Larhyss Journal, ISSN 1112-3680, n°55, Sept 2023, pp. 89-105

AN ASSESSMENT OF FLOODS' CHARACTERISTICS AND PATTERNS IN PAHANG, MALAYSIA

ABD RAHMAN A.N. [1*], OTHMAN F.[2], WAN JAAFAR W.J.[3], AHMED ELSHAFIE A.H.K.[4]

[1,2,3,4] Department of Civil Engineering, Faculty of Engineering, Universiti Malaya, Kuala Lumpur, Malaysia

(*) faridahothman@um.edu.my

Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received March 1, 2023, Received in revised form September 2, 2023, Accepted September 4, 2023

ABSTRACT

Floods have frequently and severely impacted Peninsular Malaysia's East Coast region in recent years, with Pahang being the worst hit during the 2021 flood event. Therefore, this study was carried out to determine the characteristics and patterns of previous flood events in two districts in Pahang, namely, Temerloh and Kuantan, and to investigate the effects of floods. Both quantitative and qualitative data from secondary sources are utilized in this study, where qualitative data from a literature review are used to clarify and interpret the findings of the quantitative data analysis of the DID annual flood report. According to the findings, floods occurred annually in both districts, excluding 2016, when Temerloh did not record any flood events. The flood depth reported ranged from 1 to 2 meters and lasted approximately a day. Furthermore, Pahang experienced both types of floods: monsoon and flash floods. Floods have forced locals to evacuate to flood relief to seek shelter, food, and aid supplies. Therefore, this study serves as a preliminary investigation of the flood events that occurred in Pahang. Understanding flood trends and their consequences is essential for a variety of purposes, including urban planning and flood management by stakeholders.

Keywords: Flood trends; Flood events; Temerloh; Kuantan; Climate change

INTRODUCTION

Natural disasters have an adverse economic impact and destroy infrastructure, interrupting livelihoods, essential services, and health care. Floods are one of the most common natural catastrophes caused by excessive rainfall, fluvial floods, and high tides due to storm surges. However, anthropogenic activities such as channel blocking, deforestation in headwater regions, the ineffectiveness of flood-prevention measures, and

improper land use can also contribute to it (Hountondji et al, 2019; Aroua, 2020; Remini, 2020; Hafnaoui et al., 2022; Tingsanchali, 2012; Zhang et al., 2023). River floods are a severe threat to millions of people who live in river basins around the world. The current scenario is more worrying, as flood hazards and impacts are expected to worsen in many parts of the world. Due to climatic and socioeconomic changes, flooding hotspots are predicted to occur in Asia and Africa in the future (Merz et al., 2021). This is demonstrated by referring to the Clausius-Clapeyron (CC) relation: according to it, a warmer atmosphere caused by climate change can store more moisture. Indeed, the atmosphere can hold approximately 7% more moisture for every degree of warming (Fischer and Knutti, 2016). Furthermore, changes in the water balance caused by land use, land cover, and climate change in tropical countries not only cause water scarcity during extended dry seasons but also increase flood risk due to increased rainfall intensity (Liew et al., 2021). Due to severe rainfall amplification, flooding may become more intense and frequent and will have a negative impact on human communities, aquatic and terrestrial ecosystems, and the economy (Tabari, 2020). Thus, Malaysia, one of the Asian countries located in a tropical region, faces a high flood risk, particularly in light of climate change.

Malaysia has an equatorial climate due to its location near the equator. The equatorial climate is typically hot and extremely humid, with an average annual rainfall of 2500 mm. In addition, Malaysia is directly influenced by two monsoon seasons: the southwest monsoon and the northeast monsoon (Safiah Yusmah et al., 2020; Tew et al., 2022). The Northeast Monsoon is normally around November to March, whereas the Southwest Monsoon is normally around April to September. Of the two systems, the northeast monsoon is more intense (Ziarh et al., 2021). Thus, with annual heavy monsoon rains of more than 3000 mm and such a large flood-prone region, flood risk is high, particularly in riverine areas and coastal flat lands. The flood-prone zones in Peninsular Malaysia are primarily on the east coast and in the west. Meanwhile, flood-prone regions in Sabah are in the east and north, while flood-prone areas in Sarawak are in the east and west (Abd Majid et al., 2021). There have been a series of flooding events reported in Malaysia since 1971 (Alias et al., 2019; Chan, 2014; Ghani et al., 2012).

The recent flood of 2021-2022 was reported to be one of the most devastating floods in Malaysia. The flood was caused by unusually heavy precipitation from mid-December 2021 to early 2022. Surprisingly, Peninsular Malaysia's west coast, which typically experiences dry conditions during this time, was also affected by extreme events (Tew et al., 2022). It affected 60 districts across 11 states. Selangor, Pahang, Melaka, Negeri Sembilan, Johor, W.P. Kuala Lumpur, Kelantan, Sabah, Perak, Terengganu, and Sarawak were among the states affected. According to the special report released by the Department of Statistics Malaysia (DOSM), the 2021 flood has resulted in total losses that reach up to RM 6.1 billion. Pahang state was reported to be the state with the second-highest loss after Selangor (RM 3.1 billion), with RM 593.2 million losses throughout the whole state (DOSM, 2022). In addition, among the other states, Kelantan had the most land that was inundated, whereas Pahang had the most people evacuated due to the flood (Tew et al., 2022). As a result of its vulnerability to flooding, particularly when it was

found to be one of the most vulnerable states in terms of losses and population relocation in the recent 2021 flood, a number of studies have been conducted in Pahang by previous researchers.

