# A Data-Driven Approach to Flood Risk Assessment and Public Sentiment Analysis

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## ABSTRACT

Flooding remains as the most frequent and destructive natural disaster impacting Malaysia which causing significant disruptions across social, economic and environmental systems. This study addresses the need to integrate physical risk assessment with public sentiment analysis to strengthen disaster management. Historical flood records from 1967 to 2023 were analyzed together with flood-related news articles, utilizing geographical risk mapping and transformer-based as well as keyword-driven sentiment analysis. The results identified Kelantan and Terengganu as the highest-risk states and revealed dominant emotions of fear and frustration in media coverage, with 74.5% of articles emphasizing rescue operations and only 11.8% focusing on recovery. These findings highlight critical gaps in long-term flood resilience communication and planning. By integrating data-driven flood risk assessment with sentiment insights, the study offers a more comprehensive understanding of flood impacts, supporting more targeted disaster preparedness, communication strategies and policy development in Malaysia.

**Keywords –** Data-Driven, Decision-making, Flood, Risk Assessment, Sentiment Analysis

## INTRODUCTION

Floods are among the most frequent and destructive natural disasters globally, affecting millions of people every year and causing significant economic, environmental and social losses (Saharudin et al., 2023). In Malaysia, floods occurred almost every year, primarily during the monsoon season (Rosmadi et al., 2023). In recent decades, the occurrence of flood events in Malaysia has shown an increasing pattern, caused by rapid urbanization, land-use changes and growing impacts of climate change (Abd Majid et al., 2020)(Romali & Yusop, 2021). The shape of the land and weather conditions also play a huge role in causing flood in Malaysia (Elsheikh et al., 2015). The impact of flooding is countless, ranging from damage to critical infrastructure, disruption of daily life, transportation, essential services and economic activities (Saad et al., 2024)(Kumar & Jha, 2023) (Aminah Shakirah et al., 2016). As a result, flood risk management has become a national priority, demanding more proactive and integrated strategies.

Traditional flood risk assessments mostly focused on physical and environmental dimensions such as topography, rainfall intensity and hydrological modelling which often utilizing geospatial and multi-criteria decision-making methods to map hazard zones and assess vulnerabilities. These approaches have produced valuable insights for mitigation and infrastructure planning. Moreover, the existing flood management effort in Malaysia, guided by official framework such as Directive 20, primarily emphasized operational coordination

during disaster event (Rosmadi et al., 2025). However, these strategies often overlook the social and emotional responses of the affected communities. Recent studies emphasized that understanding the public perception, sentiment and emotional reaction is essential for improving early warning communication, disaster preparedness and community resilience (Kaklauskas et al., 2024). In Malaysia, studies integrating public sentiment into flood risk frameworks are still limited, leaving a significant gap in the country's capacity to understand and respond to the numerous impacts of floods.

This study seeks to address this gap by combining geospatial flood risk assessment with sentiment analysis of flood-related news articles. Specifically, this research is guided by the following research question: How is the integrated geospatial flood risk assessment with sentiment analysis enhance understanding of flood impacts and support more effective disaster management in Malaysia?

The motivation for this research arises from the need to bridge technical hazard models with human centred insights. Understanding how communities perceive and emotionally respond to flood occurrences provides decision-makers a more robust evidence bases for developing targeted communication strategies, enhancing coordination, and building trust between authorities and the public. Furthermore, combining sentiment data with risk mapping enables more precise resource allocation and better prioritization of high-risk areas, resulting in increased readiness and resilience. By examining historical flood data from 1967 to 2023 together with the analysed public sentiment extracted from flood-related news articles, this research offers new perspective into how floods are experienced, perceived, and represented at the societal level.

**Related Works**

The current flood risk assessment generally incorporates hazard, exposure and vulnerability layers within Geographical Information Systems (GIS) and multicriteria decision analysis (MCDA) to provide actionable risks maps. Studies conducted in Malaysia and similar contexts shows that integrating topographical features (elevation, slope), hydrometeorological factors (rainfall, flow accumulation), land-use and socio-economic vulnerability enables the identification and classification of areas with varying risk levels. This approach allows authorities and planners to prioritise high-risk zones for mitigation measures, infrastructure reinforcement and flood shelter planning (Usman Kaoje et al., 2021). Similarly, the study in the Kanjiro River Basin, Indonesia (Hatta et al., 2025) demonstrates how the systematic integration of hazard, exposure and vulnerability can improve the precision and efficacy of local-scale flood risk assessment. These systematic approaches enhance decision-making, improve resource allocation and facilitate long-term flood resilience planning.

Recent years have seen a growing interest in applying sentiment analysis as a complementary tool for disaster management, particularly during flood events. In the study by U. H. Hair Zaki, R. Ibrahim, S. Abd Halim, and T. Yokoi (Hair Zaki et al., 2017), the authors investigated how sentiment analysis can help to manage the flood disasters. This study highlighted the critical importance of understanding the public opinion during such events, especially by gathering significant information from the large number of social media posts. The study emphasized that spotting posts showing fear, concern or panic could play a key role in responding to disasters. Although sentiment analysis is often used for things like product reviews, there hasn't been much research on using it during natural disasters, especially in the Malay language, which is mainly spoken in Malaysia. This gap highlighted the need for more localized and linguistically relevant approaches to disaster sentiment monitoring in Malaysia.

In similar study, the authors introduced a structured process model for analyzing flood-related sentiments on social media (Zaki et al., 2017). They combined machine learning technique along with the Rational Unified Process (RUP) and Service-Oriented Modeling and Architecture (SOMA) frameworks to develop an approach to classify and interpret the public emotions during the flood events. This method is useful for the current research as it demonstrates how integrating process models with sentiment analysis can provide structured, scalable insights for flood disasters response and coordination.

