

## SPATIAL ASSESSMENT OF THE IMPACT OF FLOOD TO MELAKA'S ECONOMY

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**ABSTRACT:** Melaka used to be a significant trading state in the 16th century. It had attracted traders from various continents to be its trading partners. Many of these traders had left their footprint enormously. Over the years, these tangible and intangible historical assets have been an attraction to tourism sector which contributes significantly to Malaysian GDP. However, due to the impact of climate change and rapid urban development in Melaka, the flood has posed a risk to Melaka's economy especially in the tourism sector. To protect its interest, Melaka has taken proactive measures in mitigating flood incidences. Thus, this study intends to examine the impact of the flood on Melaka's economy from 2012 to 2016 using spatial assessments. This study employs a quantitative approach by using secondary data obtained from the Department of Statistics Malaysia and the Department of Irrigation and Drainage. Moran's I, Local Indicator and Spatial Association and Bivariate Moran's I were used to analyze the data spatially. Findings show the mitigation measures taken have relieved the risk posed by floods towards economic activities in Melaka as a whole.

*Keywords: Moran's I, Bivariate Moran's I, Local Indicator Spatial Association, Local Moran's I, Flood Modification*

### 1. INTRODUCTION

Flood has become a global concern, as flood risks caused extensive damage and threatened the lives of many people around the globe. Climate change is causing increased flood damages [1], making flood risks no more associated with underdeveloped countries. Hurricane Katerina hit the city of New Orleans on Gulf Coast in the USA and caused serious damages to people and property [2]. In 2012 the city of New York was also hit by a hurricane. In Austria, Germany and Hungary excessive heavy rains caused serious damages and losses in billions of Euros. In 2007, England suffered a major flood which destroyed property and loss of lives [3].

Malaysia, being a tropical country suffers flood risks. Flooding is one of the major hazards facing several cities in Malaysia. However, debates around possibilities of flood occurrence, do not take place against the background of climate change only, but also against the background of rapid urbanization, resulting in 4.8 million people living in flood-prone areas [4, 5]. The Malaysian government has initiated several programs at both local and national levels to improve flood risk management. However, the effectiveness of these measures has yet to be measured using various assessment tools. Thus, this study intends to

examine the impact of mitigation measures taken on economic activities using spatial analysis. The area of this study is Melaka.

### 2. BACKGROUND

Flood is the most devastating natural disaster experienced in Malaysia. It has a terrible impact socially and economically and its likelihood to occur in the future is high. There are about 189 river basins in Malaysia, and 85 of them are prone to flood. Flood disaster in Malaysia affects an area of approximately 28,800 km<sup>2</sup>, and almost 4.82 million people are affected by this disaster (DID, 2009). There are two categories of the flood that affect Malaysia. First is a flash flood and the other is monsoon flood. The difference between these two is the time taken to recede. Flash flood will only take hours to return normal level, and monsoon flood can last a month.

#### 2.1 Mitigation Measures

Flood modification is a traditional method of mitigation that deals with the use of structural measures to keep water away from development. It requires the government to allocate some funding

which involves modifying the flow of flood water. Examples of measures are levees, dams, diversions and channel improvements, floodgates and detention basins.

Property modification measure, a non-structural measure, refers to the placement of development by keeping away from the flood-prone area using land use planning or building design. Examples of this measure are zoning and land use planning, voluntary purchase or acquisition, building regulations and house raising.

Response modification places more emphasis on risk management as it seeks to modify human behavior through activities such as planning, warning system, education and awareness campaign. Examples of this measure are state and national emergency services response, forecasts and warning systems, preparedness (planning for emergency) and information and education programs.

Nevertheless, each approach has its strengths and weaknesses. Flood modification requires a hefty amount of funding to be implemented. Usually, the responsibility of this approach lies on the government to prepare for a big budget to tackle areas currently located in flood-prone areas. Property modification will only be effective in a new development area. However, most of the flood incidences occurred in an area with completed development. Sometimes it may affect areas which had never experienced flood before. Response modification will be a reactive measure in life-saving. Nevertheless, all these approaches should be implemented in countries that are facing flood risks.

### 2.1 Impact of Flood on Economy

Floods have cost a lot of damages socioeconomically [12]. It is most pronounced in urban areas which have high densities of people, assets, economic activities and vulnerable infrastructures. Malaysia experienced massive flood damages in floods that occurred in 2011 and 2015. However, according to [13] the estimated cost of damages in the 2014 flood in Malaysia is the worst which is within RM 1 billion.