Existing studies that have been conducted within the Pahang River basin have focused more on local community preparedness strategies as well as vulnerability and resilience; the Temerloh and Kuantan districts have been extensively studied by previous researchers due to their frequent flooding (Alias et al., 2018; Lam and Chow, 2022; Mohd Idris et al., 2018; Safiah Yusmah et al., 2020). From the studies, it is found that flood risk management in Malaysia is divided among the federal government, the state government, and the district government. The National Disaster Management Agency (NADMA), the local authority, the Malaysia Civil Defense Force (APM), and the National Security Council (NSC) are among the flood-related government agencies in Malaysia (Mabahwi and Nakamura, 2020). Despite the current system, nongovernmental organizations and the community itself play important roles in flood management strategies. Among the initiatives that have been undertaken by the locals are preparing the boat, elevating the house's structures to a higher level from the ground, relocating to a new settlement, reinforcing the structural building with concrete, and keeping the ditches clean to prepare for seasonal floods (Alias et al., 2018; Mohd Idris et al., 2018). In addition, other studies, such as the potential flood drivers and flood mapping, have also been conducted in the districts (Elfithri et al., 2017; Ghani et al., 2012; Maria et al., 2014). However, fundamental information, such as studies on previous flood patterns and characteristics, remains lacking.

Flood information and trends are crucial for optimizing our response and should be included in design and safety guidelines. Understanding prior flood patterns and characteristics is necessary for forecasting and managing future floods. However, existing trend and pattern research is largely focused on climate change trends, extreme rainfall patterns, and flood risk index patterns (Othman et al., 2016; Saudi et al., 2018; Tang, 2019). Therefore, the purpose of this research is to fill gaps in current studies on flood patterns, particularly in Pahang. The objectives of this study are as follows:

- To determine the flood characteristics and patterns of previous floods in Temerloh and Kuantan
- To identify the effects of floods on locals

MATERIAL AND METHODS

This study was based on secondary research, where both qualitative and quantitative data collected from secondary sources were utilized to analyze the previous flood scenarios in Pahang, specifically in the Kuantan and Temerloh districts. Using the explanatory-sequential approach, qualitative data from the literature review were used to interpret and further clarify the findings of the quantitative data analysis of the flood report. The method used in this study is summarized in Figure 1.

Figure 1: Methodology Flowchart

All the data collected and analyzed in this study are mainly from the secondary sources provided through reliable sources. The main source of this study is the annual flood report published by the Department of Irrigation and Drainage Malaysia (DID), which was made available online through their website (https://www.water.gov.my/). Using the flood data provided in the report, this study focuses on analyzing the characteristics and trends of flood occurrences that occur in Pahang states, specifically in Temerloh and Kuantan. In addition, online newspaper and journal articles that are relevant to the topics were also used in this study to examine how floods affect locals.

Samples

To comprehend the trends of prior flood occurrences, flood data between 2016 and 2021 for the districts of Kuantan and Temerloh were obtained from the DID annual flood reports (2016-2021). The type of data retrieved from the flood report includes the flooding frequency, maximum flood depth and period, number of evacuees, and flood type.

Study Area

Pahang, which is situated on Malaysia's eastern coast, is the largest state in Peninsular Malaysia. It is one of the states that is most susceptible to flooding, and it was also one of the hardest hits during catastrophic floods that hit several states in Peninsular Malaysia in 2021 (DOSM, 2022; Tew et al., 2022). The Pahang River basin is the most important catchment area of Pahang state, and the primary river is the Pahang River, which flows for 440 kilometers, covers approximately 29,300 km^2 of catchment area and is the longest river in Peninsular Malaysia (Elfithri et al., 2017; Ghani et al., 2012). The catchment area includes seven districts in Pahang (Maran, Jerantut, Bentong, Lipis, Temerloh, Bera, and Cameron Highlands), one subdistrict in Kuantan, eleven subdistricts in Pekan, and two districts in Negeri Sembilan State (Jelebu and Kuala Pilah). During the northeast monsoon, the Pahang Basin experiences a significant amount of precipitation, which contributes to flooding incidents along the river in the basin.

Despite the fact that the state has several flood-prone areas, this study only focuses on two districts in Pahang, namely, Kuantan and Temerloh. This is because, in addition to having a significant impact on the lives and economic circumstances of residents in both

districts almost every year, both districts were also reported to be among the worst hit in Malaysia's most recent flood occurrences in 2021 (Lam and Chow, 2022; Tew et al., 2022). Therefore, a study of flood patterns and consequences in these two districts is critical for designing better flood management in both districts that can later be replicated in other districts in the state, as well as for implementation at a higher level, such as the national level, in the future.

Kuantan is one of the most flood-vulnerable areas of peninsular Malaysia; it is the state capital of Pahang and located near the mouth of the Kuantan River. The Kuantan River Basin is the crucial watershed that passes through Kuantan State and is responsible for flooding. This is due to spillovers of river flow that inundate the surrounding flood plain and low-lying areas during the wet season (Maria et al., 2014). There have been a number of major flood events reported in the Kuantan River in recent decades, causing significant damage to properties, infrastructure, and buildings. In addition, Temerloh and its surroundings are also particularly vulnerable to flooding due to their location at the confluence of the Pahang and Semantan rivers. Temerloh is the second-largest city in Pahang after Kuantan, and it is situated in the heart of Pahang (Parvin et al., 2021). Most residential areas are in the lowland and floodplain regions, where irrigation systems are poor, particularly in large residential areas. A map of the study area is depicted in Fig. 2 below.