The study by M. A. Saddam, E. K. Dewantara, and A. Solichin (Saddam et al., 2023) applied sentiment analysis to evaluate the public perceptions of flood management in Jakarta, Indonesia. The authors used the

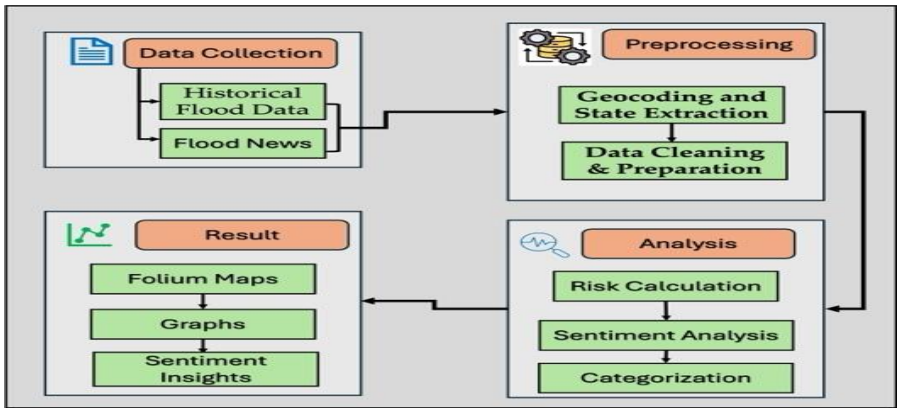
Support Vector Machine (SVM) to classify the tweets into positive, neutral and negative categories. The study showed strong results, with the 88.6% accuracy, 88.6% precision and 89.4% recall which demonstrates the potential of machine learning techniques in capturing and interpreting public sentiment during disaster events. The findings suggest that similar methodologies could be adapted to the Malaysian context to provide timely, data-driven insights to community reactions during floods.

These studies demonstrate how sentiment analysis can be strategically incorporated into disaster management systems to enhance traditional environmental and logistical data. However, most of the existing research focuses on either generic applications or non-Malay linguistic contexts, leading to a clear research gap in localized sentiment analysis for flood disaster management in Malaysia. Addressing this gap can enhance situational awareness, improve community engagement, and facilitate more efficient emergency response strategies.

## METHODOLOGY

This study used a clear step-by-step method to analyse the flood risks and emotions from news about floods. The methodology has four main steps: Data Collection, Pre-processing, Analysis and Result as shown in the Figure 1.

**Figure 1.** Step-by-step research flow




### Data Collection

There were two main data sources used in this study: (1) historical flood data and (2) flood-related news articles. The historical data dataset was downloaded from the following link: https://www.emdat.be/. This dataset includes detailed records of flood events, including dates, locations and impacts shown in Figure 2. The dataset loaded using the Pandas library, a widely used tool for data analysis in Python.

**Figure 2.** Historical flood data

| index | DisNo. | Historic | Classification Key | Disaster Group | Disaster Subgroup | Disaster Type | Disaster Subtype |
|---|---|---|---|---|---|---|---|
| 0 | 1967-0002-MYS | Yes | nat-hyd-flo-flo | Natural | Hydrological | Flood | Flood (General) |
| 1 | 1967-0002-MYS | Yes | nat-hyd-flo-flo | Natural | Hydrological | Flood | Flood (General) |
| 2 | 1978-0139-MYS | Yes | nat-hyd-flo-flo | Natural | Hydrological | Flood | Flood (General) |
| 3 | 1986-0136-MYS | Yes | nat-hyd-flo-flo | Natural | Hydrological | Flood | Flood (General) |
| 4 | 1986-0136-MYS | Yes | nat-hyd-flo-flo | Natural | Hydrological | Flood | Flood (General) |

Flood-related news articles collected from the FloodList website at https://floodlist.com/tag/malaysia to gather relevant articles. The data was collected through web scraping using the BeautifulSoup and Requests libraries in Python. The collected data is stored in a list and converted into a pandas DataFrame for analysis. This dataset includes title, articles text, link and date which will be analysed for sentiment.

**Preprocessing**

**Geocoding and State Extraction**

Geocoding and state extraction were used to identify the location of flood events. For historical data, reverse geocoding converted latitude and longitude into state names using the Google Maps API. For news articles, a predefined list of Malaysian states was used to extract state names from article titles.

**Data Cleaning and Preparation**

Missing values into the dataset were replaced with zeros using the fillna(0) method. Numeric columns like 'Start Year' and 'End Year' were converted to numeric format for proper data handling. The dataset was also filtered for the articles to include only flood events by selecting rows where the 'Disaster Type' column contained the keyword 'Flood'.

**Analysis**

**Risk Score Calculation**

Risk Score calculated based on the historical flood data. The score integrates key factors, including the Total Affected Population, Total Deaths, and the Consumer Price Index (CPI). Using this approach, flood-prone areas are classified into three risk levels:

- **High Risk:** Severe flood impact with high affected population, deaths and economic losses (CPI-adjusted).
- **Medium**-High Risk: Significant flood impact with moderately high affected population, noticeable deaths and economic losses.
- **Medium Risk:** Moderate impact with manageable population, deaths and losses.
- **Low Risk:** Minimal impact with low affected population, few/no deaths and minor losses.

**Sentiment Categorization**

In this paper, we used a combination of transformer-based sentiment analysis and a rule-based keyword matching technique to classify and analyse the news articles about floods in Malaysia. The sentiment analysis was performed using Hugging Face's transformers library, specifically the pre-trained BERT (Bidirectional Encoder Representations from Transformers) model, which excels in natural language processing (NLP) tasks. This model processes the text by splitting it into manageable chunks, evaluates the sentiment (positive, negative) for each chunk, and aggregates the results to provide an overall sentiment score.

**Sentiment Analysis**

To refine sentiment analysis, keyword-based classification was used across several categories. Severity was determined by keywords related to "loss_of_life", "property_damage" and "logistical_issues". Emotional impact was classified using words linked to fear, frustration, sadness and helplessness. Keywords like "rescued", "donation" and "aid" identified articles on rescue and recovery efforts. Neutral reports, including weather updates, government actions, community support and health advisories, were also categorized. All these keyword groups are shown in Figure 3.

