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The Use of Correspondence Analysis on the Visualization of Locality and Seasonal Behaviour on the Flood Pattern in Malaysia

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ABSTRACT

Flood mitigation and assessments are crucial in current time. The seasonal and non-seasonal of flood occurrence in Malaysia provide risk towards country growth and productivity. In this study, the flood pattern will be analysed by using correspondence analysis. The data involve the occurrence of flood based on month and locality from 2013 to 2018. The test of independence ($\chi 2$ test) between month and locality indicated independency among the variables (p=0.615). The symmetric plot suggested that Perak, Melaka, Selangor, Johor, Terengganu, Sarawak inclined to have flood occurrence during December to March, while Kedah and Penang during March. This analysis will help authorities to better planning flood mitigation accordingly.

Keywords:
Flood pattern, flood visualization, correspondence analysis, locality and seasonal behavior

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1. Introduction

Flood mitigation and assessments are crucial in current time. The risks of flood disaster do not only limited to the loss of tangible lives and properties [1,2]. It damages country economic growth [3,4], hinders productivity of its people [5,6], and exposes health concern among citizen [7,8], to name only a few. The severity of such phenomenon saw establishment of a framework specifically to assess and manage flood risk in the European Union [9], and the prioritization made by England and Wales to use their capital expenditure on flood and coastal risk management [10].

Some identified factors that can contribute to flood disaster includes the natural occurring phenomena and human activities. Such human activities involve poor management of drainage system [11,12], the management and organization of land [11], the burning of more fossil fuel that increase the release of CO2 and other greenhouse gases [13], urbanization, the agriculture practice, and deforestation that leads to the altering of the river basin and thus resulting in larger sediment

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yield from water catchments [12]. Besides, climate change is also among the contributing factor that worsen flood disaster [13-15]. The United Nations estimated that 9.6 million people are currently affected by the flood disaster in Southeast Asia [16].

In Malaysia, flood occurrence can be seen as seasonal, and non-seasonal. Malaysian Drainage and Irrigation Department categorized floods in Malaysia into the monsoon flood and flash flood [17]. Malaysia resides in the equator, which is susceptible to full daily sunlight and high temperature with averaging temperature of 27°C [12]. Most of its rainfall distribution is heavily affected by the coastal area facing the South China Sea. Such location is vulnerable to intense convective precipitation. Besides, there are expected two monsoons – the Southwest Monsoon from end of May to September, and the Northeast Monsoon from November to March occur annually. The Northeast Monsoon is responsible to carry the yearly average of rainfall at approximately 250 cm. Though such rainfall is important for fertility of soil and water resource [18], its excessive rain causes seasonal floods, commonly known as monsoon flood [17].

For non-seasonal occurrence of flood, the flash flood is normally occurred within the city center, mostly contributed by inefficient drainage system and blocks in the river systems. Normally, the duration of flash flood is quick, it takes about few hours to reside. On the other hand, the monsoon flood can last for a month [19]. The severity of flood disaster in Malaysia were more pronounced in the year 2014, where the monsoon flood simultaneously hit several states, with Kelantan saw RM200 million in losses and 42,163 people affected [20].

Such tragedy shows the needs to improve understanding of flood disaster in Malaysia, thus this study aims to explore the flood patterns and trends from historical data. The correspondence analysis is utilized to visualize the flood pattern and relation between locality and seasonal behavior will be established by using the correspondence analysis. Arrington and Winemiller [21] studied the clustering and patterning habitat structure that has been affected by flood in Venezuela by using this method, however at present, there is still no study using the correspondence analysis to the flood pattern in Malaysia.

The remainder of the paper is structured as follows. We discuss on its research methodology and research results, respectively. Later, in the last section, a concluding remark will be delivered.

2. Methodology

2.1 Data

We retrieve monthly flood data in Malaysia (year 2013 – 2018) from the FloodList, a free databank funded by Copernicus, one of the European Union (EU) programme responsible to monitor global environment [22]. The data is qualitative in nature.

2.2 2D Plots of Data

The data is then transferred into visual based on locality and month. The 2D plots is constructed by using XLSTAT 2014, add-in software for MS Excel. The visual representation of the data will be easier to understand and provide better efficiency [23].

2.3 Correspondence Analysis (CA)

In this article, we will adopt correspondence analysis (CA) to measure associative behavior between the months (row) and locality (column), specifically for categorical data. This categorical data can be binary, ordinal and nominal [24]. CA is selected as it is able to decompose measurement of row-column association in term of chi-square (χ2) value [25]. This value is responsible to show dependencies between the variable that represented by column and row.

