DEVELOPING A FLOOD VULNERABLE MAP IN PASIR MAS, KELANTAN

by

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DECLARATION

I declare that this thesis entitled developing flood vulnerable map in Pasir Mas, Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date :____

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Developing Flood Vulnerable Map in Pasir Mas, Kelantan

ABSTRACT

Kelantan is one of the state that received frequent flood disasters including Pasir Mas. The flood events are now intense because of localized physical and climatic factors, resulting in risks to the environment and population. Besides, by the difficult to identify the flood vulnerable area at Pasir Mas had become the main problem. The lack of comprehensive information which as a medium to communicating the flood risk, new unplanned developments and insufficient drainage systems made the situation more considerable. However, the development of a vulnerability map for flood risk of flooding management is still lacking. Vulnerability is the main construct in flood risk management. Therefore, this study aim identifies the variables which contribute to the risk of flooding based on the characteristics of the area and develop a flood vulnerability map using Geographical Information Systems (GIS) and Remote Sensing. In this study the land use data, the average amount of rainfall data and digital elevation model (DEM) data were used to produce a flood vulnerable map for the study area. The hydrology and weight overlay (spatial analyst) techniques were used to determine the flood vulnerable area on physical and climatic factors that cause flooding in Pasir Mas and to develop the flood vulnerable map in Pasir Mas. The vulnerability area had been determined based on the scale 1 (no vulnerability), 2 (low vulnerability), 3 (reasonable vulnerability), 4 (moderate vulnerability) and 5 (high vulnerability). The finding show that the area located at the water bodies recorded high vulnerable compared to other areas. Besides, from the flood vulnerable map, it can be observed that most of the area in Pasir Mas, Kelantan was falling under reasonable to high vulnerability classes. It is expected within this flood vulnerable map will able to assist the responsible parties to communicate and give an option to those affected people to ensure the effectiveness of the emergency response assistance and aid to victims for better preparedness capability.

Membangunkan Peta Keterancaman Banjir di Pasir Mas, Kelantan

ABSTRAK

Kelantan adalah salah satu negeri yang sering dilanda bencana banjir termasuk di Pasir Mas. Kejadian banjir kini berbahaya disebabkan keadaan faktor fizikal and iklim setempat yang telah mengakibatkan risiko kepada alam sekitar dan penduduk. Selain itu, kesukaran untuk mengenal pasti kawasan terancam disebabkan banjir di Pasir Mas telah menjadi masalah utama. Kekurangan maklumat yang komprehensif sebagai medium untuk menyampaikan maklumat risiko banjir, pembangunan baru yang tidak dirancang dan sistem saliran yang tidak mencukupi telah menjadikan keadaan lebih memudaratkan. Walau bagaimanapun, membuat peta keterancaman banjir masih berkurangan disebabkan pengurusan banjir masih lemah. Keterancaman adalah faktor utama dalam pengurusan risiko banjir. Oleh itu, kajian ini bertujuan untuk mengenal pasti pemboleh ubah yang menyumbang kepada risiko banjir berdasarkan ciri-ciri kawasan dan membangunkan peta keterancaman banjir dengan menggunakan aplikasi Sistem Maklumat Geografi (GIS) dan Penderian Jarak Jauh. Dalam kajian ini data jenis penggunaan tanah, purata jumlah data hujan dan model ketinggian digital (DEM) digunakan dalam membuat peta terdedah banjir untuk kawasan kajian. Teknik hidrologi dan penganalisis spatial digunakan untuk menetukan kawasan yang terancam terhadap banjir dengan menganalisis faktor fizikal and iklim yang menyebabkan banjir di Pasir Mas dan membuat peta keterancaman banjir di Pasir Mas. Kawasan keterancaman banjir telah ditentukan berdasarkan skala 1 (tiada keterancaman), 2 (keterancaman rendah), 3 (keterancaman munasabah), 4 (keterancaman sederhana) dan 5 (keterancaman tinggi). Hasil kajian menunjukkan bahawa kawasan yang mengandungi air, mencatatkan nilai yang tinggi keterancaman terhadap banjir berbanding kawasan lain. Selain itu, peta keterancaman banjir telah menunjukkan bahawa kebanyakan kawasan di Pasir Mas, Kelantan berada di skala sederhana dan tinggi keterancaman terhadap banjir. Diharapkan peta keterancaman banjir ini dapat membantu pihak-pihak yang bertanggungjawab untuk berkomunikasi dan memberi panduan kepada mangsa banjir untuk memastikan keberkesanan bantuan kecemasan dan juga bantuan kepada mangsa untuk membuat persediaan yang lebih baik.

TABLE OF CONTENTS

	PAGE
DECLARATION	**i**
ACKNOWLEDGEMENT	**ii**
ABSTRACT	**iii**
ABSTRAK	**iv**
TABLE OF CONTENTS	**v**
LIST OF TABLES	**vii**
LIST OF FIGURES	**viii**
LIST OF ABBREVIATIONS	**ix**
LIST OF SYMBOLS	**x**
CHAPTER 1 INTRODUCTION	
1.1 Background of study	1
1.2 Problem statement	3
1.3 Research question	4
1.4 Objectives	4
1.5 Scope of study	4
1.6 Significant of study	5
CHAPTER 2 LITERATURE REVIEW	
2.1 Natural disaster	7
2.2 Research framework	8
2.3 Identification of flood area	9
2.4 The impacts of flooding	10
2.5 Significant factors in developing flood vulnerable map	11
2.6 Produce flood mapping to reduce the flood risk	14
2.7 Application of GIS and remote sensing	15

CHAPTER 3 MATERIALS AND METHODS

3.1	Study area	17
3.2	Research flowchart	19
3.3	Data collection	20
3.4	Data analysis	21
	3.4.1 The physical and climatic factors cause flooding	22
	3.4.1.1 Land use analysis	22
	3.4.1.2 Spatial interpolation method for rainfall data	23
	3.4.1.3 DEM and slope using spatial analyst tool	24
	3.4.1.4 Drainage analysis	25
	3.4.2 Develop flood vulnerable map	25
	3.4.2.1 Weighted overlay spatial analyst technique	25

CHAPTER 4 RESULTS AND DISCUSSIONS

4.1	Flood vulnerable on physical and climatic factor	27
	4.1.1 Process data images	27
	4.1.2 Land use area change analysis	28
	4.1.3 Average amount of rainfall distribution	37
	4.1.4 Slope and DEM	40
	4.1.5 Flow accumulation	44
4.2	Flood vulnerability	46
	4.2.1 Introduction flood vulnerability in Pasir Mas	46
	4.2.2 Flood vulnerability analysis	47

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1	Conclusion	51
5.2	Recommendations	52
REFERENCES		53
APPENDICES		58
	Appendix A: Tables	58

LIST OF TABLES

No.	TITLE	PAGE
2.1	The flood vulnerable factors	14
3.1	Data requirement for the analysis	20
4.1	Overall accuracy assessment and kappa statistics for 2014, 2016 and 2018 using Landsat 8 OLI/TIRS C1	27
4.2	The result of spatial area change for 2014, 2016 and 2018	27
4.3	The transition area change for 2014 and 2016	30
4.4	The transition area change for 2016 and 2018	30
4.5	The slope and DEM of Pasir Mas	39
4.6	The flow accumulation of Pasir Mas	42
4.7	Weighted overlay flood vulnerability	45