**Figure 3.** Sentiment Categorization

```
# Define keywords for severity-based sentiment classification
severity_keywords = {
    "loss_of_life": ["dead", "death", "fatal", "killed", "casualty"],
    "property_damage": ["damage", "destroyed", "loss", "ruin", "collapse", "damaged", "wrecked", "devastation"],
    "logistical_issues": ["evacuation", "displaced", "shelter", "rescued", "trapped", "inaccessible"]
}

# Define keywords for emotional impact classification
emotion_keywords = {
    "fear": ["fear", "scared", "panic", "afraid", "terrified", "anxiety"],
    "frustration": ["frustration", "anger", "irritated", "disappointment", "upset"],
    "sadness": ["sad", "grief", "mourning", "heartbroken", "loss", "tragic"],
    "helplessness": ["helpless", "hopeless", "despair", "overwhelmed"]
}

# Define keywords for recovery and rescue efforts
rescue_recovery_keywords = {
    "Rescue Operation Highlighted": ["rescue", "rescued", "evacuated", "trapped", "saved"],
    "Recovery Efforts Mentioned": ["recovery", "aid", "support", "donation", "volunteer", "assistance", "help"]
}

# Define keywords for neutral coverage indicators and their categories
neutral_keywords = {
    "Weather Report": ["weather forecast", "weather report", "rainfall report", "flood report", "meteorological"],
    "Government Steps": ["government action", "policy", "initiative", "response team", "announcement", "assistance program"],
    "Community Support": ["community support", "volunteers", "donation", "relief", "helping", "assistance", "charity"],
    "Health Advisory": ["health advisory", "public health", "safety tips", "preventive measures"]
}
```

# RESULT AND DISCUSSION

## Historical Data Analysis

The analysis showed the distribution of floods across different states in Malaysia. Figure 4 presented a bar chart highlighting the states that experienced the most flood events from 1967 to 2023. Figure 5 displayed a time series chart showing the number of floods each year, helping to identify trends over time. This visualization highlighted years with severe floods and years with fewer incidents. Understanding these patterns helped improve flood management and preparedness strategies.

**Figure 4.** Flood occurances by states

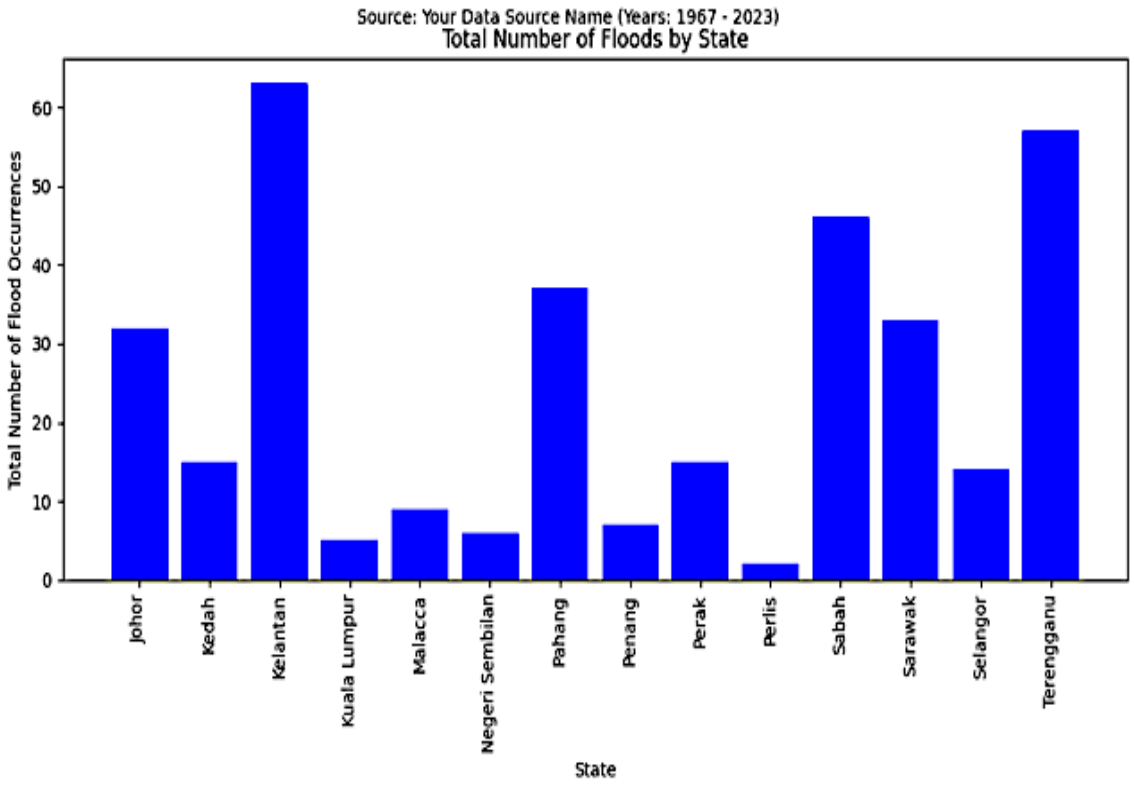
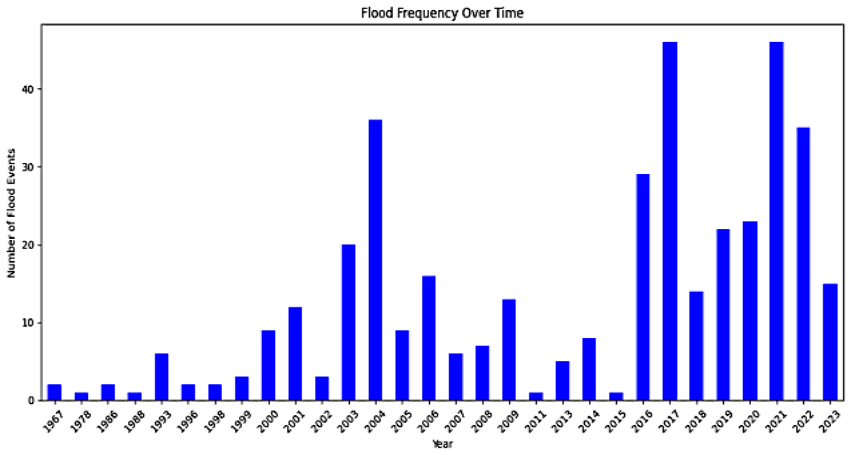
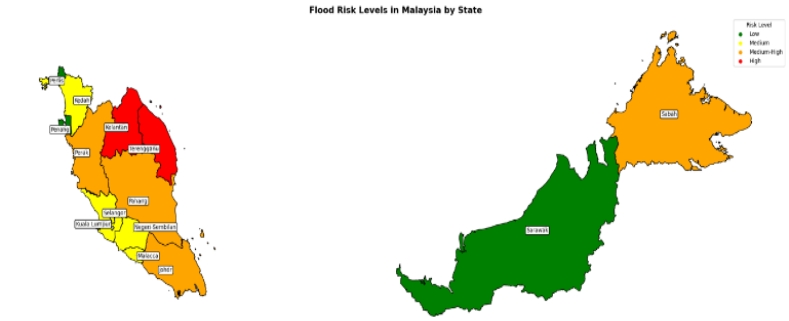


**Figure 5.** Flood frequency over time




The risk levels for the state were categorized based on the number of flood occurrence count. The visualization showed in Figure 6, that some states, particularly those with more severe events, were marked with higher risk levels.