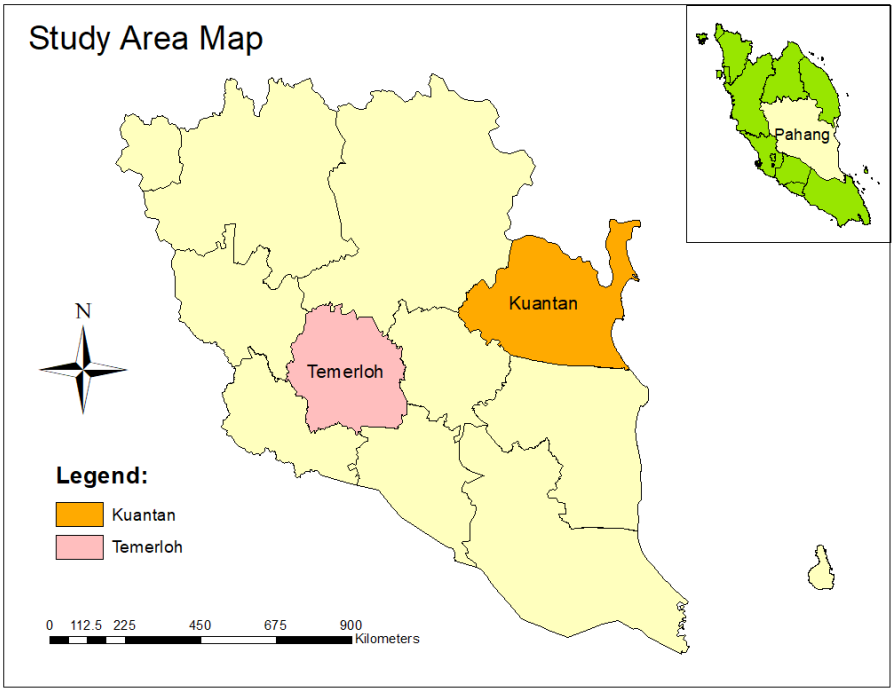


Figure 2: Study Area Map

Data Analysis

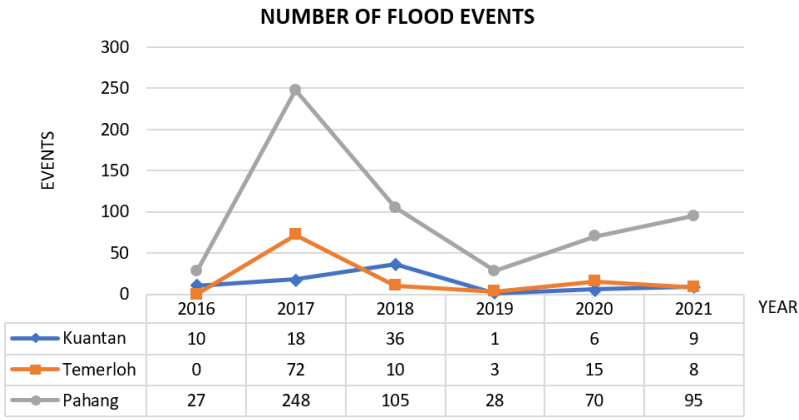
The flood characteristics and trends are analyzed using simple graphs and tables. The flood scenarios from 2016 to 2021 in Kuantan District are compared and analyzed with those in Temerloh using line and bar chart graphs. Some of the graphs also included flood data from the entire state of Pahang to show the significance of floods in both districts in relation to the state's flood scenarios.

RESULTS AND DISCUSSION

Flood Characteristics and Patterns

To understand past flood patterns and characteristics in the study area, first, the frequency of flood events reported in Kuantan and Temerloh districts, as well as in Pahang, were extracted from the flood reports. The analysis also included data from the overall state of Pahang to determine how much flooding in both districts contributed to and influenced the number of overall flooding events in Pahang. According to the findings shown in Fig. 3, Pahang has recorded a total of 573 flood events over the last six years, with Kuantan reporting 80 and Temerloh reporting 108. The total number of flood occurrences recorded in both districts was observed to exceed 30% of the total number of flood events recorded in the state. This finding is very interesting given that a very high number of flooding events were reported just from these two districts in a state with a total of 11 districts. As a result, these two districts are considered to be among the districts in Pahang that have the most flood-prone areas. To develop a flood plan that will aid in managing floods and their effects in the states, particularly in these two districts, further identification of flood-prone areas in these districts is needed, and some information from past flood patterns may help in the process.

These flood patterns in the study area may be seen in Fig. 3 for the previous six years. From the findings, floods have been reported to occur annually in both districts, excluding 2016 when Temerloh did not report any flood events. Thus, flooding is considered an annual occurrence in both districts and should not be taken lightly by the authorities or the community. Proper planning and preparation for upcoming flood events may help to reduce losses and damage. Moreover, 2017 witnessed the highest number of flood events in Pahang as well as in Temerloh. Fortunately, in the following year, the number of flood events continued to drop until the lowest number of events was reported in 2019, before it gradually increased in the next two years. Although the statistics from these findings do not truly demonstrate an increasing trend in the number of flood event cases in either district, the effects of flooding are typically exacerbated in some circumstances, such as the most recent flood occurrences in 2021. This scenario is usually associated with climate change, which is predicted to increase the number of unpredictable events due to increased rainfall intensity. Therefore, future studies could make use of these flood trends by associating them with rainfall or climate change patterns to project future flood scenarios in both districts.