LIST OF FIGURES

No.	TITLE	PAGE
2.1	Research framework	8
3.1	Map of Pasir Mas, Kelantan	18
4.1	The spatial area change graph for 2014, 2016 and 2018	28
4.2	Land use map of Pasir Mas 2014	32
4.3	Land use map of Pasir Mas 2016	33
4.4	Land use map of Pasir Mas 2018	34
4.5	The average amount of rainfall for 2014, 2016 and 2018	36
4.6	The average amount of rainfall map for 2014, 2016 and 2018	37
4.7	The slope degrees map of Pasir Mas	40
4.8	The DEM map in Pasir Mas	41
4.9	The flood accumulation map of Pasir Mas	43
4.10	Flood vulnerable area map in Pasir Mas	46

LIST OF ABBREVIATIONS

UN	United Nation
GIS	Geographical Information System
RS	Remote Sensing
NIDM	National Institute of Disaster Management
DID	Department of Irrigation and Drainage
DEM	Digital Elevation Model
WMO	World Meteorological Organization
USGS	U. S. Geological Survey
SRTM	Shuttle Radar Topography Mission
GADM	Global Administrative Areas
ROI	Region of Interest
TIN	Triangular Irregular Network
3-D	3-Dimension
MMD	Malaysian Meteorological Department

LIST OF SYMBOLS

%	Percentage
km	Kilometre
km^2	Kilometre per square
ha	Hectare
mm/year	Millimetre per year
^{o}	Degree
m	Metre

CHAPTER 1

INTRODUCTION

1.1 Background Of Study

Flood is one of the natural disasters can occur anytime as one of the weather-related natural disasters. Floods are a number of the most recurring and devastating natural hazards, impacting upon human lives and inflicting severe economic damage throughout the world. It is understood that flood risks will no subside within the future, and with the onset of weather trade, flood intensity and frequency will threaten many areas of the world (Ibrahim, 2016).

The capability for flood casualties and damages is likewise developing in Malaysia that happens every year and regularly. This appears because of the fact of social and economic development. The human population growth, circulation and channel obstruction due to lower drainage control system and other anthropogenic activities. This is because of several factors such as land use development and urbanization.

Flood risk is predicted to grow in frequency and severity, thru the influences of change on climate, intense weather within the form of heavy rains and river discharge conditions (Dihn, 2012). Flood arise due to the fact of the fast accumulation and launch of runoff waters from upstream to downstream. This happens due to heavy rainfall. The contemporary trend and future situation of flood risk consequently demand accurate spatial and temporal facts on the potential hazards and risks of floods. Kelantan becomes one of location that gets greatly impact by enormous flood disaster that located at the east coast of Peninsular Malaysia. Since 1927, the enormous flood in Kelantan with about the return period of rainfall of 1:1000 years (Hassan, 2006).

One of the main components of flood management is evaluating flood vulnerability. It is the main element in flood risk assessment and damage appraisal. There is a need to increase the information about the vulnerability due it acts as the root reason for catastrophe. The vulnerability may be evaluated as a percentage of assumes losses (United Nation, 1982). The flood result can be in direct and indirect damages with determined quantity and become expressed as a scale from 0 to 1. It is divided into two categories no damage and total damage (Hussain, 2014). Vulnerability is normally portrayed in poor terms as the susceptibility to being harmed (Adeoye, 2009).

The flood vulnerability mapping can provide a hundred percent safety in opposition to flood (Barroca, 2010). However, mapping has emerged as the keystone for flood hazard control and verbal exchange in representing spatial relationships among risk and vulnerability (Jayasselan, 2011). Therefore, Geographical Information Systems (GIS) tool is necessarily important to flooding mapping in predict flood vulnerability for effective flood management (Prakash, 2002).

1.2 Problem Statement

A natural event such as flood always happens in some of the country and it occur no matter how hard a government or society tried to stop it completely until now. The assume of predicted area vulnerable to flood that the cost of damage to infrastructure in Kelantan due to the floods at over RM30 million (Hashim et al., 2015). Based on the previous research, the flood event contribute human life and properties risk and this happen due to difficult to identify the flood vulnerable area (Fatihah et al., 2017). This was happened in Pasir Mas that becomes main issues due to lack of environmental disaster management and information.

Mitigation of flood catastrophe may be success most effective when certain information obtained about the physical and climatic information on hazards and areas vulnerable to hazards are sufficient and having updated information. The distinctive information was continually not comprehensive due to lack in management and the medium of communicating the flood risk in the study area (Zikri Muhamad, 2017). With the lack of comprehensive information, the forming of mapping in the study area was also lack.

In the event of a flood, low-level areas were typically more vulnerable to the floods that dependent on geographical and metrological situations. Within new unplanned development, it can cause the problem with raise run-off and produce the risk during the flooding increases (Rimba et al., 2017). Many developers did not longer recognise that the hazard and possibilities of the flood able cause damage to their place. As reported by NIDM (2014) has stated that because of the flood damage increase over time due to more development in flood-affected areas. Hence, mapping and regulation of flood hazards zones were important to the mitigate damage of flood event.

1.3 Research Questions

The research questions of this study as follow:

i. What are the physical and climatic factors that will cause flooding in Pasir Mas, Kelantan?

ii. How to determine the flood vulnerable area in Pasir Mas, Kelantan?

1.4 Objectives

The research objectives of this study are as follow:

i. To determine the flood vulnerable area on physical and climatic factors that cause flooding in Pasir Mas, Kelantan

ii. To develop flood vulnerable map in Pasir Mas, Kelantan

1.5 Scope of Study

The study were focused on collecting and gathering all relevant information in producing the flood vulnerable map including the potential risk and casualties of each physical and climatic factors of the study area, Pasir Mas, Kelantan. The flood mapping data were collected from authoritative organizations and also some other resources. This study was used secondary data that also referred others resources and expert opinions and availability of data to achieve the outcomes.

In this study, the GIS tools were used in combination with the spatial analyst and weight overlay technique. The study was developed through ArcGIS 10.3 software which specifically models the extent and depth of the prone areas with an emphasis on land use, slope basin and amount of precipitation rainfall. This study attempts to extend the application of spatial analysis and weight overlay analysis because the method needs to identify the level of vulnerability of the areas.

As now flooding occurs often and its casualties and the threat due to flooding boost, the want for enhancing approaches for mapping and monitoring of flood vulnerable has to turn out to be extra vital. As a result, zoning was located to demarcate and map regions for development control. The scope area of this study has been focusing on Pasir Mas, Kelantan due to one of the famous location that was got great impact and high-risk area that regularly faced the flood catastrophe each year. Hence, it was used to help the communities in mitigating the flood in future.

1.6 Significant of Study

In this study, dedication of the vulnerability assessment has to discover the flood area which requires special attention (Pradhan, 2009). From here, the usefulness of the GIS and remote sensing which one of the contributions method to determine the physical and climatic factor has been used. This method had been determine to identify the flood vulnerable area in the Pasir Mas, Kelantan by developing the flood mapping. Furthermore, it able to implement broadly besides reduces the casualties and losses during the flood disaster.