**Figure 6.** Flood risk level by state in Malaysia




The classification of flood events by subtype provided a detailed view of flood occurrences. Figure 7 showed the yearly distribution of different flood subtypes from 1967 to 2023, helping to track how often each type occurred over time. Figure8 compared the three main flood subtypes: general floods, riverine floods and flash floods. Categorizing floods this way gave better insight into their causes, characteristics and impacts on different regions. This classification helped improve flood risk assessment and mitigation planning.

**Figure 7.** Flood risk level in Malaysia by state

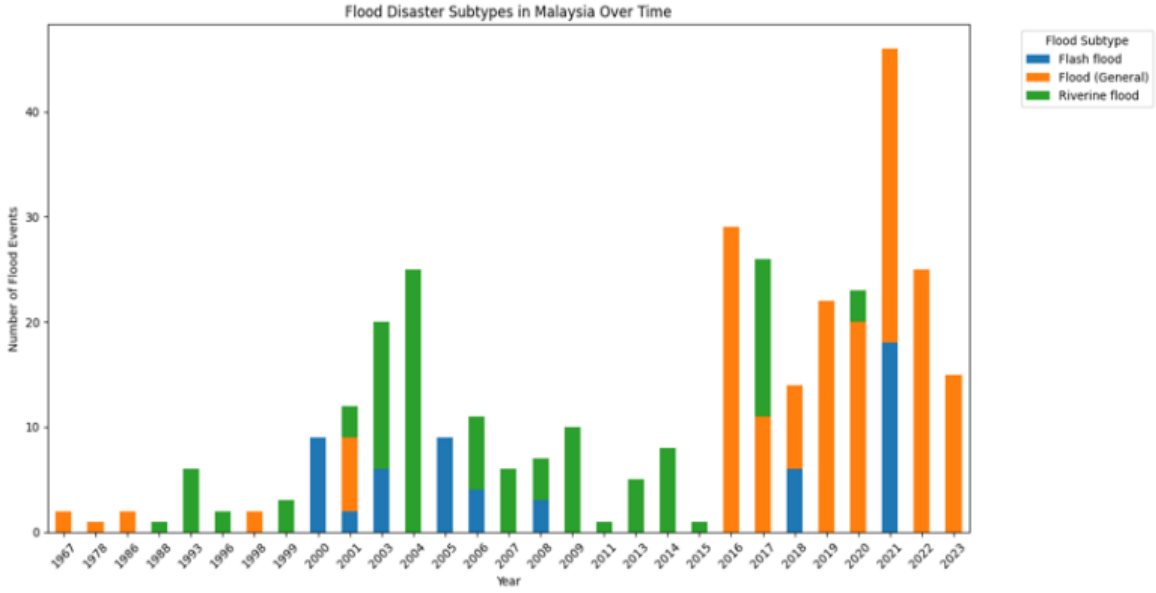
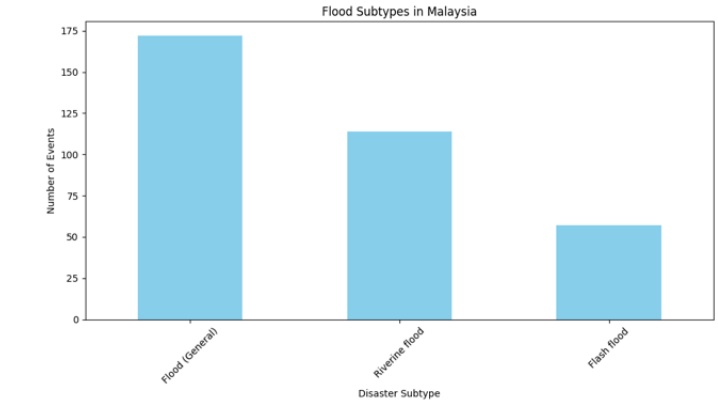
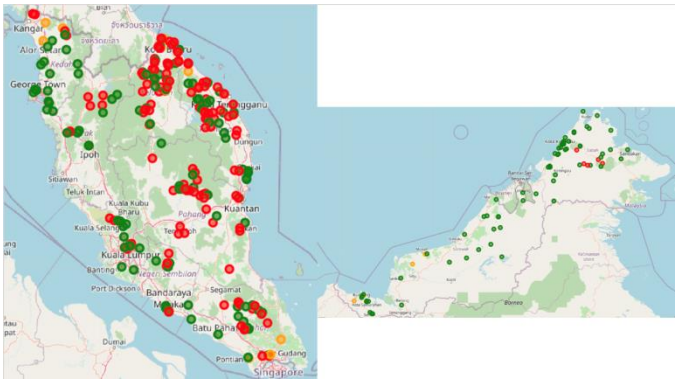


**Figure 8.** Flood subtype in Malaysia



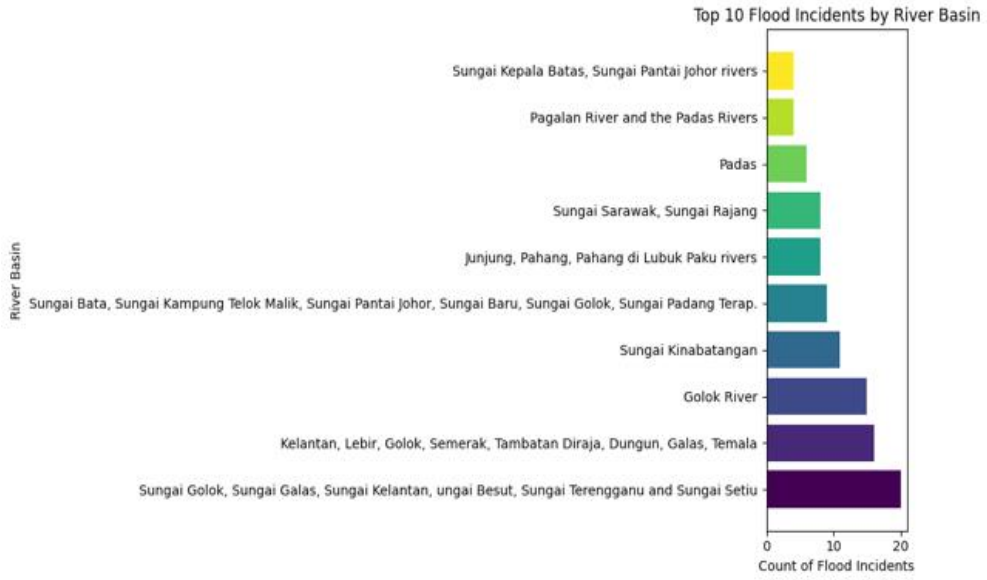

A comprehensive risk map was created, visually displaying in Figure 9, the relative flood risk of each place. This map helps to identify high-risk areas based on historical flood data.