	2016	2017	2018	2019	2020	2021
Kuantan	10	18	36	1	6	9
Temerloh	0	72	10	3	15	8
Pahang	27	248	105	28	70	95

Figure 3: Number of flood events in Pahang, Kuantan and Temerloh

Next, flooding in Malaysia is frequently associated with heavy rainfall, particularly during the monsoon season. Therefore, the average highest daily rainfall for Pahang from 2016 to 2021 was plotted in Fig. 4 to observe the rainfall patterns in the state and evaluate the impacts of rainfall on the flooding events. From the findings, the average highest daily rainfall in Pahang over the past six years has been considered to be of very heavy rainfall intensity (> 60 mm), with the highest daily rainfall recorded in 2016 at 429 mm. As a result of the high intensity of rainfall, Pahang has experienced multiple flood episodes, causing high runoff that worsens the river's capacity and causes overflow. However, the number of flood incidents reported in the state as well as in both districts is difficult to explain solely by the highest daily rainfall, as shown by Figs. 3 and 4. Existing studies have found that there are also additional potential factors and drivers that can amplify flood events. The forest area, elevation, and population size each have a significant impact on the temporal variation in flood impacts (Alias et al., 2019). The percentage of vulnerable individuals, household income, the region's economy, and the proportion of foreign nationals were four additional criteria listed by Ziarh et al. (2021) as part of the seven main factors influencing the likelihood of flooding in Peninsular Malaysia. In addition, a study by Elfithri et al. (2017) showed that increased wetland reclamation for development, widespread forest clearing, and the village's location in a lowland and flood plain area could also contribute to flooding in Pahang. Thus, flooding can occur as a result of heavy rainfall events, but it is not the only cause; other factors can also cause flooding and sometimes amplify current flooding scenarios, which may be related to the type of flood itself.

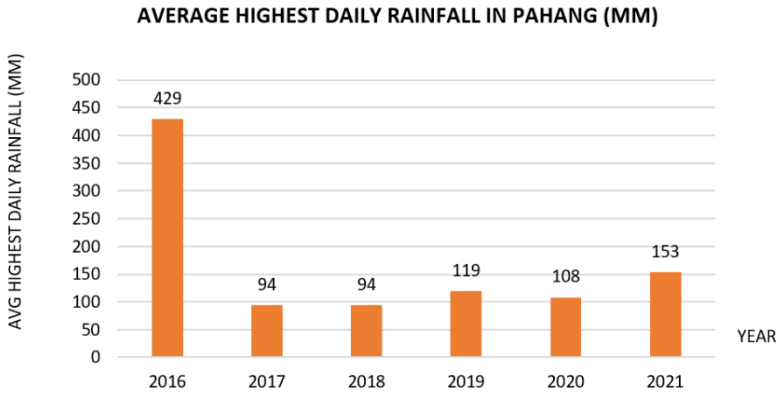


Figure 4: Average highest daily rainfall in Pahang

In Malaysia, floods are normally classified as flash floods and monsoon floods. Monsoon floods and flash floods may have different characteristics due to their nature of occurrence (Maqtan et al., 2022). A flash flood is a surge of water caused by only a few hours of rainfall, normally in a small catchment area. Thus, flood effects are quite dangerous and devastating because they frequently involve rapidly rising and moving water (Doswell, 2015). Monsoon floods, on the other hand, are common during the monsoon season due to prolonged duration with intermittently intense bursts of monsoon rains, and the intensity can occasionally exceed several hundred mm in 24 hours (Tew et al., 2022). As a result, it is critical to first determine which types of flooding are more significant and occur more frequently in the study area. Therefore, these data were extracted from the annual reports and plotted in Fig. 5 below. According to the findings, both districts have experienced both types of flooding. In 2017 and 2018, Temerloh and Kuantan reported a high number of flood occurrences, with the majority of the flood events reported in both districts being monsoon floods. In contrast, in 2016 and 2020, the types of floods that mainly occurred were flash floods. Since both types are significant in both districts, it is crucial for stakeholders to predict when both types of flooding events are most likely to occur in the districts.

Therefore, the months of flooding reported in both districts for the past six years are tabulated in Table 1. This is to determine which month the flood usually occurs in previous years and relate it to the type of flooding in that year. From the results in Table 1, floods in 2017 and 2018 occurred primarily between November and February during the monsoon season. During that time, rainfall is common and might linger for many hours, leading to monsoon floods. On the other hand, floods in 2016 and 2020 are more likely to occur in the middle of the year, from April to September. During this period, any high-intensity rainfall might cause flash floods. Thus, after relating the month of flooding with the type of flooding in Fig. 5, some patterns could be observed. Monsoon floods normally occur between the months of November and February, whereas flash floods may occur in the middle of the year for both districts. Based on these findings, locals and key

stakeholders can plan effective and appropriate flood management for both types of flooding throughout that season of the year. In addition, other important details, such as the depth of the flood, the maximum flooding period, and the recession time of flooding, can also be incorporated in the development of flood control.