Hence, the flood mapping was developed which can identify the possible type of land use that makes contributions to the flood high-risk region of the study area. This able assisting people to make it as references in order to develop the new development and to provide more details in form of map. The information was able to assist in the improvement of early warning systems. They have used the information to decide the best site for human settlements. This ability to enhance the implementation of planning with the proper methods. Besides, this can also help all stakeholder know to play well to enhance the management besides reduce the unplanned rapid development for future.

The information from the flood mapping was used in the decision-making process to mitigate the risk of vulnerable area. Many authoritative organizations, local authority and also others can used the information, thereby act as function to determine and control the flood risk. Consequently, this has a look at additionally may be visible as a first step aiming at enhancing information management in the study area. Moreover, they capable used the information in the preparation of better flood disaster management plans which can minimize from extra losses and damage affected from the flood. By through this, it able help the flood victims to increases their readiness to faced flood and increase the flood recovery.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural Disaster

The natural disaster was event that affected life, property and source of income (Nelson, 2018). The flood frequently happened destructive natural event giving impacts for both rural and urban community. Since the year 2000, extreme rainfall events with high intensity was now not a new problem in Malaysia especially in Kelantan as one among an area that been affected greatly from it every year. Essentially approximately 31% of economic losses because of natural disaster account for flood (Dano et al., 2019).

Most of the population explosion witness in a developing country in which Malaysia was the urban centres. This happens due to the shift from rural to urban centres because of perceived improvement in dwelling situations in these urban regions (Ishaya, 2009). The unseen outcomes of this shift and explanation were unsustainable use of environmental assets, environmental pollution that lead to canes. It happens within the state and direction of the natural biosphere, breakdown of most environment and biological process that aid lifestyles and preserve development, variability in climate circumstance, the conversion of lands to build up environments and residential estates and buildings on natural drainages (Udika, 2010).

Flooding catastrophe has been consequences of decay of the surroundings and climate cane. Those elements have intensified the frequency and severity of the risk. This natural catastrophe usually happens alongside the rivers and regularly it was connected to the channel morphology inclusive of the overbank flood (Schwarz et al., 2018). Any area where rain falls was vulnerable, although that rain has not the handiest impetus for the flood.

2.2 Research Framework

Figure 2.1 shows the research framework of this study which start from identify or formulation of issue and problem.

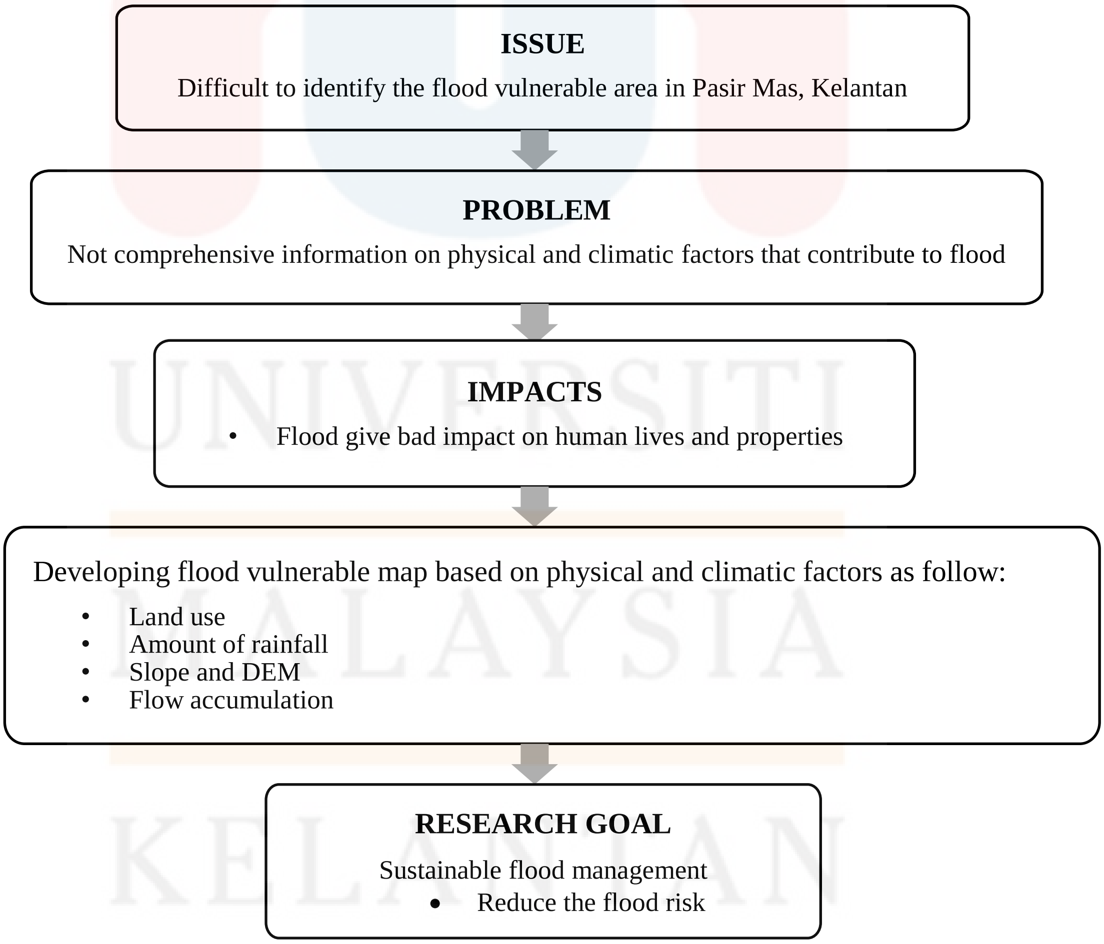

Figure 2.1: Research framework

2.3 Identification of Flood Area

The determination of flood area was important to identify flood zones in community, the boundaries of the flood area and the level of flood elevation besides it was gathered in a show the flood risk (Okpokwu, 2016). Based on this, determination of flood area and updating is important for identifying flood zones in the community, the boundaries of the flood area and the level of flood elevation besides in was gathered in a show the flood risk. Within this, the issue that needs to face the problem was to determine the flood area of Pasir Mas, Kelantan. Serious flood has hit Pasir Mas, Kelantan and has been flooded by four episodes in the Northeast Monsoon season of 2016 and 2017 (DID, 2017). Hence, Pasir Mas was the third most frequently flooded by the district in Kelantan State in 2016 and 2017.

The preliminary hazard was constituted using of the area's characteristics without consideration of mitigation and risk transfer measures and the population vulnerability. Each mitigation and risk transfer measure reduces the general threat to some degree, but it was impossible to eliminate risk. A flood risk management strategy identifies and implements measures that reduce the overall risk and what remains is the residual risk.

Flood risk management is not capable to solve in the form of alienation however it need involvement all parties in order to make it effectiveness. In spite of the high level of vulnerability and altering risk in the study area, there is insufficient comprehensive information and make lack of flood mapping. In addition to the high level of vulnerability and high risk due to floods, there was insufficient risk information and vulnerability mapping for Pasir Mas (Thilagavathi, 2011).

2.4 The Impacts of Flooding

In Malaysia especially in Kelantan, it commonly flood was happened and this disaster was occur usually every year. Flood damages refer to all varieties of damage through flooding. It encompasses an extensive range of consequences on human, cultural heritage, ecological system, industrial production and the competitive strength of the affect economy. Flood damages vary now and then.