**Figure 9.** Flood prone areas




Using a dataset of flood incidents, categorized and visualized the top 10 river basins based on the frequency of flood occurrences presented in Figure 10. This visualization helps in understanding which river are at the greatest risk. The use of horizontal bar charts allows for a clear comparison of flood frequency across these basins, highlighting critical hotspots of flood activity.

**Figure 10.** Top ten flood incidents by river basin




Overall, this section provided a quantitative insights and visualization, that how floods affect in Malaysia. It is important to find out the areas that get flooded often in Malaysia.

**Sentiment Analysis**

This section presents the sentiment analysis from the flood-related news articles. Figure 11 shows the negative and positive emotions in the news where the occurrences of negative sentiment is higher than the positive . It provides understanding about how strong these emotions were about floods. Figure 12 presents the overall distribution of emotions, a compressive overview of the people's emotions in the news. By studying these patterns, we can understand how the public felt and reacted to the flood events over time. This analysis is important to understanding public awareness, response and concern during the flood events.

**Figure 11.** Sentiment Distribution

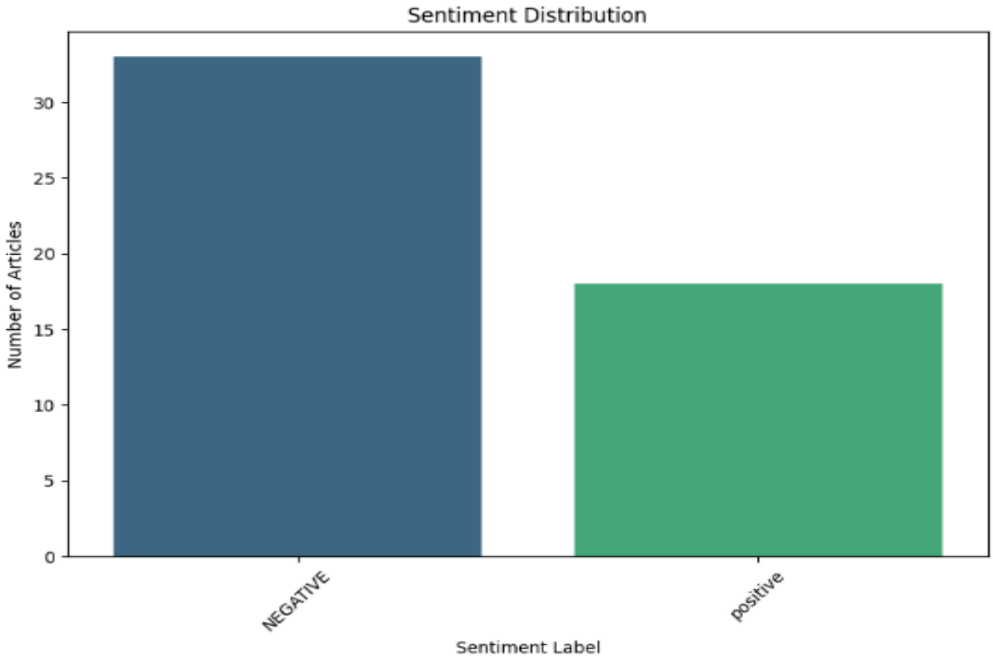


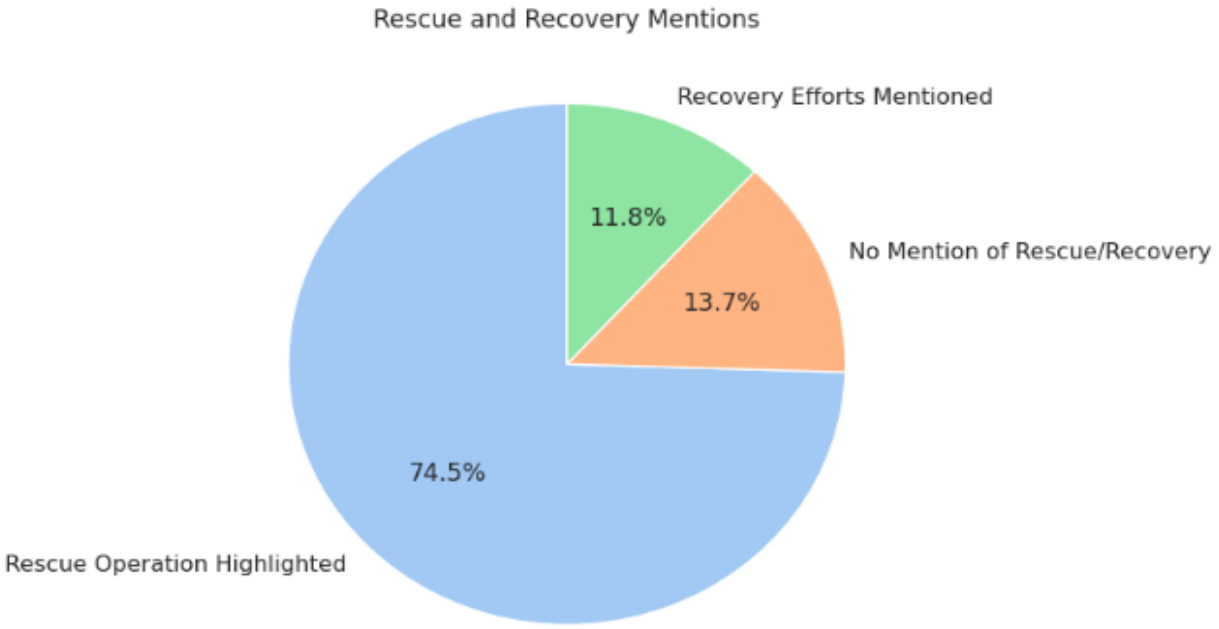

**Figure 12.** Sample of positive and negative keywords

```
Sample Articles for 'NEGATIVE':
57    sharesharesaveshareshareOver 3,000 people have...
79    sharesharesaveshareshareHeavy rainfall in Mala...
13    sharesharesaveshareshareUpdate, 15 January 202...
Name: Full_Text, dtype: object
Example Keywords: ['loss', 'overwhelmed', 'disappointment', 'helpless', 'mourning', 'heartbroken', 'fear', 'tragic',

Sample Articles for 'positive':
11    sharesharesaveshareshareAt least 4 people have...
5     sharesharesaveshareshareAt least 3 people have...
73    sharesharesaveshareshareThe National Disaster ...
Name: Full_Text, dtype: object
Example Keywords: ['volunteer', 'good news', 'donate', 'gratitude', 'positive', 'rescue', 'thankful', 'assistance', '
```

Figure 13 shows how many news articles specifically talked about the rescue operations, recovery efforts or both. By looking at this data, we can see how often the flood responses are reported and highlighted. This helps us to understand the trends in news coverage and the focus on rescue and recovery over time. It also helps to evaluate how well the public is informed about flood management actions.