Table 1: The month of flooding recorded in Kuantan and Temerloh districts

District	The month of flooding in Kuantan and Temerloh					
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Kuantan	Aug, Sep, Dec	Jan, Feb	Jan, Dec	Nov	Nov, Dec	Jan, Mar, Dec
Temerloh	-	Jan, Feb, Sep, Jul, Nov	Jan, Apr, Oct, Nov	Jun, Dec	Apr, May, Jul, Aug, Sep, Oct, Dec	Jan, Mar, May, Nov, Dec

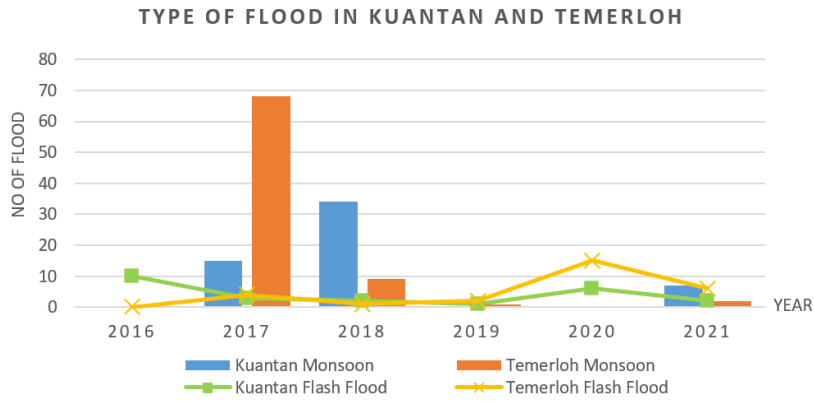


Figure 5: Type of flood in Kuantan and Temerloh

Next, information on the maximum flooding period and depth is required to develop an effective flood management plan in the study area. Therefore, the flooding period and depth from 2016 to 2021 were extracted for both districts, as well as in Pahang state. Similarly, the analysis also includes the statistics from the entire Pahang state to compare the patterns in both districts to the state outcome and assess how severe the scenarios are. From the results, floods in Pahang typically last several days. In 2018, the maximum flood duration was six days, as depicted in Fig. 6. In both districts, the highest flooding period only lasted a day or so for the previous six years, with the exception of the extreme event of 2018, when the longest flood duration at Kuantan was reported to be nearly 5 days. The flooding in January 2018 was exacerbated by heavy rainfall, where the rising number of flood evacuees in Kuantan was due to the continued heavy rainfall as well as the high tide phenomenon. Flooding appears to have increased and amplified in the catchment

over the last decade, owing to the influence of erratic torrential rain and high tides (Maria et al., 2014). Therefore, it can be noted that the recession time of flooding in both districts is relatively high given that the flood often lasts only for a short time, except during extreme catastrophes, when the number of evacuees will escalate at that time as well.

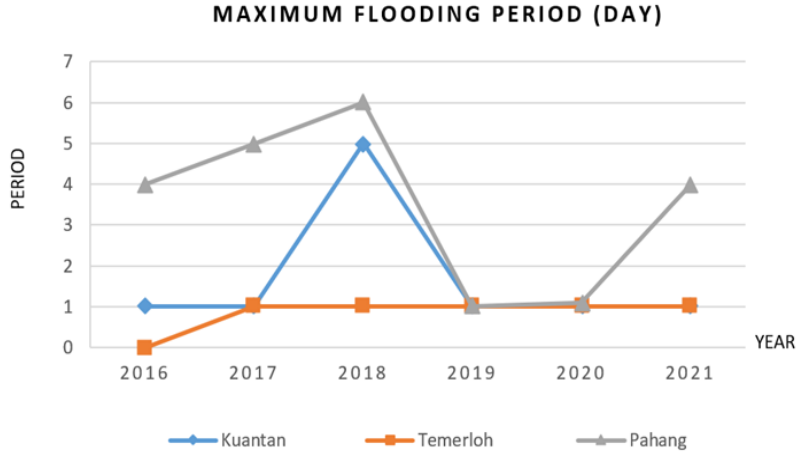


Figure 6: Maximum flooding period in Pahang, Kuantan and Temerloh

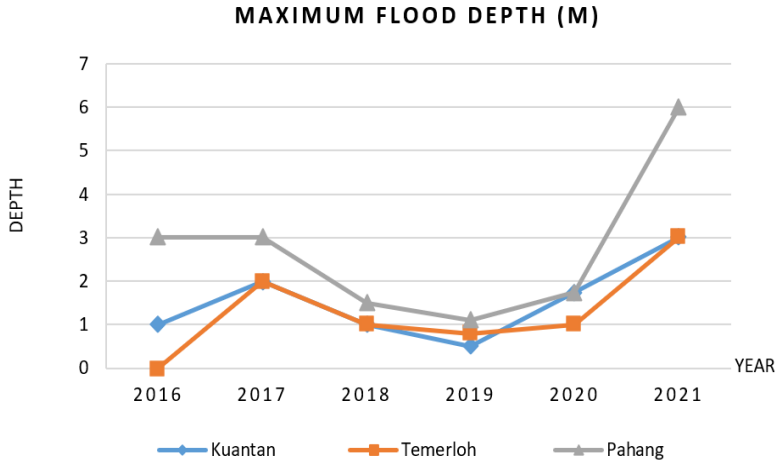


Figure 7: Maximum flood depth in Pahang, Kuantan and Temerloh

Fig. 7 depicts the maximum flood depth for both districts as well as the state of Pahang. From the findings, it is observed that the highest flood depth ever recorded in Pahang in the past six years was 6 meters in 2021. In addition, in the same year, Temerloh and Kuantan both reported the highest flood depth, which was 3 meters. These depths are considered very high and can easily inundate the entire house, causing severe damage to the property as well as other issues such as drowning. These findings are not surprising given that the 2021 flood is regarded as one of the most devastating in Malaysian history (DOSM, 2022; Tew et al., 2022). Other than the extreme flood case in 2021, the flood depth is most likely to be approximately 1 to 2 meters in both districts. Nevertheless, locals should still always be careful, even though the flood depth in both districts is not that high. Even with a low flood depth, it can still be dangerous, especially when the flow of water is high, as it can cause drowning. As a result, it is recommended that all flood victims evacuate during the flooding period, as flooding has negative consequences for the victims.

