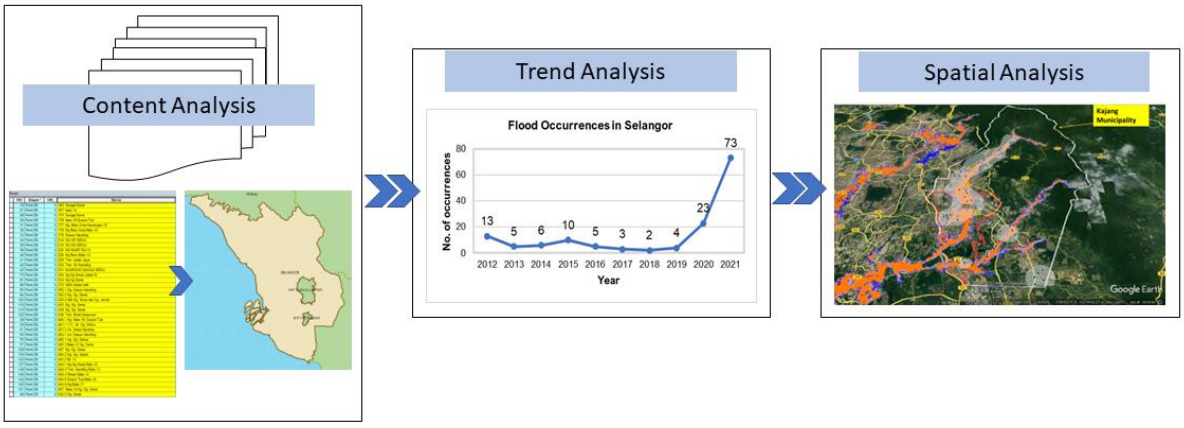

Figure 1. Methodology workflow

A quick probe of recent disaster-hit areas within Selangor local municipality was conducted through spatial analysis. This study uses the Kajang Municipality as a pilot test following frequent flooding events in this area since the 1970s and the latest in December 2021. Spatial analysis was performed using the Kernel Density method to measure the density of features around each output cell within the Kajang Municipality boundary. The Kernel Density was conducted in addition to secondary data obtained from PLANMalaysia to detect and visualise event cluster area (in this study, we used the term concentration) to facilitate qualitative investigation of the features pattern.

2.2 Study area

Selangor has the highest population compared of all states in the country, with 6,538,100 inhabitants out of 32,657,300 inhabitants throughout Malaysia (DOSM, 2020). Selangor often experiences disasters, especially in urban areas. In 2021, Selangor was reported to be the highest state to incur losses due to floods (DOSM, 2021). The increase in population in this state increases the infrastructure to accommodate the dense population, further exposing the infrastructure to disaster risk.

This study is narrowed down to Kajang Municipality, which often experiences repeated flash floods in the exact location (Figure 2). Kajang Town, which lies within this municipality, is a bustling old town that frequently encounters urban floods with a record of recurring incidents in several areas such as Sungai Ramal, Jalan Reko, Jalan Semenyih and Kampung Sentosa from 2016 to 2018. Kajang Town is located within Hulu Langat District under the administration of the Kajang Municipal Council (MPKj). The planning in Kajang has been somewhat ad hoc to cope with the rapid pace of development in the 1990s, resulting in increased floods for more than two decades (Muhamad et al. 2017). This situation is exacerbated by various risk elements that are significantly important for the functioning of both cities and the well-being of the local community. Risk elements located in the study area will tend to experience functional disruption, especially during a disaster. Local community activities not only have the potential to be disrupted, but the exposure of these risk elements can also cause economic loss and disrupt the livelihood of local communities.