**Figure 13.** Rescue and recovery mentioned in articles




In this section, the articles are sorted by how serious the flood impacts are. It covers things like problems with logistics, loss of life, damage to property or no serious damage at all. Figure 14 illustrates how frequently each of these categories is mentioned in the news articles, providing a clearer picture of the media's focus on different aspects of flood severity. This breakdown aids in understanding the narrative of flood coverage and how often the severity of different impacts is underrepresented or emphasized. The emotional impact reflected in the flood-related articles by categorizing them into four key emotional responses: no emotion, frustration, fear, and sadness. Figure 15 visualizes the frequency of each emotional impact, highlighting how the media portrays the emotional response to floods in Malaysia.

This result shows how people reacted emotionally and socially during flooding events. They were frustrated with slow recovery, scared of rising the water level and sad about the loss and damage. These feelings help us to understand what they went through into the time of flood.

**Figure 14.** Severity sentiment distribution

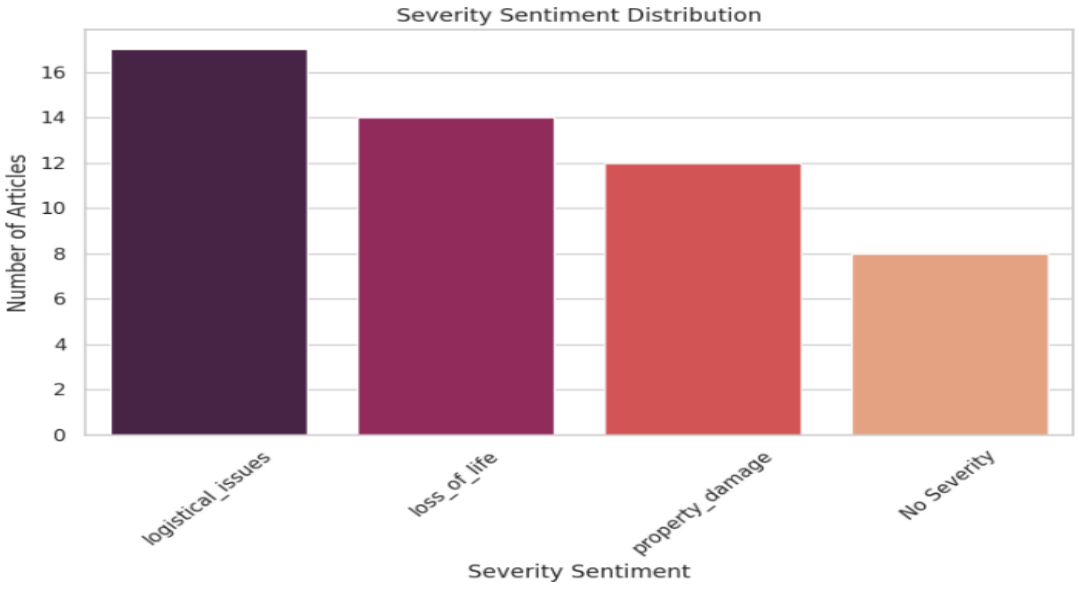


**Figure 15.** Emotion impact distribution

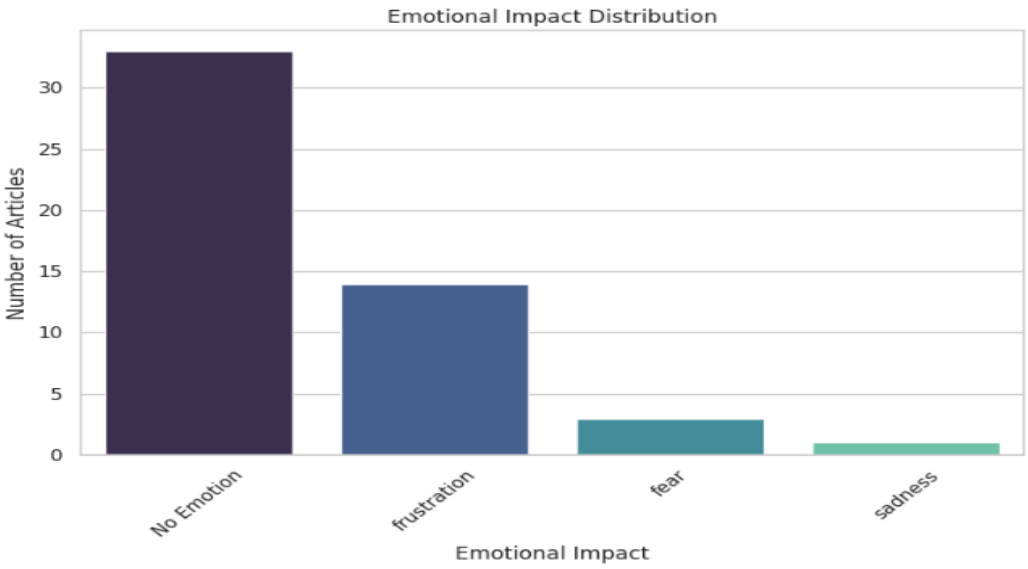



Figure 16 shows how often neutral topics like community support and weather reports appear in the news articles about floods in Malaysia. Articles about community support highlight how people and groups come together to help those affected, showing strength and unity during tough times. On the other hand, weather reports give clear, factual updates about the conditions, which help keep the public informed and support better decision-making during flood events. By analyzing these neutral reporting categories, we can understand how the media balances emotional narratives with factual updates, thereby influencing public perception and response during the flood emergencies. Figure 22 the heatmap showed the link between the severity in flood news and the emotions expressed. Most articles, even when reporting serious issues like property damage or loss of life, did not show any strong emotion. However, frustration appeared more often when discussing logistical issues and loss of life. Fear and sadness were rarely used. This meant that while most reports stayed neutral, some emotions did come through, especially in more serious or stressful situations. This helped us understand how the media presented emotional impact during flood events.