Social Impact Assessment of the Floods

Flooding has significant impacts on society, the environment, and infrastructure. This study, however, will concentrate on the social impacts of flooding. Flooding has affected victims in many ways, such as through loss of life, property destruction, the spread of illness, and other significant losses (Ismail et al., 2018). In addition, every year, thousands of people are forced to evacuate due to flooding, particularly during the monsoon season. Emergency evacuation is required to increase access to temporary shelters and basic supplies, as well as to reduce the number of fatalities from electrocution and drowning. From the annual flood reports, the number of evacuees from 2016 to 2019 was extracted to understand how much the flood affected the victims in both districts in terms of relocation during the events. The NADMA Monthly Reports from its official website (https://portalbencana.nadma.gov.my/) were then utilized to augment the evacuee data that were missing from the flood reports for 2020 and 2021. These data, together with the flood depth and period data, are summarized in Table 2 to evaluate the relationship between them.

According to the statistics, over 45,000 evacuees were recorded for both districts between 2016 and 2021. Despite the fact that case data were only obtained from two districts, this was found to be an extremely high number. However, there is no clear pattern, and future estimations of the number of evacuees can be made for future events, as this number will surely vary according to the number of areas affected and their severity. Despite this, we can still observe that the maximum flood depth, maximum flood period, and number of evacuees are all correlated and dependent on one another. The worsening flood conditions in January 2018, which lasted 5 days, undoubtedly contributed to Kuantan's higher number of evacuees in 2018, with 5425 evacuees. More victims are forced to evacuate to seek shelter, food, and aid supplies because of the longer flood duration. In addition, a similar pattern is also noticed; when the flood depth is high, such as in 2017 and 2021, a greater number of evacuees is reported. In both districts, the severe 2021 flood episodes

saw the greatest flood depth of 3 meters, which could easily inundate a one-story dwelling. As a result, we saw the largest number of evacuees in both districts—over 15,000. During this time, everyone was advised to evacuate, and no one in the flood area was allowed to stay at home because it was too unsafe; in addition, their house may also have been entirely submerged. Therefore, we can conclude that the maximum depth and duration of the flooding had a major influence on the number of evacuees at the flood relief center.

Next, other than the direct impacts of flooding, such as loss of property and lives, and the evacuations that occur during flood occurrences, there are also indirect impacts that happen to victims during or after flood events. Impacts that are not caused by physical contact with the floodwater are known as indirect impacts. This normally relates to the emotional problems suffered by the victims due to losses such as the loss of a loved one, property, and residence, as well as the fear of repeated floods in the future (Ismail et al., 2018; Ogunbode et al., 2018). It has been discovered that the loss of property and the loss of a loved one experienced by victims are linked and are the most common causes of emotional problems during flood events. Aside from evacuation and emotional issues, there are also financial concerns due to property losses during flooding. Although all the victims had difficulties and challenges due to flood occurrences, it was found that low-income victims were hit harder than high-income victims because they required more money and other sources of income to return to their daily lives. Many everyday appliances and goods must be repaired or replaced, which is expensive for the poor (Safiah Yusmah et al., 2020). Therefore, governments should plan for better management and coordination of flood aids, relief efforts, and financial assistance to ensure that the most affected group receives the most help and support, which may also greatly reduce the emotional and financial problems suffered by them.

Table 2: The flood depth, flood period, and number of evacuees in both districts

Year	Maximum Flood Depth (m) [a]		Maximum Flood Period (day) [a]		Number of Evacuees [a, b]	
	Kuantan	Temerloh	Kuantan	Temerloh	Kuantan	Temerloh
2016	1	0	1	0	0 [a]	0 [a]
2017	2	2	1	1	1078 [a]	1293 [a]
2018	1	1	5	1	5425 [a]	89 [a]
2019	0.5	0.8	1	1	0 [a]	323 [a]
2020	1.74	1	1	1	185 [b]	180 [b]
2021	3	3	1	1	19823 [b]	16626 [b]
Total Number of Evacuees in Both Districts					**45022**	

Source:

(a): The DID Annual Flood Report (2016-2021)
(b): The NADMA Monthly Report of Disaster Events Across the Country

CONCLUSION

Flooding is an annual occurrence in Malaysia, particularly during the monsoon season; however, with climate change, the flooding risk and impacts have become more devastating and unpredictable. Pahang was identified as one of the most vulnerable states following the devastating flood of 2021. Many existing flood studies have been conducted in the Pahang River basin, but fundamental information, such as studies on previous flood patterns and characteristics, remains lacking. Therefore, the purpose of this research is to fill gaps in existing studies by comparing and analyzing flood events in Kuantan and Temerloh using secondary flood data obtained from the DID annual flood report. According to the findings, these two districts are considered to be among the districts in Pahang that have the most flood-prone areas. In addition, flooding is considered an annual occurrence in both districts, with flood depths ranging from 1 to 2 meters and lasting only a day or so. Monsoon floods in both districts typically occur between November and February, whereas flash floods can occur at any time of year but are most likely to occur between April and September. In addition, flooding has also significantly impacted victims in many ways, including the loss of life and property, relocation to shelters during the events, and emotional problems caused by the losses.