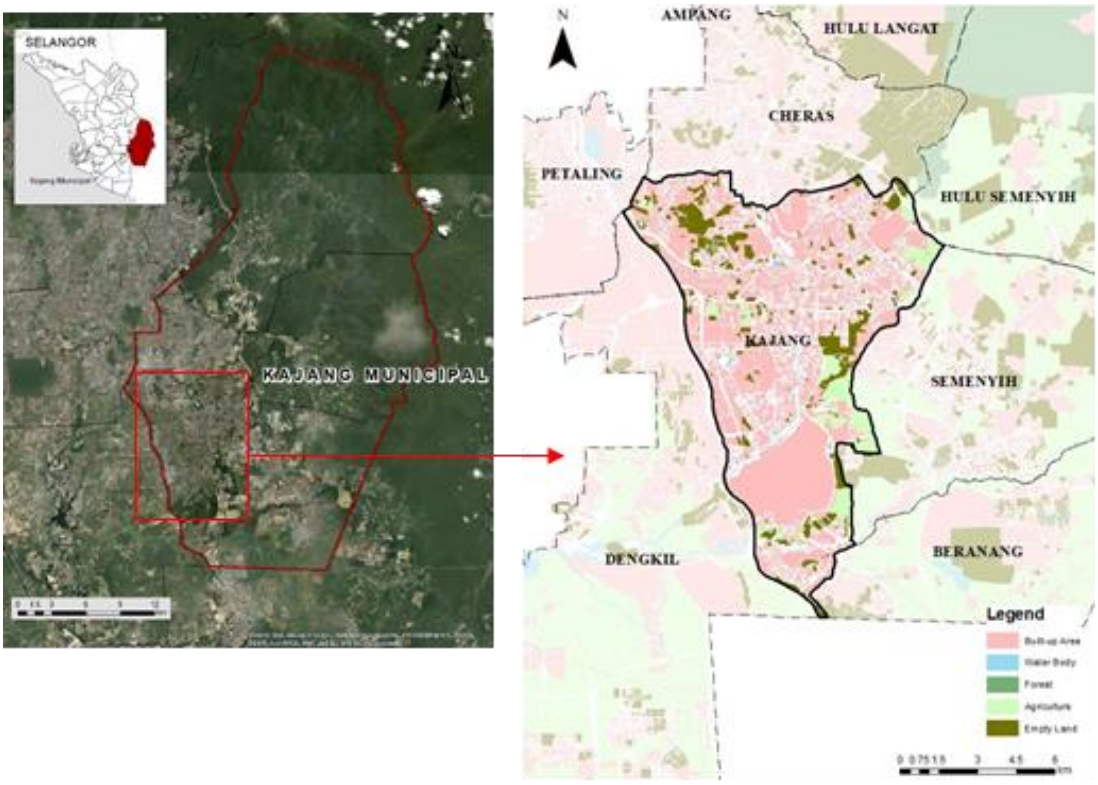

Figure 2. Kajang Town (map not to scale) is located within the Kajang Municipality, Selangor

3. Results and Discussion

3.1 Brief Overview of Flood in Selangor

Selangor has been experiencing a flood. The study recorded almost 150 total flood occurrences in Selangor from open-source data from 2012 until 2021 (Figure 3a). These events were compiled from various sources that are spatial and non-spatial. Some of the events were recurrent at the exact location. The graph shows that the events start rising to 23 in 2020 and spike up to 73 in 2021. In 2020, the Hulu Langat District, consisting of Kajang Municipality, was the worst-hit area among the four affected districts. The flood has forced more than 200 people to seek shelter. This was then followed by a sharp increase to 73 occurrences in 2021. This was due to the "Selangor Great Flood" that happened in December 2021 that have wreaked havoc on the country; where the situation in Selangor was described as unprecedented with many areas submerged in water, significant roads impassable, caught many unprepared, either trapped at home or stranded along the flooded streets. These events were reported to cause the highest total loss value, about RM 3.1 billion, among all other states affected (DOSM, 2021).

The trend analysis has shown coverage of the events throughout Selangor is highly spatially distributed in the central part of the state (Figure 3b). The central part of Selangor consists of Klang, Petaling, Gombak and Hulu Langat, known as hubs of activities covering industry, businesses, health facilities, educational facilities, and many others. This is in line with what was reported by DOSM (2021), where Klang, Petaling and Hulu Langat are the top three districts that suffered losses due to floods. The increase in the risk of flooding, especially in urban areas, is projected for the next decade not only because the climate is becoming more extreme, but also because the density of people and assets is increasing.

3.2 Kajang Flood Concentration

Kajang Municipality, especially the town of Kajang, has been severely affected by the flood. Previously, the city has been experiencing many episodes of urban floods in the past (Muhamad et al., 2015; Muhamad & Pereira, 2018; Bari et al., 2022). Flooding has been a major problem in Kajang Town since the 1970s. The water levels have been reported to submerge houses along the river up to the roof level (Muhamad et al., 2015). In 2021, more than 50 events were recorded in Kajang Municipality (Figure 4). Most of the events fell in the high flood potential area when overlaid with the secondary PLANMalaysia flood data. During the 18 December 2021 flood, Kajang Municipality recorded about 20 events. Out of the 20 events, four (4) were reported to be in Kajang Town, and all are in high flood potential.