Malaysia which includes on Asian countries that highly vulnerable to floods because of their geographical locations and other factors. Approximately 90% of natural catastrophe associated injuries in Malaysia were caused by the flood (Mohd, Daud, & Alias, 2006). According to Department of Irrigation and Drainage (DID) in 2017, around 22,000 km^2 of the land region and over 4.82 million people or 22% of the overall population were affected by flood annually with residents of low-lying areas, mainly near to riverbanks and it makes contributions more vulnerable to flood. In dealing with the flood damages, millions of dollars with an average yearly cost of around RM915 million have been spent each year and this includes the Kelantan State (Jonkman, 2012).

Floods are the universal most often happen and most ruinous of a natural disaster. Flooding affects people in a multitude of ways. People suffer stress on multiple fronts, not just as flooding occurs, but also in the anticipatory period preceding a flood and during the clean-up and recovery phase. In the study area, the flooding frequently occurs but the impact of flooding is still great and this happens due to lacking preparation and current system management (Ologunorisa, 2009).

Flooding has damaged properties, destroy homes, create a financial burden and cause emotional hardship. For example for flood damage in term of properties, floodwaters damaged land by eroding shorelines and stripping soils. It also was taking out whatever natural vegetation may be in the path of the flowing water. The location where there lack preparation, floods were damaged by the property and also drive the communities to leave their homes. Besides, the damage that caused by natural causes was not universally covered by insurances. This also affected people emotional such as flooding has made people to experienced difficulty sleeping, loss of appetite and height feeling of anxiety. Hence, when people is facing flood without preparedness and readiness, they have had a profound impact due to flood.

Therefore, the preparedness in facing the flood events has reduced the associate the impacts. For example it including the temporary loss of communication to the outside, loss of documentation, insured and property recovery issues (Ferris et al., 2010). Therefore, it is important to know the location of the flood plain and determine possibility potential of risk by taking some appropriate mitigation actions such as flood mapping.

2.5 Significant Factors in Developing Flood Vulnerable Map

The lack of details and comprehensive information usually lack in most areas of developing country including Malaysia. Pasir Mas even though it becomes one of the main urban areas in Kelantan, but it still lacking in management and information relates to the flood. The GIS method has been proved as an effective and high quality tool in extracting the flood inundation extent in time. The GIS value also tremendous manner for the remote basin areas, in which accomplish conventional surveys was very hard (Goel et al., 2015). Flood contain spatial components and it was suitable to merge with GIS technologies informed flood mapping (Aggarwal et al., 2009).

Within the unplanned rapid development, the nature able faced high degree of vulnerability. The flood vulnerability has raised specifically due to the growth stage of exposure of the factors under treats. One of the contribution that happened due to the unplanned rapid development. Thus, basin area or area surrounded with water bodies has possibility to the high vulnerable flood area. Hence, the development in the basin area has contribute to the increases of runoff. It overwhelming the flow of rainfall and finally the rainfall was channelization into rivers. Due to this, it had reduced the quantity of discharge they were accommodated (Jeb, 2010). All these elements can raise the risk of flooding in the area. In continuous updated and monitored by used vulnerability map, it was contributed to produce efficiency flood management.

Flood vulnerability map provided information relating to the previous flood track records, potential evacuation risk area to the communities (Osti et al., 2008). Based on the previous study, the GIS tools were effective in extracted the flood inundation extent in a time and cost effective manner that able accomplishing in conventional surveys (Nerantriz Kazakis, 2015). Besides, it giving benefits for long-term flood disaster management. In producing the map, it can contribute to effective development and solve the loss of top-down approach in catastrophe strategic, while enhance the sustainable management.

Table 2.1: The flood vulnerable factors

Flood Vulnerable Factors	Authors				
	(Elsheikh et al., 2015)	(Jeong & Yoon, 2018)	(Roslee et al., 2017)	(Martina et al., 2016)	(Korah & López, 2015)
Slope and Digital Elevation Model (DEM)	√		√	√	√
Average amount of rainfall	√	√	√	√	√
Flow accumulation		√	√	√	
Land use	√	√		√	√

Based on Table 2.1 there are many factors of flood vulnerable area including the slope and DEM, amount of rainfall, flow accumulation and land use. From the table, the physical vulnerability factors in the Pasir Mas that contribute to the flood catastrophe are a Digital Elevation Model (DEM) of slope and elevation. This factor form by raster datasets on morphometric elements had automatically extracted from the DEM. Besides, the slope and DEM played an essential position in managing the stability of a basin that it capable impact the route and quantity of surface runoff. Besides, the flow accumulation had related to the surface runoff also been identified. The flow accumulation shows the possible stream channels in an event of water runoff.

Next physical factor is land use that display the type of land use and the spatial area change accordingly to years. This land use able assist to determine the major type of land use that contributed to the vulnerable area of flooding. Moreover, the average amount of rainfall has been determined which able contributed to flooding. Many researchers had used the multi-year amount of rainfall informing flood vulnerable map.

2.6 Produce Flood Mapping to Reduce the Flood Risk

Flood catastrophe has been documented more than thirty years act as flood national disaster and in Malaysia the flood disaster had frequently happen every year (Ejeta, 2018). Pasir Mas as the spot area that frequently occurs flood disaster that located in Kelantan. Flood risk the probability of some risks for which includes the prevalence and the vulnerability of a specific area to be laid low with the risk (Lawal et al., 2014).

Moreover, the flood risk can reduce by enhance the sustainable disaster management with GIS as tools to develop flood vulnerable map. The GIS tools will function in preventing, providing an alarm for monitoring and responding towards flooding hazards (Gabriel de Oliveira et al., 2015). The flood map does not avoided floods from happening, but they become an important tool in reducing the harm to belongings and loss of life as a result of the floods. Besides it also essential for communicating flood risk and flood management.

Identification of flood vulnerable areas has probable to assisted in the making plans and flooding control of a more effective emergency response (Muhammed, 2013). It can help in increases efficient of management in the study area. It was needed that certain infrastructure such as the emergency services can continue and maintain to function during a flooding phenomenon. The production of flood maps was therefore allowed planners to determine the location where has low flood risk.

The flood vulnerable map can help the public authorities to evaluate the capability impact of flood hazard and start-up appropriate measures to reduce. This was included of the initiative for a pre-catastrophe and post-catastrophe situations in minimizing the risk (Heywood, 2008). Once the database was built, decision makers with even no experience with GIS can use them for decision making towards planning for flood management. Alternatively, flood vulnerable map had highlighted as a requirement to shield those elements from flooding.

2.7 Application of GIS and Remote Sensing

The flood was a multi-dimensional event that consists of spatial components and this had to merge with Geographical Information System (GIS) and Remote Sensing (RS) technologies informing flood mapping, (Kourgialas & Karatzas, 2011). The GIS was the computer-based systems that used to collect, keep, process, analyze and display data in the form of spatial analysis. GIS used spatio-temporal (space-time) area as the important thing index variable for all different information (Kenneth, 2015).