## 3. METHODOLOGY

This study employs a quantitative approach. It uses secondary data which are basic data retrieved from Melaka State Government official website, flood, and mitigation measures from the Department of Irrigation and Drainage (DID) Melaka Tengah, mitigation measures from Melaka State Structure Plan and also demographic data from the Department of Statistics Malaysia. Data

obtained from these sources were analyzed using Moran's I, Local Indicator Spatial Association (LISA) and Bivariate Moran's I. Moran's I is used to measure the spatial autocorrelation of a data set. It will look for similarities of an object of its surrounding. The results of its analysis will determine whether the pattern of the dataset is clustered, dispersed or random [18]. LISA, on the other hand, is used to indicate significant spatial autocorrelation. There are two types of LISA. First is Local Spatial Statistics which indicate significant spatial autocorrelation for each location and the other is Local-Global Relation which refers to the sum of LISA proportional to a corresponding global indicator spatial autocorrelation. The former can search for relationships between locations based on a certain variable [16]. On the other hand, the latter measures the spatial correlation between locations on a global scale. As compared to Local Moran's I, the global indicator is not able to measure spatial autocorrelation. Two assumptions by Local Moran's I are to be met if this measurement is used. First is that it needs to measure the extent of spatial autocorrelation of each observation in a dataset. Secondly, the sum of local indexes is by the proportion of the global measure of a spatial association [14].

Another spatial statistics tool used in this study is Bivariate Moran's I. Unlike Local Moran's I, Bivariate Moran's I can examine two variables at any one time. This analysis tool determines the existence of spatial autocorrelation between two variables [17].

### 3.1 Melaka

The selected area for this study is Melaka. It is one of the states in Malaysia that experiences flood annually. It has three main districts namely Alor Gajah, Melaka Tengah and Jasin. Most of the tourists' attractions are located in Melaka Tengah District. Figure 1 shows the location of the districts in Melaka.



Fig. 1 Districts in Melaka.

Melaka was selected because it has a lot of tourism areas that are invaluable and flood posts high impact on its well-being, economically and socially. The worst flood that ever occurred in this state was in December 2006. Areas that were affected are Sungai Melaka river basin, Sungai Duyung, and Sungai Kesang. Almost 70.4 hectares of its area was flooded with a height of 1.5 meters. Almost 19000 families were evacuated. Loss of properties and public facilities reached almost RM54.139 million. [6].

Melaka experiences flood annually. According to Melaka State Structure Plan Report (2011), these floods occurred due to heavy rains, overflow river stream and high tide throughout the year that leads to flooding in areas adjacent to the sea. However, Melaka is not affected by the monsoon rain. Table 1 shows the number of areas that were affected by flood annually according to districts [6] from 2011 until 2015.

Table 1 Number of Areas Affected by Flood in Melaka by Districts from 2011 to 2015 [6]

Districts	'11	'12	'13	'14	'15
Alor Gajah	5	7	2	15	14
Jasin	2	5	2	21	18
Melaka	2	15	1	40	36
Tengah					

Figure 2 shows the flood area in Melaka. Most of the affected areas are located in Melaka Tengah and Jasin districts.

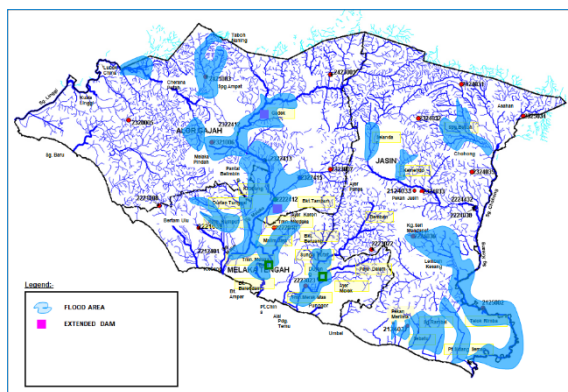


Fig. 2 Rivers and flood affected area (DID Melaka Tengah, 2016)

#### 4. FINDINGS

Results of the analysis are described according to the mitigations measures employed in Melaka, population distribution, and economic indicator from 2011 to 2015.

#### 4.1 Mitigation Measures in Melaka

Melaka has taken a drastic measure to address flood issues in its state. Two main approaches are being used which are flood modification and response modification.

##### 4.1.1 Flood modification: Water Reservoir, Detention Ponds, and Warning System

Melaka through the Department of Irrigation and Drainage builds a water reservoir and detention ponds to alleviate the flood water from overflowing into the city and build up areas. Watergates control these reservoirs and detention ponds. Figure 3 shows the water reservoirs and water gates in Melaka.

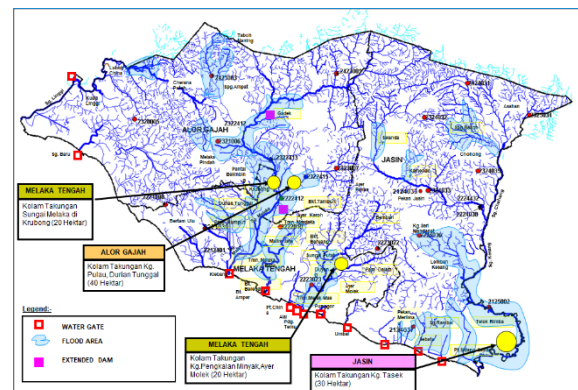


Fig. 3 Water reservoirs in Melaka (DID Melaka Tengah, 2016)

Warning systems are also placed in strategic areas along the rivers that often overflow. Once water level reaches a danger zone, the warning system will signal a siren to the water station. Melaka has five flood warnings systems which are placed in Lubok China, Kg Gadek, Pekan Jasin, Parit Sidang Seman (Sg Rambai) and Taman Malim Jaya.