By using this method, the information will be changed into representative metric and decomposed to obtain directions in lower dimensional space. The lower dimensional space can provide better representation of the information due to its simplicity [25]. This process will allow for achieving its primary goal, i.e. to illustrate the relationship among the variables response (row and column) categories using graphical representation in terms of symmetrical plot. Besides, this method is selected as it does not require distributional assumption prior to analysis [24].

3. Results

In Figure 1, we illustrates a 2D plot for the year 2013 to 2018 with respect to its locality of the occurred flood.

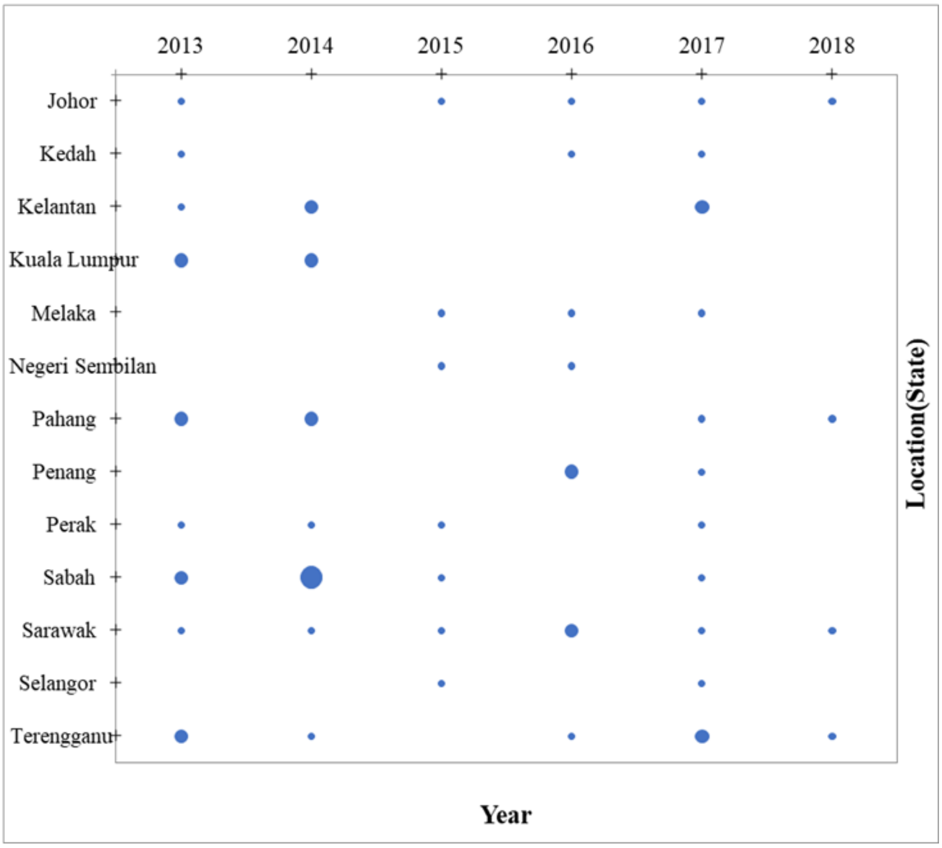

Fig. 1. 2D Plots of flood in Malaysia (based on state and year). The bigger the circle the higher the occurrence of flood

We can see from Figure 1 that the year 2017 showed the highest occurrence of flood. The flood occurs in almost all state with exception to Kuala Lumpur and Negeri Sembilan. The larger circle inside 2D plot signals a higher number of floods occurrence at the particular locality. Example include Sabah with larger circle in 2014, since three flood occurrence had affected Sabah during that year.

In Figure 2, a 2D plots for month and locality of flood during the year 2013 to 2018 is presented. The plot suggested that December, January and February are months with highest occurrence of flood for all state with exception for Kedah and Penang. In December throughout year 2013 to 2018 for instance, many larger circles can be seen, which were consistent with flood occurrence more than one. The least of flood occurrence was in March, consistent for every locality except Sarawak.