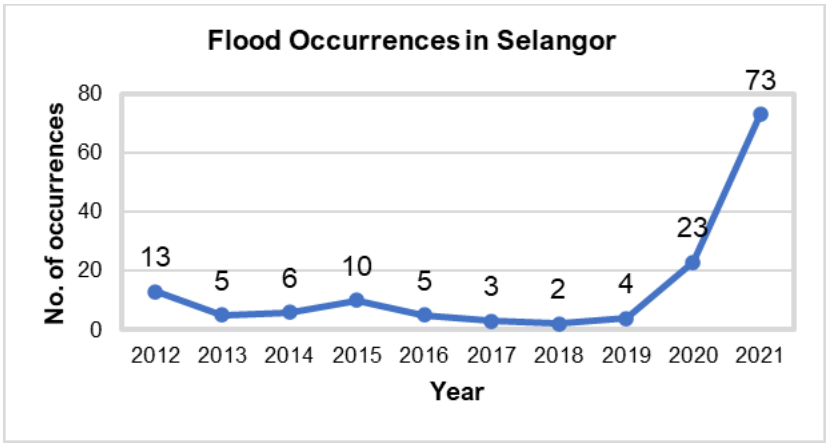

Figure 3(a)

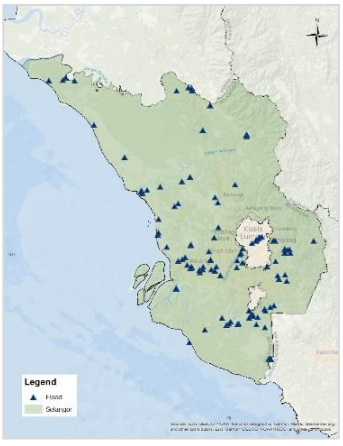

Figure 3(b)

Figure 3. (a) Flood occurrences in Selangor recorded from open-source data. (b) The spatial distribution of floods in Selangor

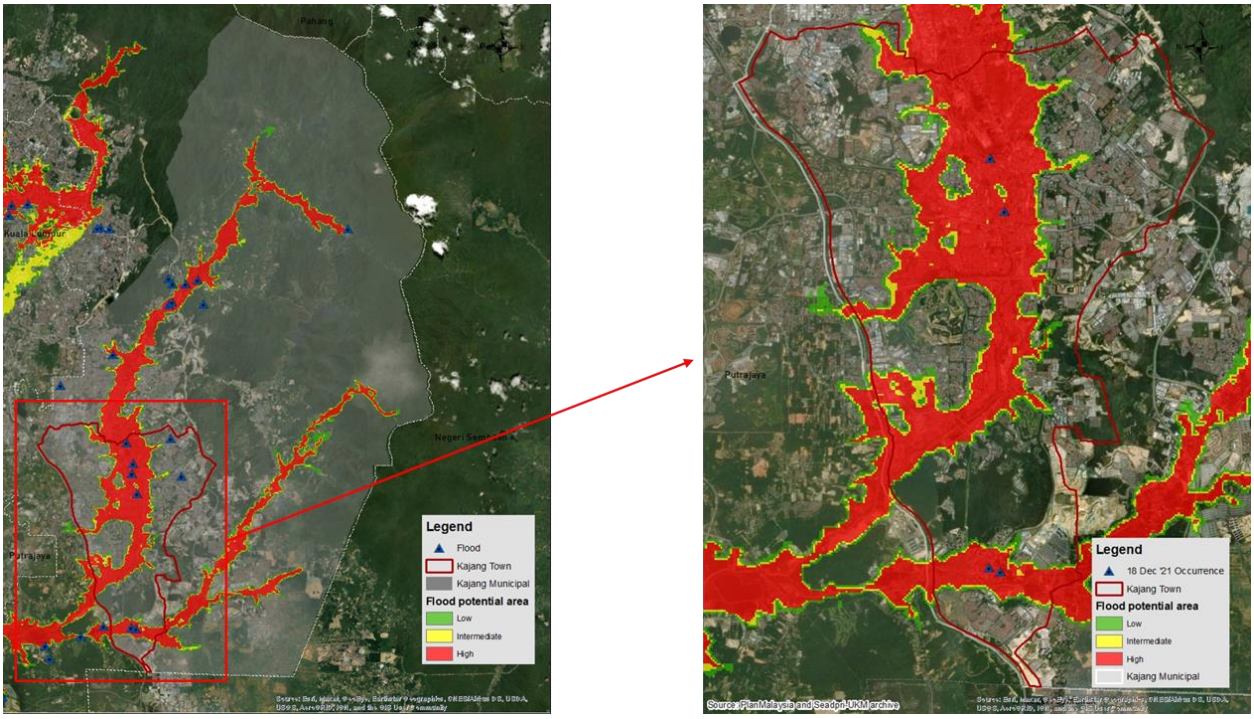

Figure 4. Location of flash flood in Kajang Town (map not to scale) for the year 2021, including 18 December 2022 events

Using the best available information, the area of flood concentration (*kawasan penumpuan banjir*) was developed using the Kernel Density method. The concentration has been classified into very high, high, moderate, and low. The very high, high and moderate concentrations accounted for almost 40% of the investigated area. Two clusters that have been identified are Kg. Sungai Serai Hulu Langat and Kajang Town (Figure 5).