This study has some limitations because it mainly focuses on secondary data from flood reports, uses a straightforward statistical data analysis method, and only examines two districts in Pahang. However, the potential of this study is that it demands further investigation and would direct such an investigation. Local authorities, town planners, and other relevant stakeholders may incorporate the results from this study to provide a better flood management plan in both districts that can later be replicated in other districts in the state, as well as for implementation at a higher level, such as the national level, in the future. Furthermore, this study suggests that the locals themselves need to prepare for upcoming flood events, such as elevating the house structure to at least 1 meter high, following the trend of flooding in both districts, and keeping important documents and items at a higher level. Finally, because climate change may increase the frequency and severity of flood events in the future, every household should have at least one flood kit in case of emergency, as it can speed up the evacuation process.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGEMENT

The authors highly appreciate the financial support by the Ministry of Higher Education via FRGS grant (Grant number: FRGS/1/2020/TK0/UM/02/19). We would also like to acknowledge and express our thanks to all the relevant agencies for their support and assistance in performing this study.

REFERENCES

ABD MAJID N., RIZAL RAZMAN M., SYED ZAKARIA S.Z., AHMED M.F., ZULKAFLI S.A. (2021). Flood disaster in Malaysia: approach review, causes and application of Geographic Information System (GIS) for mapping of flood risk area, Ecology, Environment and Conservation Paper, Vol. 27, Issue May Suppl., pp. 1–8.

ALIAS N.A., SIWAR C., ISMAIL M.K., IDRIS N.D.M. (2018). Flood disaster management in Sungai Pahang Basin: case of Temerloh, Improving Flood Management, Prediction and Monitoring, Vol. 20, pp. 91–102. https://doi.org/10.1108/s2040-726220180000020017

ALIAS N.E., SALIM N.A., TAIB S.M., MOHD YUSOF M.B., SAARI R., ADLI RAMLI M.W., OTHMAN I.K., ANNAMMALA K.V., YUSOF H.M., ISMAIL N., YUZIR A., BLENKINSOP S. (2019). Community responses on effective flood dissemination warnings—a case study of the December 2014 Kelantan Flood, Malaysia, Journal of Flood Risk Management, Vol. 13, Issue 1. https://doi.org/10.1111/jfr3.12552

AROUA N. (2020). Flood risk reduction strategy in Algiers, a brief modern history (XVIthC -XIXthC), Larhyss Journal, No 43, pp. 73-89.

CHAN N.W. (2014). Impacts of disasters and disaster risk management in Malaysia: the case of floods, Resilience and Recovery in Asian Disasters, pp. 239–265. https://doi.org/10.1007/978-4-431-55022-8_12

DOSWELL C. (2015). Hydrology, Floods and Droughts | Flooding. Encyclopedia of Atmospheric Sciences, Second Edition, Elsevier, pp. 201–208. https://doi.org/10.1016/b978-0-12-382225-3.00151-1

DOSM (2022). Special Report on Impact of Floods in Malaysia 2021. Department of Statistics Malaysia Official Portal, 2 p.

ELFITHRI R., HALIMSHAH S., ABDULLAH M.P., MOKHTAR M., TORIMAN M. E., EMBI A.F., ABDULLAH M., YOOK HENG L., AHMAD MAULUD K.N., SALLEH S., MAIZAN M., RAMZAN N.M. (2017). Pahang flood disaster: the potential flood drivers, Malaysian Journal of Geosciences, Vol. 1, Issue 1, pp. 34–37. https://doi.org/10.26480/mjg.01.2017.34.37

FISCHER E.M., KNUTTI R. (2016). Observed heavy precipitation increase confirms theory and early models, Nature Climate Change, Vol. 6, Issue 11, pp. 986–991. https://doi.org/10.1038/nclimate3110

GHANI A.A., CHANG C.K., LEOW C.S., ZAKARIA N.A. (2012). Sungai Pahang digital flood mapping: 2007 flood, International Journal of River Basin Management, Vol. 10, Issue 2, pp. 139–148. https://doi.org/10.1080/15715124.2012.680022

HAFNAOUI M.A., MADI M., BEN SAID M., BENMALEK A. (2022). Floods in El Bayadh City: causes and factors, Larhyss Journal, No 51, pp. 97-113.

HOUNTONDJI B., CODO F. P., DAHOUNTO S. V. H., GBAGUIDI T. B. (2019). Flood management in urban environment: case of the Cotonou city in Benin, Larhyss Journal, No 39, pp. 333-347. (In French)

ISMAIL K., IBRAHIM M.H., ISA N.K.M., MARZUKI M. (2018). Flood relief management for residents in Temerloh, Pahang, Malaysia, International Journal of Academic Research in Business and Social Sciences, Vol. *7*, Issue 12, pp. 1281-1288.

https://doi.org/10.6007/ijarbss/v7-i12/3763

LAM F.S., CHOW B.Y. (2022). Disaster response network analysis in rural Temerloh, Pahang communities during the Malaysia 2020-2021 flood, E3S Web of Conferences, ICCEE 2022, Vol. 347, pp. 05003. https://doi.org/10.1051/e3sconf/202234705003

LIEW Y.S., DESA S.M., MD NOH M.N., TAN M.L., ZAKARIA N.A., CHANG C. K. (2021). Assessing the effectiveness of mitigation strategies for flood risk reduction in the Segamat River Basin, Malaysia, Sustainability, Vol. 13, Issue 6, Paper 3286.