**Figure 16.** Neutral reporting categories

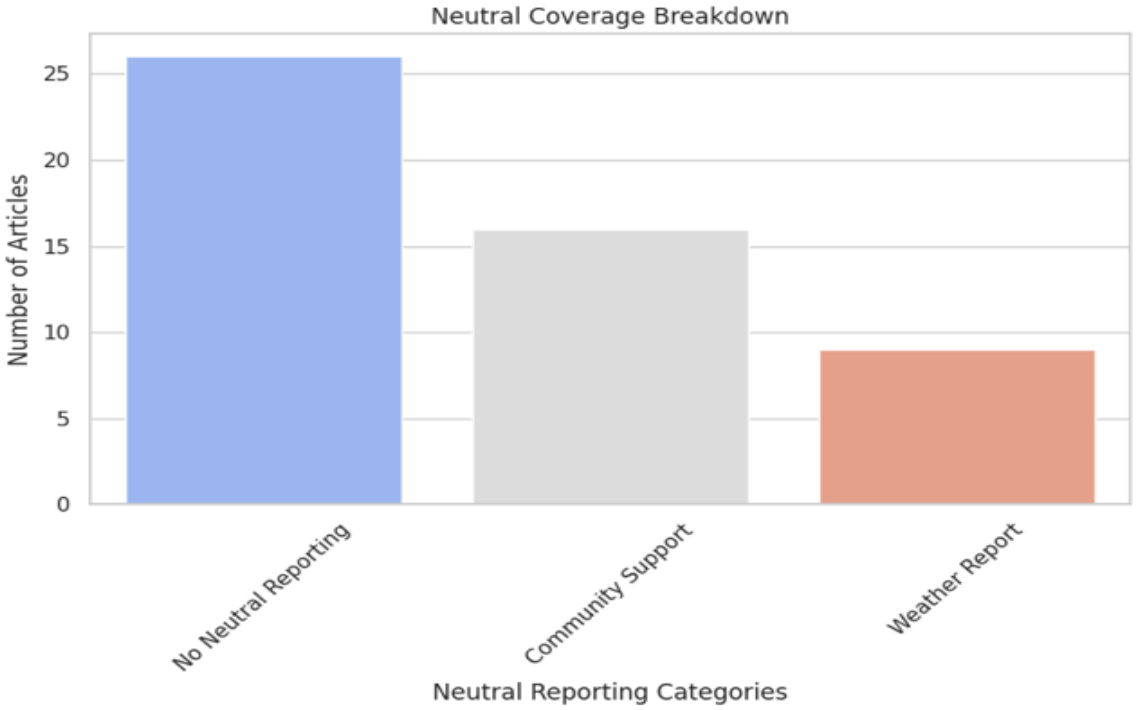
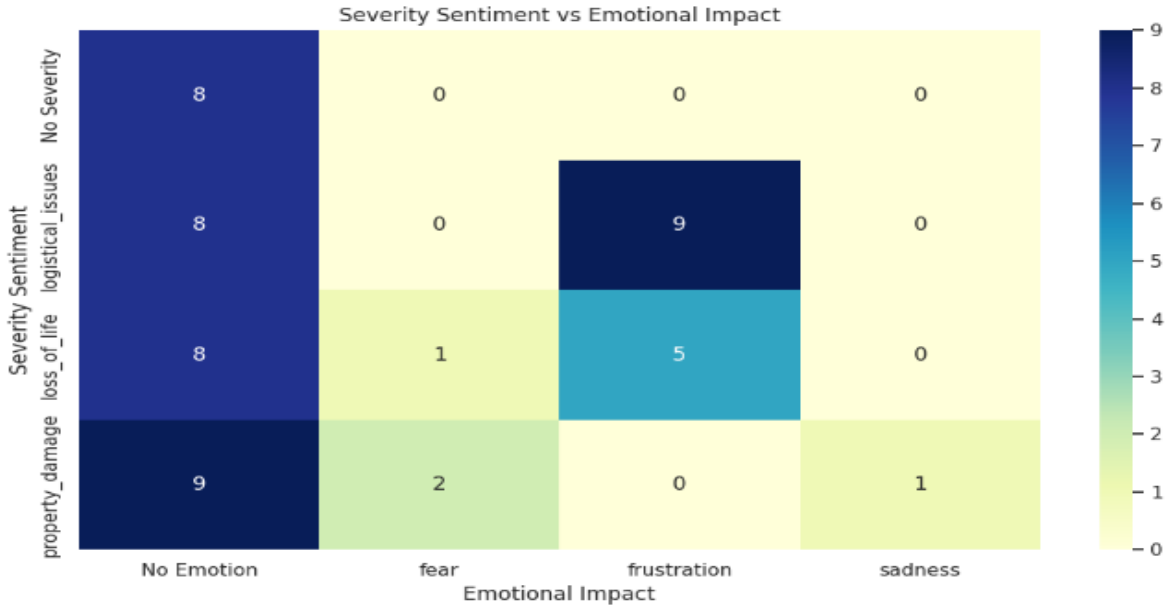
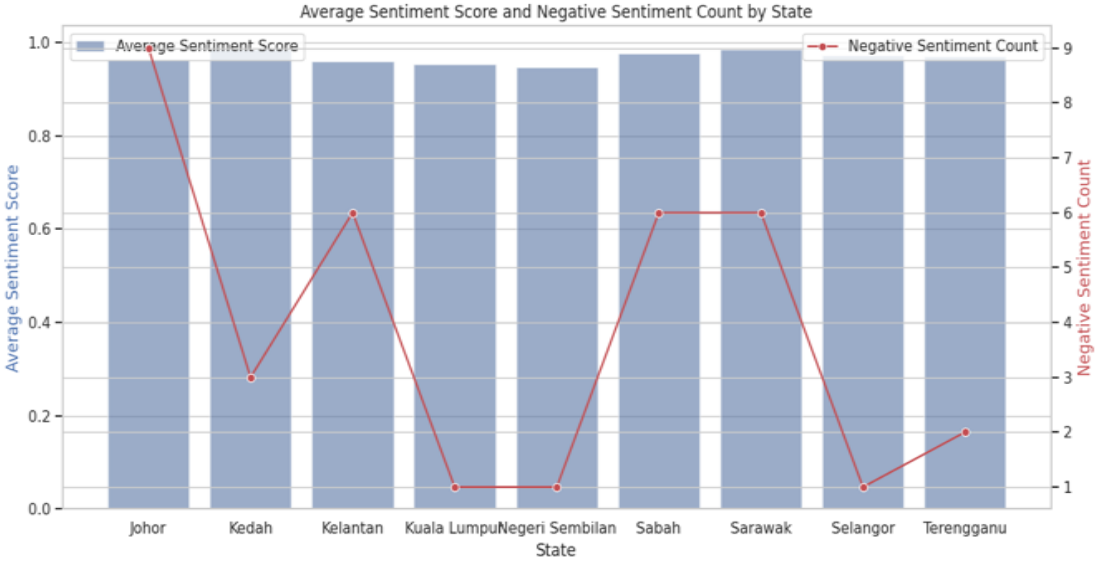