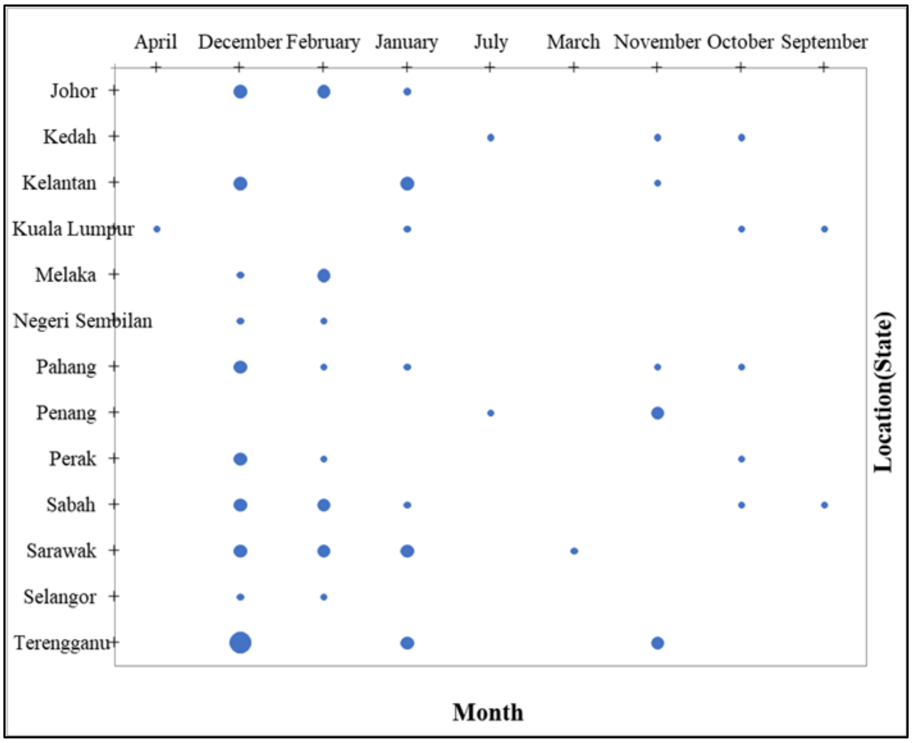

Fig. 2. 2D Plots of flood in Malaysia (based on state and month). The bigger the circle, the higher the occurrence of flood

Table 1 shows the test of independence between month and locality using the chi-square, χ^2 test.

Table 1
Test of Independence between month and locality (state)

	χ^2 (Observed value)	χ^2 (Critical value)	DF	p-value
Value	91.3549	119.8709	96	0.6150

This test showed that the critical value is higher than the observed value, leading to the p-value higher than 0.05. It failed to reject null hypothesis and show there is no association between month and locality of the flood occurred. While Table 2, we present the eigenvalues and percentages (%) of inertia based on the CA.

Table 2
Eigenvalues and percentages (%) of inertia

	Eigenvalue	Inertia (%)	Cumulative %
Factor 1	0.5949	37.7708	37.7708
Factor 2	0.4575	29.0441	66.8149

These eigenvalues and inertia percentages were used in CA to verify the quality of variables that have been considered in this study. Eigenvalue lower than 0.1 indicates poor representation of the variable in the computed dimension [26]. Thus the result shows the reasonable eigenvalues for Factor 1 and Factor 2 are 0.5949 and 0.4575, respectively. While eigenvalues represent the relative relevance to the total inertia. From the cumulative inertia percentages (%), Factor 1 and Factor 2 represent 66.8% of variable based on the computed dimension. These Factor are being illustrated in symmetric plot in Figure 3.

Among possible reason that contributed to the poor result in the test of independence (χ^2 test) and eigenvalue may be due to significant overlapping of the flood data. Other than the particular month that being listed, the flood can still occur. Such example in Figure 2 is in locality Perak, where the flood did not only occur in December to March, but also in October.

The finding of no association between month and locality can be explained by understanding the flood itself. Flood is known to occur numerous times and can either happen slowly in the span of several hours of rainfall, or it can happen very quickly. Most of flood occurrence in Malaysia are contributed largely by human activities, in which the mismanagement of the sewage system, drainage and the likes, leading to the global climate change heavily influenced this disaster.

Thus, flood occurrence had the potential to occur at random month and locality if global climate change continues to increase and poor management of land keep on continuing. The prominent scenario can be seen in Bertam, one of locality in Malaysia. The Bertam catchment is normally dries with no history of flood. However, the overflowing of water and water release from nearby dam caused 80 houses located on the fringes of Bertam River destroyed by the sweeping water in year 2013 [27]. In conclusion, flood can happen in any given month as it is mostly subjected to human activity rather that the natural occurrence. Nevertheless, such investigation on the flood pattern will be able to provide valuable information for better management within their locality.