Hence, there had two wide techniques used to store data in a GIS for both forms of abstractions mapping references which are raster and vector. Besides, there additionally have point, line and polygons were the stuff of map location attribute references. The GIS has the data analysis possibility within the system because of its technology capability, completeness quantity and data resources layers update. Here some capabilities within the flood which represent as a research capability. Meaning that it capable to find an applicable and reliable result for a special problem. For example, GIS has capable to determine the flood area using search capability.

Moreover, it also able to identify other data for example access routes and urban area to determine the suitable visual outputs including maps. Besides, GIS can merge data and information by adding data layers together and produce merge maps. These beneficial could review some factors such as topography, geology, rivers and flood ways effects throughout the special subject by mixing current information layers within the system. The used GIS capability after identifying flood area, it could merge with the layers of route network and routes data demographic.

It acts as the technology that describing the information regarding the Earth's natural and anthropogenic activities. This tool was used to develop the flood vulnerable map (Forkuo, 2011). The flood vulnerable factors were analysed based on GIS tools using the spatial analyst. The GIS spatial analyst and GIS tool had increases corresponding to the rapidly changing field for example used of analytical tools as standard built-in facilities and optionally available toolsets.

Remote sensing was used for delineating the flood-affected areas information, determining the impact and feeding models that used for the flood vulnerability prediction of inland and coastal area. High temporal resolution act as a main in remote sensing data for flood observance to located the cloudiness. From this viewpoint, satellite imagery was needed to identify the flood land use area. The approaches result can be used for the formulation of flood detection in a better way.

The eventual delineation of the flooded area has ultimately intended toward assessing the flood consequences on the economy and livelihood. The land use maps provided particularly from optical remote sensing that been overlaid throughout the flood maps for determining inundated area and the type of land uses. Different land use classification strategies were already used by researchers to determine the flood risk. The biographical land use condition for the study area over different seasons and assist the method of change detection. Within that, the information set can remote sensing of inundated areas which turn into a useful tool in flood management and mitigation.

CHAPTER 3

MATERIAL AND METHOD

3.1 Study Area

Kelantan is one of the states on the East Coast of Peninsular Malaysia. The state is exposed to the winds of the Northeast Monsoon from November to January and thus vulnerable to the flood event. Pasir Mas is one of the districts in Kelantan threated by the flood risk, with geographical coordination of 6º 02' 57.62" North and 102º 08' 23.53" East (Hua, 2018). Pasir Mas has been affected flood every year and it was reclassified under top five districts that most got affected by flood in Kelantan (Rahman et al., 2018).

Pasir Mas is one of fundamental town and centre of industrial exchange and management in the Kelantan state. Referred to its geographical location, it is present as the main gateway along the East Coast of Malaysia to Thailand and is additionally traversed by major road transport routes to the urban centre of Kota Bharu. The total population in Pasir Mas was about 185, 878 which represent the second largest district in Kelantan accordingly to data in 2010 (Zakaria et al., 2017). However, due to its geographical characteristics, unplanned urbanization and proximity to the South China Sea, Pasir Mas has become extremely vulnerable to monsoon floods every year (Ibrisam et al., 2016).

Rainfall plays a critical function to flood risk within the study area and with maximum threatening events from November to January. In 2014, Pasir Mas is one of location that get the big impacts from the “tsunami-like disaster” besides in 2016 and 2018, Kelantan state had confronted flooding within four episodes and Pasir Mas is one of location that got affected within all the episodes. The number of people at evacuation centres at this location also higher every year due to its geographical location and hydrological factors (Ouma & Tateishi, 2014). The total area of Pasir Mas is 139 km^2 and the density around 1300/km^2 (Hashim et al., 2015). Figure 3.1 shows the map of Pasir Mas, Kelantan as a study area.