**Figure 17.** Severity vs emotional impact




The number of negative sentiment articles about floods in different states of Malaysia presented into the Figure 18. It highlighted which states had the more negative coverage in the media. States with the higher negative sentiment may have faced more serious flood impacts or had issues with response efforts.

**Figure 18.** Historical flood data




# DISCUSSION

## Spatial Distribution of Flood Risk

The geospatial analysis demonstrates that Kelantan and Terengganu continue to be Malaysia's most flood-prone states, with persistently high flood frequencies over the last five decades. These findings are consistent with prior hydrological and GIS-based evaluations, which have identified the east coast's vulnerability to monsoon-driven riverine floods. The historical trends identified in this study show that flood occurrences have become more frequent and severe, which is consistent with broader regional patterns associated with urbanisation and climate variability. The spatial concentration of flood events in specific river basins highlights the ongoing vulnerability of critical infrastructure and settlements, with substantial implications for disaster preparedness, infrastructure investment, and long-term resilience planning. By establishing a robust spatial baseline, this study provides a critical foundation for integrating physical risk with social dimensions of disaster management.

### Public Sentiment and Disaster Communication

The analysis of sentiment in flood-related news articles indicated that fear and frustration were the predominant emotions expressed during flood events. Emotional responses serve as indicators not only of disaster severity but also of public perceptions regarding institutional readiness and the effectiveness of response mechanisms. The significant focus on rescue operations (74.5%) relative to recovery narratives (11.8%) indicates a structural communication imbalance that favours immediate emergency responses over long-term community recovery efforts. This pattern corresponds with findings from disaster communication research indicating that emergency-focused narratives can increase public anxiety and limit awareness of resilience measures. The prevalence of neutral reporting indicates that Malaysian media frequently portray floods as normal events, which may lead to public desensitisation. The integration of sentiment assessment into flood management systems may enhance adaptive communication strategies, improving community trust and compliance in response efforts.

### Regional Variation and Policy Implications

The state-level sentiment analysis indicates significant regional variations, with higher negative sentiment primarily observed in developed states such as Negeri Sembilan and Kuala Lumpur. This may indicate increased exposure, more extensive media coverage, or perceived deficiencies in local response capabilities. The findings indicate that flood communication strategies must avoid a single approach. They need to be customised to the socio-economic and infrastructural context of each region. High-risk rural areas may benefit from enhanced early warning systems and community-based preparedness programs, while urban regions might need improved inter-agency coordination and information transparency. The insights correspond with the overarching policy framework of Malaysia's National Security Council Directive No. 20, which prioritises localised disaster response. Integrating sentiment data into spatial risk mapping enables policymakers to prioritise resources more effectively, enhance targeted messaging, and strengthen community engagement.

### Limitation, Contribution and Future Research

This study opens to several limitations. First, sentiment extracted from news articles may inadequately represent the complexity of public perception, as media coverage often reflects editorial decision and language framing. Second, the temporal resolution of the data may not correspond precisely with flood event timelines, which creating potential biases in emotion classification. Third, while the BERT-based model demonstrated robust performance, incorporating additional local language models could further improve sentiment detection accuracy. Despite these limitations, this study contributes methodologically by integrating geospatial and sentiment analysis to provide a richer, multidimensional understanding of flood impacts in Malaysia. Future work could expand this framework by embedding the causal relationships between flood severity indicators and public emotion into disaster communication simulations and decision-support dashboards to build dynamic and localized flood intelligence systems. This will enable agencies to anticipate public reactions, optimize communication strategies, and strengthen trust during crises. Together, these advancements will extend the current study beyond analytical insight toward actionable, impact-oriented disaster management solutions.

## CONCLUSION

This study provides a comprehensive understanding of flood risks in Malaysia by integrating historical flood risk analysis with sentiment analysis derived from news articles. The findings highlight the spatial distribution of flood-prone areas and reveal how communities have experienced and responded to the flood events over the years. The analysis indicates that certain states particularly Kelantan and Terengganu have faced recurrent flood incidents, indicating higher levels risk and the needs for sustained mitigation and preparedness planning. The sentiment analysis further reveals strong public emotions, including fear and frustration, in conjunction with accounts of rescue and recovery efforts. These dual perspectives capture not only physical and infrastructural impacts of floods but also the social and emotional dimensions, providing more comprehensive understanding of disaster impact in Malaysia. A key insight from this study is that 74.5% of flood-related news articles emphasized on rescue operations, while only 11.8% highlighted recovery and long-term resilience efforts. The difference indicates an essential communication gap in how flood events are presented to the

public. When media narratives focus predominantly on emergency response, communities may perceive floods as short-term crises rather than recurring hazards that ongoing preparedness, resilience-building and post-disaster rehabilitation. To address this communication imbalance, this study recommends introducing a post-disaster communication framework to ensure more balanced and informative flood reporting. The framework should require media coverage to highlight not only rescue operation but also post-disaster recovery and long-term resilience initiatives. This should provide unified communication guidelines and strengthen coordination between media organizations and disaster authorities to improve public awareness and support more effective community preparedness.

The flood risk map is useful for the disaster management agencies, facilitating more targeted response strategies and more efficient resource allocation. By combining the data-driven risk assessment with sentiment analysis, this research contributes to better flood preparedness, response planning and overall resilience in Malaysia. Future work may focus on developing a flood prediction model based on the identified flood-prone areas, which could enhance early warning systems and strengthen disaster management strategies in Malaysia.

## ACKNOWLEDGMENT

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