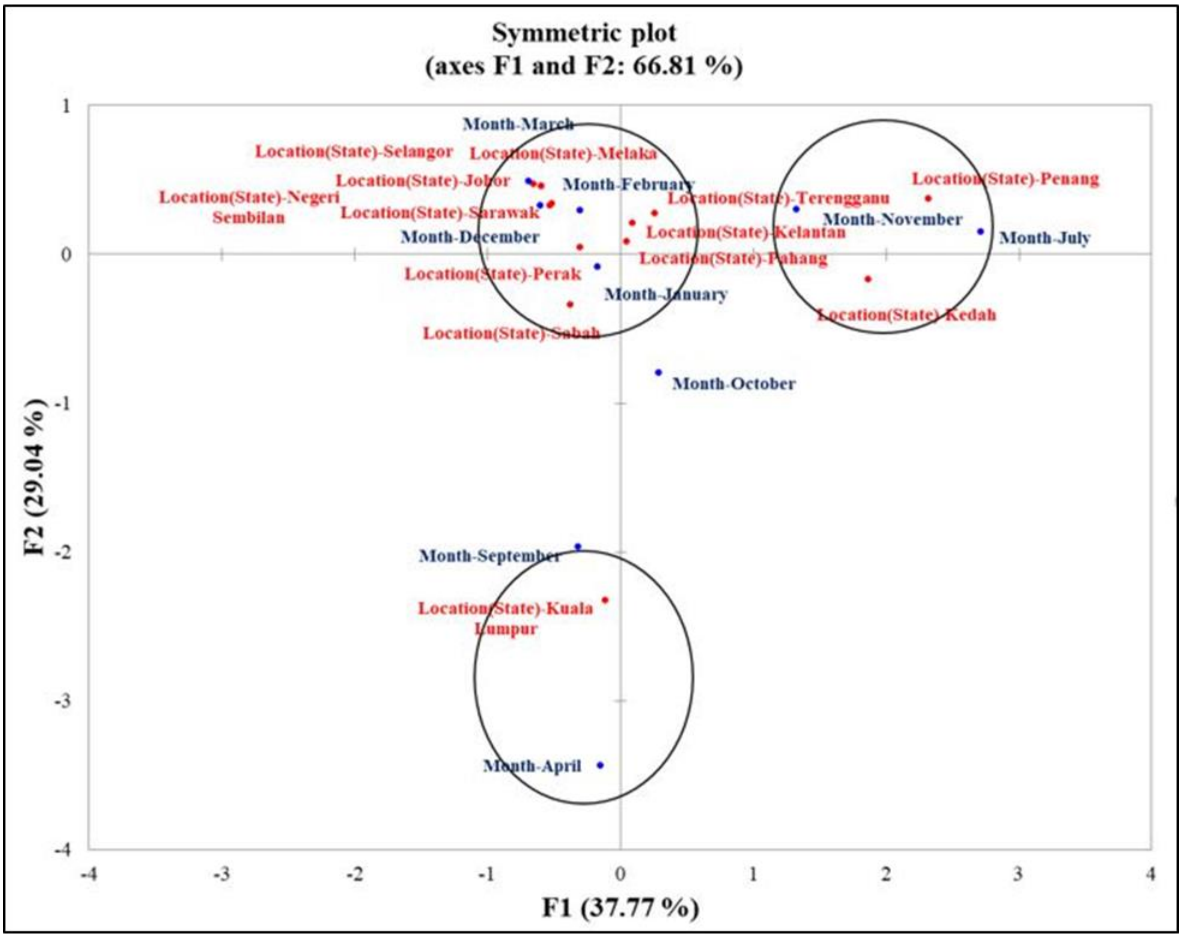

Fig. 3. The symmetric plot of location (state) of flood and month it occur (10)

We can see in Figure 3 that the symmetric plot where locality and month the flood occurred were plotted according to Factor 1 and Factor 2. Based on the symmetric plot, we can observe that Perak, Melaka, Selangor, Johor, Terengganu, Sarawak inclined towards flood during December to March. While in Kedah and Penang, the tendency of flood occurrence is in March. Kuala Lumpur showed regular flood occurrence in September.

4. Conclusions

In this article, we have illustrated the visual representation of the symmetric plot by using correspondence analysis. Though the correspondences analysis does not show association between the month and locality of flood occurrence, such 2D plot can help governing body to have better understanding of the flood behavior in Malaysia. This visualization of qualitative data into feasible graph helps to conclude the possible month and locality of the flood to occur in the future.

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