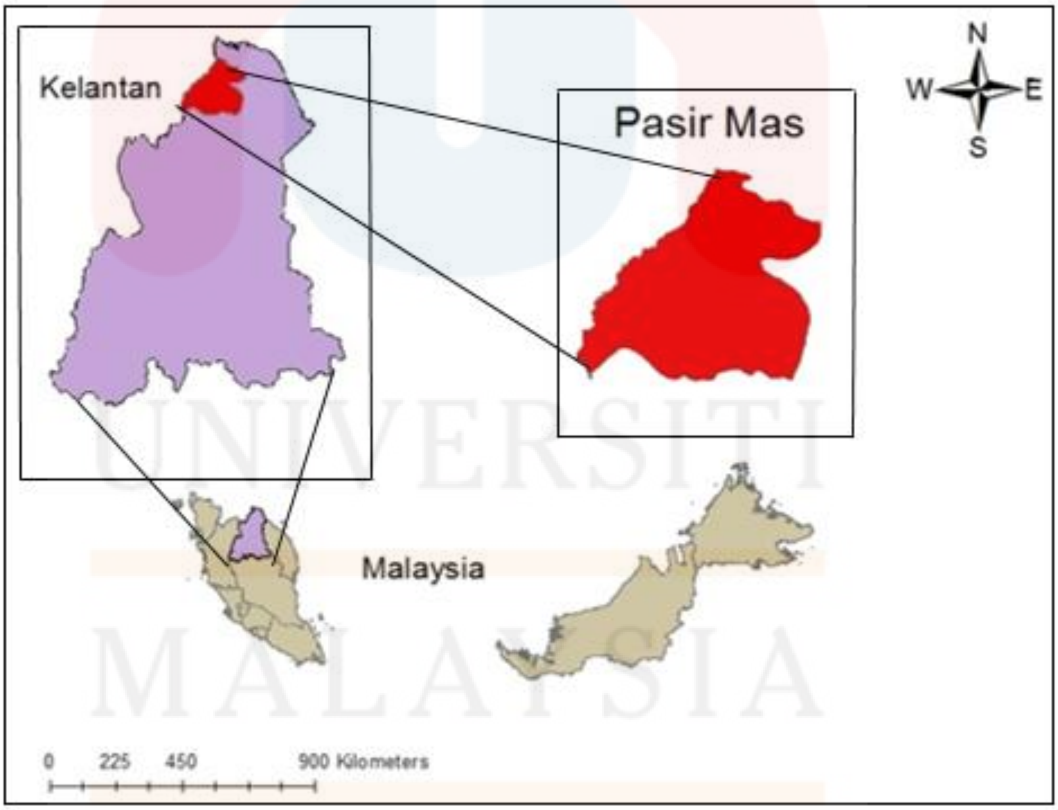

Figure 3.1: Map of Pasir Mas, Kelantan

3.2 Research Flow Chart

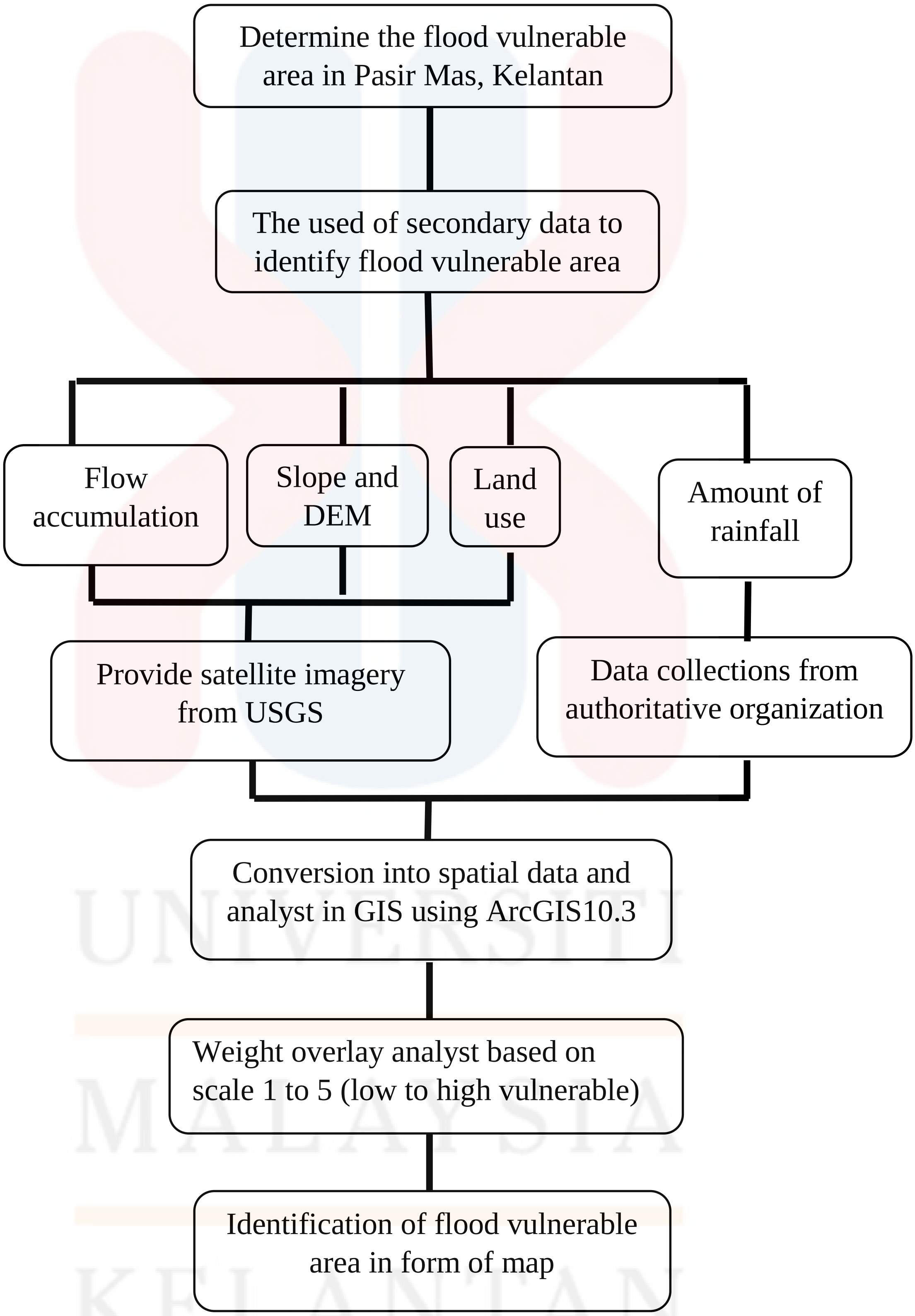

Figure 3.2: Research flowchart

3.3 Data Collection

Flood vulnerability map requires the extensive number of information regarding the study area, essential for informed interpretations for achieving the objectives. In this study, only secondary data was required. The data required for running the various step for produced flood vulnerable map obtained from different sources. The data collection was involved in constructing a spatial database from physical and climatic factors.

Most of the data have obtained from authoritative organizations such as the Department of Irrigation and Drainage (DID) for obtaining the annual amount of rainfall data in Pasir Mas. The data that obtained was in 2014, 2016 and 2018 to look at the trend of the rainfall due to it one of the factors that cause of the flood and the overflow river basin that cause flooding. Besides, from the official web of public information of DID website (http://publicinfobanjir.water.gov.my/) also capable of extracted and pick out the water-degree to determined which district has high water-level and more vulnerable to the flood.

Meanwhile, the data was acquired from online methodologies which from the U.S. Geological Survey (USGS) (http://www.usgs.gov/) for getting the satellite imagery for providing the land use data on the study area. Landsat 8 OLI/TIRS C1 was downloaded from USGS for 2014, 2016 and 2018. However, Shuttle Radar Topography Mission (SRTM) 30M Global was downloaded to determine the other indices which Digital Elevation Model (DEM), slope and flow accumulation of drainage network in Pasir Mas. In this satellite imagery, the additional spatial data about the connection, meteorological and population data at Pasir Mas district also was provided including its coordinates, latitude and longitude of Pasir Mas.

3.4 Data Analysis

The deductive and inductive approaches have used to utilize in this study to choose the statistically important indicators. This study has used the statistical intensity of flood risk (Behanzin et al., 2016). The combination of historical flood commonness and the flood vulnerable factor which were the slope and DEM, land use, the amount of rainfall and the flow accumulation of drainage network has used to determine in order the flood vulnerability in Pasir Mas districts.

A GIS-based tool was used to identify Pasir Mas's most vulnerable area and create flood vulnerable map that reflected the spatial distribution of risk and the locations and frequency of events possibly to occur. This tool takes into account flood associated with physical and climatic factors in the form of spatial data shown in Table 3.1. The factors were transformed in remote sensing using ENVI 5.1 and then converted into GIS data type using ArcGIS 10.3. This is a beneficial software for visualizing, exploring, querying and analyzing data geographically (ESRI, 2017).

Table 3.1: Data required for the analysis

Data Type	Spatial Data	Attributes
Shapefile	Kelantan state borders	Polygon
	Pasir Mas district borders	Polygon
	Network data	Line
	Precipitation	Average amount of rainfall
Raster	Data Digital Elevation Model (DEM)	Slope, elevation and flow accumulation
	Land use data	Land use type

3.4.1 The Physical and Climatic Factors Cause Flooding

3.4.1.1 Land Use Analysis

The land use data that obtained from USGS was downloaded based on Landsat 8 OLI/ TIRS C1 and this satellite image was processed by using remote sensing method which ENVI 5.1 and ArcGIS 10.3 to produced land use maps for Pasir Mas district in 2014, 2016 and 2018. The satellite images picked out based on much less cloud coverage and have a terrific pleasant with a view to getting a clear vision of land use in Pasir Mas. Then, the satellite images were subset by using administrative map of the study area which was defined the boundaries that obtained from an official website of the Global Administrative Areas (GADM) (https://gadm.org/) to extract the area of interest from the image.

Moreover, after the stack was formed, a colour composite of bands 6, 5 and 4 was represented and resampled in the form of a new display. The band combination was used to provide efficient and adequate when using landsat image data for detecting the flood vulnerability relation with land use classification. The land use classification are water body, agriculture, build up area, cleared land and forest. Once the colour composite, Region of Interest (ROI) vector frame was used for subset the images by using 250 random points and this ROI was represented from the Pasir Mas administrative map. Google Earth act as references images to determine the geometric correction where all other images utilized in this process were re-sampled and co-registered in the references image. Further, process classification of the subset colour composite image was used maximum likelihood classification and from here it will represent the land use classes.