##### 4.1.2 Mitigation measure: Melaka State Town and Country Planning Department and Local Authority

Flood areas are considered as sensitive areas for development by the State Town and Country Planning Department [7, 8]. Most of these flood-affected areas are located in the buildup areas, especially in Melaka Tengah. The only mitigation measures that are documented in the structure and local plan include increasing drainage capacity to handle the flood, to control flood-affected areas effectively [8] and to provide a complete irrigation system to overcome flood issues [7].

#### 4.2 Population Distribution in Melaka

Melaka has a population of 790,136 people distributed in its three districts; Alor Gajah with 173,712; Jasin with 131,539; and Melaka Tengah with 484,885 [9]. Melaka Tengah has the highest number of the household of 119,120. Alor Gajah ranked second with 40,385 and finally Jasin with 31,888. Moran's I analysis shows the distribution of households is slightly significant with a p-value of  $< 0.05$  (0.03) with a  $z = 2.14$ . The  $z$  score obtained shows the distribution of households is clustered. Local Indicator Spatial Association (LISA) analysis shows that its working population is concentrated in Melaka Tengah. Figure 4 shows the output of this analysis.

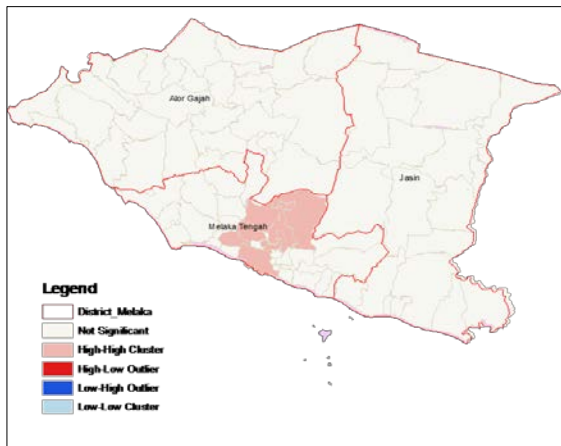


Fig. 4 LISA Analysis on working population

### 4.3 Economic Indicator in Melaka from 2011 to 2015

Melaka relies heavily on three main economic sectors namely services, manufacturing, and agriculture. However, services and manufacturing contributed more than 75% of its gross domestic product (GDP) annually for the past six years [10]. The outcome reflects the importance of tourism-related products such as attractions, accommodations, and eateries. Table 2 shows the gross domestic product for Melaka from 2011 to 2015.

Table 2 Gross Domestic Product (%) by Sector, Melaka from 2011 to 2015

Sector	'11	'12	'13	'14	'15
Services	46.2	52.5	53.2	53.4	53.5
Manufacturing	41.6	23.2	22.9	23.0	23.0
Agriculture	9.3	9.8	9.5	9.2	8.9

Floods that occurred in 2011 and 2015 were

quite bad. These two floods hit many states in Malaysia including Melaka. Costs in damages in these floods were not revealed to the public and unknown to researchers. The only analysis that can be done is by using the percentage of gross domestic product (GDP) disclosed yearly. Since the available data is only until 2015, it is quite difficult to observe the impact of the flood in 2015. As shown in Table 2, a flood that occurred in 2011 does not give any negative impact to Melaka's GDP. Similarly to floods that occurred in 2014. GDP for both services and manufacturing sectors are on the increasing side. However, agriculture sector experienced a declining percentage in 2015.

Due to limited data availability, a Bivariate Moran's I analysis was carried out to only examine the correlation between flood-affected areas from 2011 to 2015 and the total household. Melaka was hit badly in flood. Table 3 shows the Moran's I score accordingly.

Table 3 Results of Bivariate Moran's I Analysis

Flood	Morans'I Score
2011	0.191
2012	-0.499
2013	0.496
2014	-0.467
2015	-0.477

The negative correlations can be observed in flood-affected areas in 2012, 2014 and 2015. The result shows the higher number of affected areas is located in areas with a low number of households. Thus, these results show the mitigation measures used have been effective in reducing the cost of damages to the household.

### 5. DISCUSSION AND CONCLUSION

Do the mitigation measures heavily taken by the Department of Irrigation and Drainage, Department of Town and Country Planning and the local authority make any difference to Melaka's GDP? The results of Bivariate's Moran's I show a negative correlation between 2012, 2014 and 2015 flood affected areas. The state's GDP reflected this condition. Mitigations measures taken by the authorities have helped minimize the negative impact of flood although the numbers of affected areas are more from the previous years.

However, development in many areas should be carried out sustainably. The United Nations has proposed the Sustainable Development Goals to demand all the countries in the world to be committed to handling climate change issues and flood is one of them [11]. Although some of the mitigations measures seem to be effective,

developments should be controlled sustainably. The mitigations employed today might not be able to handle future disasters if preventive measures regarding sustainable developments are not handled properly.

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