https://doi.org/10.3390/su13063286

MABAHWI N.A., NAKAMURA H. (2020). The issues and challenges of flood-related agencies in Malaysia, Environment-Behaviour Proceedings Journal, Vol. 5, Issue 13, pp. 285–290. https://doi.org/10.21834/e-bpj.v5i13.2069

MAQTAN R., OTHMAN F., WAN JAAFAR W.Z., SHERIF M., EL-SHAFIE A. (2022). A scoping review of flash floods in Malaysia: current status and the way forward, Natural Hazards, Vol.114, pp.2387-2416. https://doi.org/10.1007/s11069-022-05486-6

MARIA Z.S., AKBARI A., FAIZAL W.I.W. (2014). A critical review of floods history in Kuantan River Basin: challenges and potential solutions, International Journal of Civil Engineering and Geo-Environmental, Vol. *5*, pp. 2180-2742.

MERZ B., BLÖSCHL G., VOROGUSHYN S., DOTTORI F., AERTS J.C.J.H., BATES P., BERTOLA M., KEMTER M., KREIBICH H., LALL U., MACDONALD E. (2021). Causes, impacts and patterns of disastrous river floods, Nature Reviews Earth and Environment, Vol. 2, Issue 9, pp. 592–609. https://doi.org/10.1038/s43017-021-00195-3

MOHD IDRIS, N.D., SIWAR C., GHAZALI R., ALIAS N.A. (2018). Adaptation strategies for flood mitigation in Pahang River Basin, Improving Flood Management, Prediction and Monitoring, Vol. 20, pp. 1–12.

https://doi.org/10.1108/S2040-726220180000020009

OGUNBODE C.A., BÖHM G., CAPSTICK S.B., DEMSKI C., SPENCE A., TAUSCH N. (2018). The resilience paradox: flooding experience, coping and climate change mitigation intentions, Climate Policy, Vol. 19, Issue 6, pp. 703–715.

https://doi.org/10.1080/14693062.2018.1560242

OTHMAN M.A., ZAKARIA N.A., AB GHANI A., CHANG C.K., CHAN N.W. (2016). Analysis of trends of extreme rainfall events using Mann Kendall test: a case study in Pahang and Kelantan River Basins, Jurnal Teknologi, Vol. 78, Issues 9–4, pp. 63-69. https://doi.org/10.11113/jt.v78.9696

PARVIN G.A., AHSAN S.M.R., YUSOP A.Y. BTM., GORDON J. A., ABEDIN M. A., AHMAD M.H. (2021). Kampung (village) flood resilience: an empirical analysis in Malaysia, Environmental Hazards, Vol. 20, Issue 5, pp. 550–574. https://doi.org/10.1080/17477891.2021.1887800

REMINI B. (2020). Oued M'Zab's I.R.S development population and floods, life in harmony part 1: hydraulic structures, Larhyss Journal, No 42, pp. 63-95.

SAFIAH YUSMAH M.Y., BRACKEN L.J., SAHDAN Z., NORHASLINA H., MELASUTRA M.D., GHAFFARIANHOSEINI A., SUMILIANA S., SHEREEN FARISHA A.S. (2020). Understanding urban flood vulnerability and resilience: a case study of Kuantan, Pahang, Malaysia, Natural Hazards, Vol. 101, Issue 2, pp. 551–571. https://doi.org/10.1007/s11069-020-03885-1

SAUDI A., KAMARUDIN M., RIDZUAN I., ISHAK R., AZID A., RIZMAN Z. (2018). Flood risk index pattern assessment: case study in Langat River Basin, Journal of Fundamental and Applied Sciences, Vol. 9, Issue 2S, pp. 12. https://doi.org/10.4314/jfas.v9i2s.2

TABARI H. (2020). Climate change impact on flood and extreme precipitation increases with water availability, Scientific Reports, Vol. 10, Issue 1. https://doi.org/10.1038/s41598-020-70816-2

TANG K.H.D. (2019). Climate change in Malaysia: trends, contributors, impacts, mitigation and adaptations, Science of the Total Environment, Vol. 650, pp. 1858–1871. https://doi.org/10.1016/j.scitotenv.2018.09.316

TEW Y.L., TAN M.L., JUNENG L., CHUN K.P., HASSAN M.H.B., OSMAN S.B., SAMAT N., CHANG C.K., KABIR M.H. (2022). Rapid Extreme Tropical Precipitation and Flood Inundation Mapping Framework (RETRACE): initial testing for the 2021–2022 Malaysia flood, ISPRS International Journal of Geo-Information, Vol. 11, Issue 7, pp. 378. https://doi.org/10.3390/ijgi11070378

TINGSANCHALI T. (2012). Urban flood disaster management, Procedia Engineering, Vol. 32, pp. 25–37. https://doi.org/10.1016/j.proeng.2012.01.1233

ZHANG W., LIU Y., TANG W., WANG W., LIU Z. (2023). Assessment of the effects of natural and anthropogenic drivers on extreme flood events in coastal regions, Stochastic Environmental Research and Risk Assessment, Vol. 37, pp. 697-715. https://doi.org/10.1007/s00477-022-02306-y

ZIARH G.F., ASADUZZAMAN M., DEWAN A., NASHWAN M.S., SHAHID S. (2021). Integration of catastrophe and entropy theories for flood risk mapping in peninsular Malaysia, Journal of Flood Risk Management, Vol. 14, Issue 1. https://doi.org/10.1111/jfr3.12686