Post classification operations consist of the confusion matrix was determined by using ground truth ROI, sieve class clump class, majority analysis, segmentation and classification to vector (Ejenma, 2014). In order to ensure the assessment in the effective ways, the accuracy assessment that forms the statistical outputs which used to determine the results classification quality. This method was need to determine and reclassify the land use type. The high resolution imagery important for got a clear visual of the extent of vulnerability beside it can produce to provide more accurate outcome (Alaghmand, 2010). The image was then imported to ArcGIS 10.3 where it was vectorised and the area extent of flooded area and other land use classes determine after the post classification operations.

3.4.1.2 Spatial Interpolation Method for Rainfall Data

In an attempt to identify the amount of rainfall, the meteorological data from the Department of Irrigation and Drainage (DID) in Pasir Mas was acquired for the duration in 2014, 2016 and 2018. Analyzing the data was the next step based on the average amount of rainfall which in form as point shapefile that including the longitude and latitude of each station. From this, it was clipped out with the desired rainfall data in ArcGIS 10.3. Now, the data had used ArcGIS Statistical Analyst has the potential to use the spatial interpolation to input point data.

The spatial interpolation methods were used ordinary kriging for spatially distributed rainfall data due to it acts as the developed geostatistical procedure. It generated for evaluated surface produce from a scattered set of points with z-values (Lyu et al., 2016). Moreover, statistical models were assessed for this method which including autocorrelation. Besides, it has the capability of producing a prediction surface and also has a high accuracy of the predictions (Dixon, 2014). The kriging method was one of the results of weighted estimates of the actual data which include the small data of rain and hence utilize the contours more agreeable trend.

3.4.1.3 DEM and Slope Using Spatial Analyst Tool

Data Digital Elevation Model (DEM) was downloaded from SRTM 30M Global at the USGS website. The DEM emerges land surface morphology information that used to represent the hydrology process of surface runoff (Sri Legowo, 2019). From the DEM data, the elevation of Pasir Mas able was determined by using 3-Dimension (3-D) analyst tool in form of Triangular Irregular Networks (TIN) and it was converted into raster data. The DEM was classified based on the district's area elevation in form of meters into five classes.

The slope is considered as the rate of maximum change in z-value from each cell. The analysis method of the slope was produced from Digital Elevation Model (DEM) (Ishaya et al., 2009). The overall procedure was asses using the GIS environment and a grid format which describe the spatial distribution of values among the variables involved. The slope of the land in the watershed was a major factor in determining the water velocity.

The spatial analyst tool was utilized with the purpose to determine the slope degrees. The value range was around 0-30 and where the higher the slope degree, the lower the possibility of runoff and vice-versa. The slope degree values were subdivided into five classes. The topographic parameters of slope and DEM are inversely proportional to the level of floods.

3.4.1.4 Drainage Analysis

Flow accumulation was the indirect method of measuring drainage network and area. Moreover, it increases constantly starting at drainage divided to the outlet and river channels. The spatial analyst tool was applied to fill all depressions in the Digital Elevation Model (DEM) as a way to produced hydrology analysis. This ensures perfection within the data to help prevent wrong depression areas. Hence, it allows the formation of flow direction using flow direction tool which the 3-D DEM was applied in each raster cell within the basin. The depressionless DEM extracted from the fill was used to develop a flow direction raster (Dem et al., 2018). The flow direction represents any possible direction of water runoff on the elevation model. This method was developing to the identification of the water accumulation points by utilizing the flow accumulation tool and used flow direction raster as input. Output cells with a high accumulation were determined for the areas with the concentrated flow and were used to produce stream channels or network. This map was as given it determines the locations where the water accumulation happen.

3.4.2 Develop Flood Vulnerable Map

3.4.2.1 Weighted Overlay Spatial Analyst Technique

Lastly, the data used to overlay command and assign a colour ramp to reveal the physical and climatic factors and inundation area layers to graphically displayed vulnerability that liable to flooding. The input raster has cell values and it was multiplied using the raster's weight. After that, the resulting cell values were added to form the final output raster (Caldas et al., 2018).

The output raster was produce used to flood vulnerable map that represent areas with different levels of flooding. The weighted overlay analysis was implemented to overlay the land use, average amount of rainfall, slope and DEM and flow accumulation raster datasets that were reclassified the form of usual measurement scale and weights. From here, each of them was correspond based on their importance to develop the final map. This methodology was represented on the scale that the relative vulnerability of the Pasir Mas district based on expert opinions by using weight overlay analysis. This analysis based on 1 to 5 that was represented from low to high vulnerable area to the flood.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Flood Vulnerable on Physical and Climatic Factors

4.1.1 Process Data Images

In order to answer first objective, process data images was used in remote sensing to determine the physical factor. In this section, the image enhancement was used for identification of the image quality of the satellite image. Therefore, accuracy assessment was analyzed using similar validation dataset among the image. After process the data image, post classification was analysed and the result show the accuracy assessment. This results was tabulated in table 4.1 that in 2014 show 88.59%, 2016 with 89.48% and 2018 the overall accuracy is 91.90%. The table class confusion matrix of accuracy assessment for all land use class was included in Appendix A. The accuracy assessment was differentiate based on classification during selected the random points in produce land use map.

Table 4.1: Overall accuracy assessment and Kappa Statistic for 2014, 2016 and 2018 using Landsat 8 OLI/TIRS C1

Year	2014	2016	2018
Overall accuracy (%)	91.43	88.20	91.53
Kappa Statistics	0.8529	0.8175	0.8478

4.1.2 Land Use Area Change Analysis

The land use of Pasir Mas had been indicated based on their colour for different classification that been shows in Figure 4.1, Figure 4.2 and Figure 4.3. From the results shows in figures, that there was increased land use changes for most of the classes but for the forest, it shows the result decreased. The unplanned urbanization has resulted decreased in the existence of forest area including the natural catchments that urban growth as the vital reason. Land use like agriculture or forest affected the negative consequences on the capacity of the soil to play the role of water storage. Land use changes provide urbanization and growth of agriculture crucial roles in raising the intensity and frequency of floods which it forms from forestry to agriculture, the cleared land used for development, shift agricultural use to urbanized areas and become drivers of the flood. The outcome proved that the urbanization areas were without forest cover and it also contributes vulnerable to flooding due to the nature of their landscape that being mostly pavement (Ouma & Tateishi, 2014).

The land use change analysis was needed to determine the land use changes in the study area. Figures show the spatial area change for 2014, 2016 and 2018 respectively of five classification classes which are agriculture, build up area, cleared land, forest and waterbody. Moreover, the result percentages of spatial area change had been determine for comparing spatial area change for each year in Figure 4.4. This result was used to determine each area of classes and to compare between years to see the development that contributed to the flooding.