This study has also revealed that Kajang Town is very highly concentrated on flooding. Previous studies and unpublished media, including a physical interview with the local community, have reported that the occurrences of floods in this town are due to the urban density and the drainage capacity, which cannot accommodate the sudden heavy downpour (Muhamad et al., 2015; Bari et al. 2022). To cope with the flood, the local authority has built several retention ponds to help ease the flooding and deepen the main drainage in Kajang Town. The local community in that area has established their adaptation capacity by building flood walls for their buildings (Muhamad et al. 2017). However, flooding is still occurring in Kajang Town, with some emerging areas already flooded. This study illustrates the reality of flooding in Kajang that needs attention. Local level research specific to Kajang is rather limited in peer-reviewed literature. The impact of

urban flood issues in Kajang is localised, and local-level studies offer the best options for monitoring and early warning adaptation measures (Pereira et al. 2021). Evidence-based information is needed to make an informed decision (evidence-based decision-making) at an appropriate scale to manage disaster risk better.

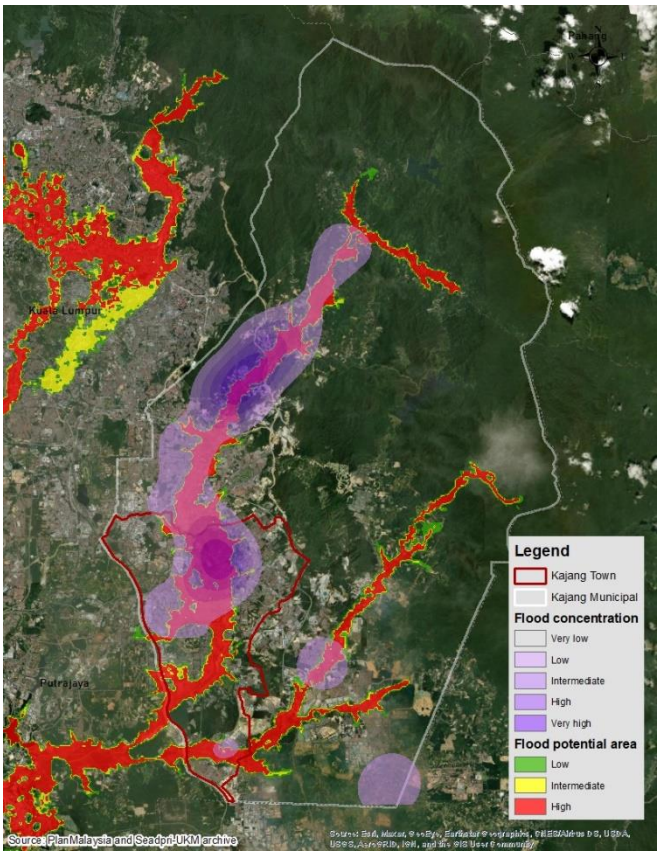

Figure 5. A flood concentration area was identified in the Kajang Municipality area

3.3 Way Forward to Infrastructure and Community Resilience

The consequences of small and localised floods in a densely populated areas such as Kajang have been increasingly becoming problematic around the globe. Local communities' vulnerability has increased due to continuous development upstream of Kajang. A recent study by Bari et al. (2022) has shown significant monetary evidence from the physical losses and damages due to the floods. Although flooding has been a significant problem since the 1970s, studies assessing the spatial distribution of flood events, susceptibility area of Kajang to flood and element at risk within the municipality is rather limited. The flooding issues are only found in the newspaper report whenever a heavy downpour causes several areas to be submerged.

Further scientific research needs to consider identifying hazards with due regard to the scale of scientific information based on natural boundaries using open source data to facilitate local authorities and supply the public with relevant information. Multi-dimensional information needs to be investigated its relevance to flood in the area, for example, selected elements at risk such as health and education facilities. Such facilities are essential to remaining functioning to provide service during the flood. Access to these facilities may need to be assessed for any case of emergency. Advance geospatial technology and decision-making systems are also required to support and use planning. This study hopes to promote open source data to be accessible to the public and suggests that the DRR Approach needs to be strengthened for the five phases of the disaster management cycle.

4. Conclusion

Selangor has been experiencing flash floods and monsoon floods. The study recorded almost 150 flood occurrences in Selangor from 2012 until 2021. Kajang Municipality is among the municipalities in Selangor experiencing many episodes of urban flood. The majority of the events fall in the high flood potential area. Using the best available information, cluster areas of flood concentration (*kawasan penumpuan banjir*) in Kajang Municipality have been developed with two coverage identified as very high concentrated on flooding. This study illustrates the reality of flooding as the impact of such flooding is localised, and local-level studies always offer the best options for DRR in building community resilience.

Acknowledgement

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