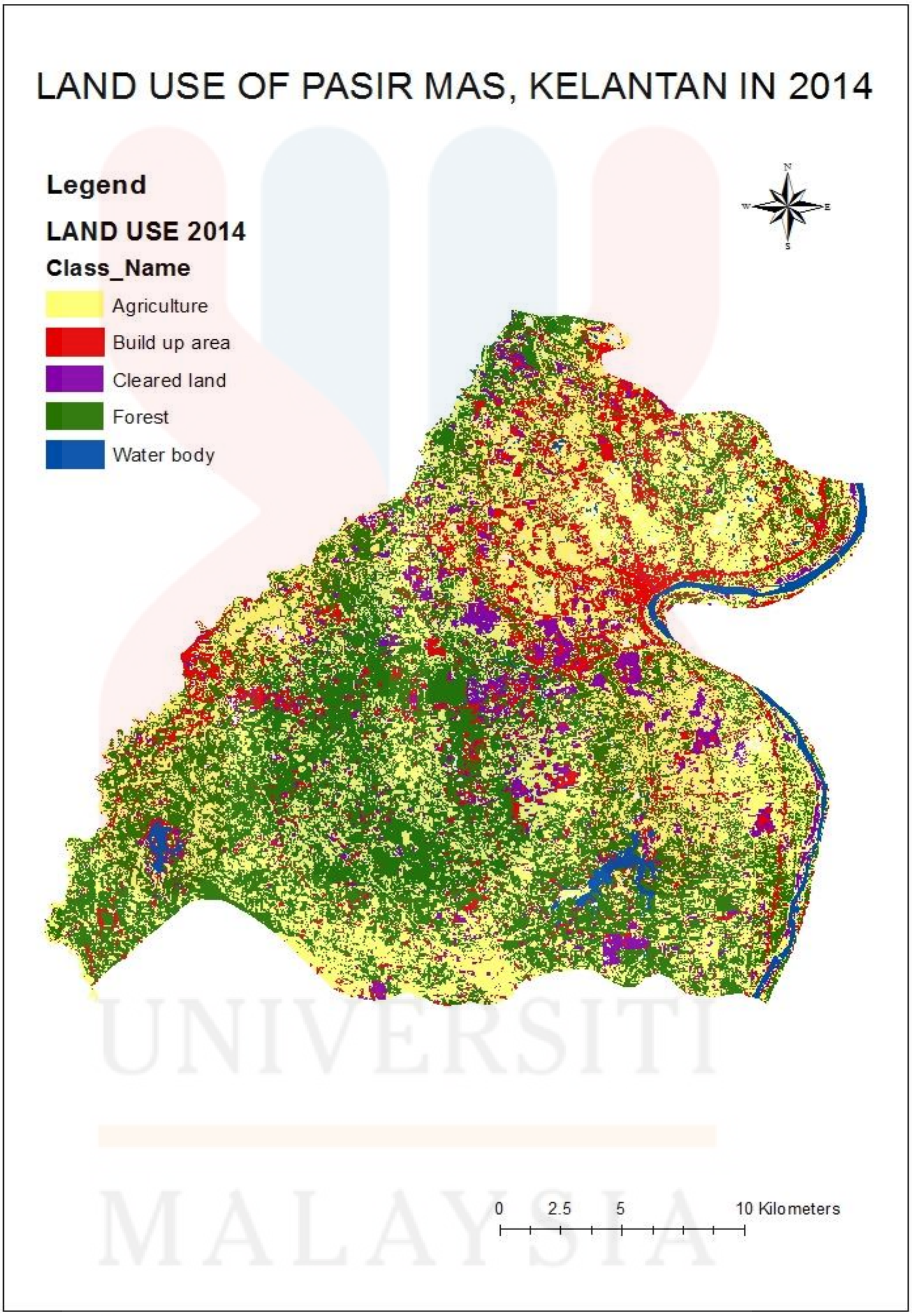

Figure 4.1: Land use map of Pasir Mas in 2014

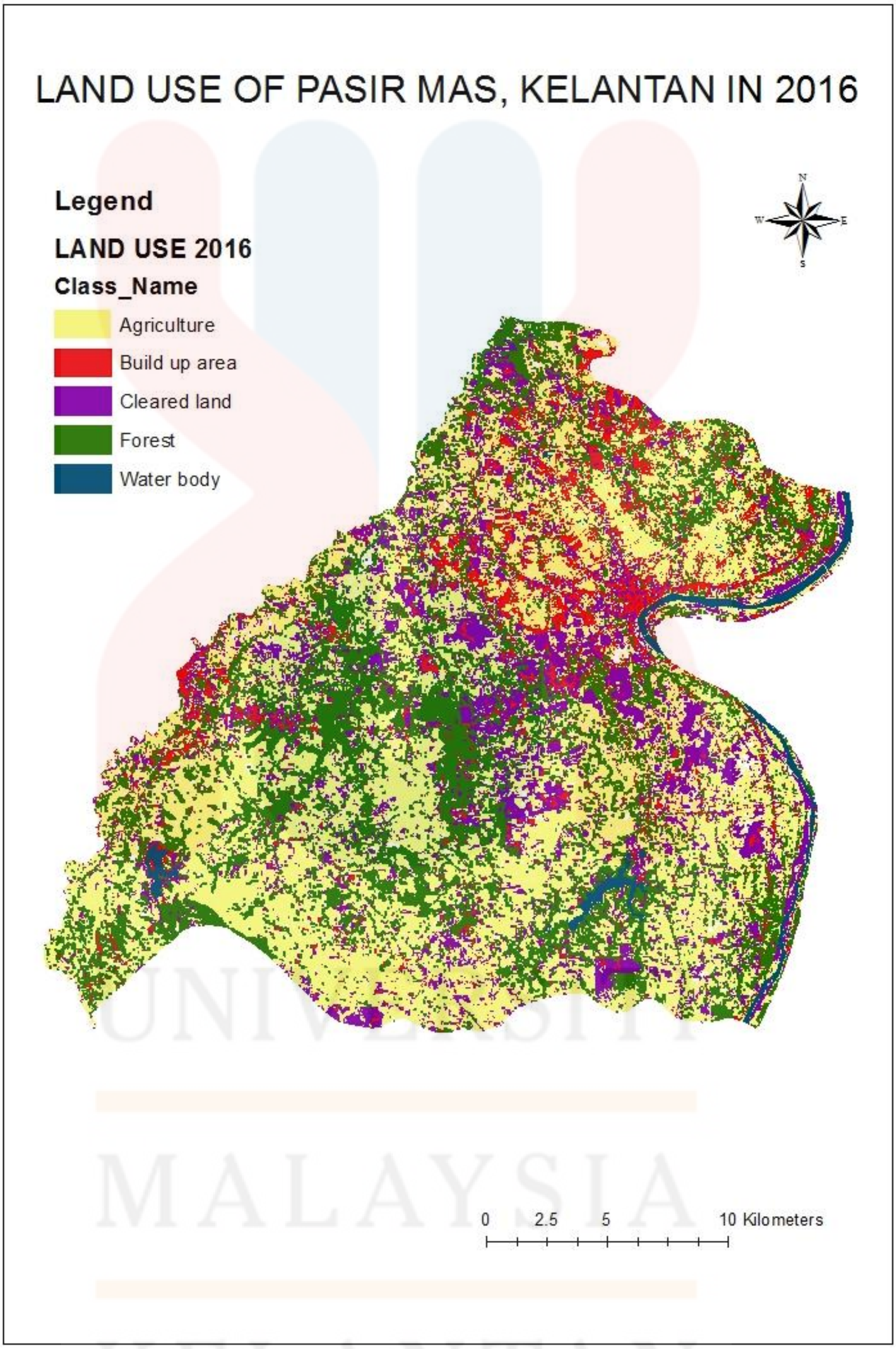

Figure 4.2: Land use map of Pasir Mas in 2016

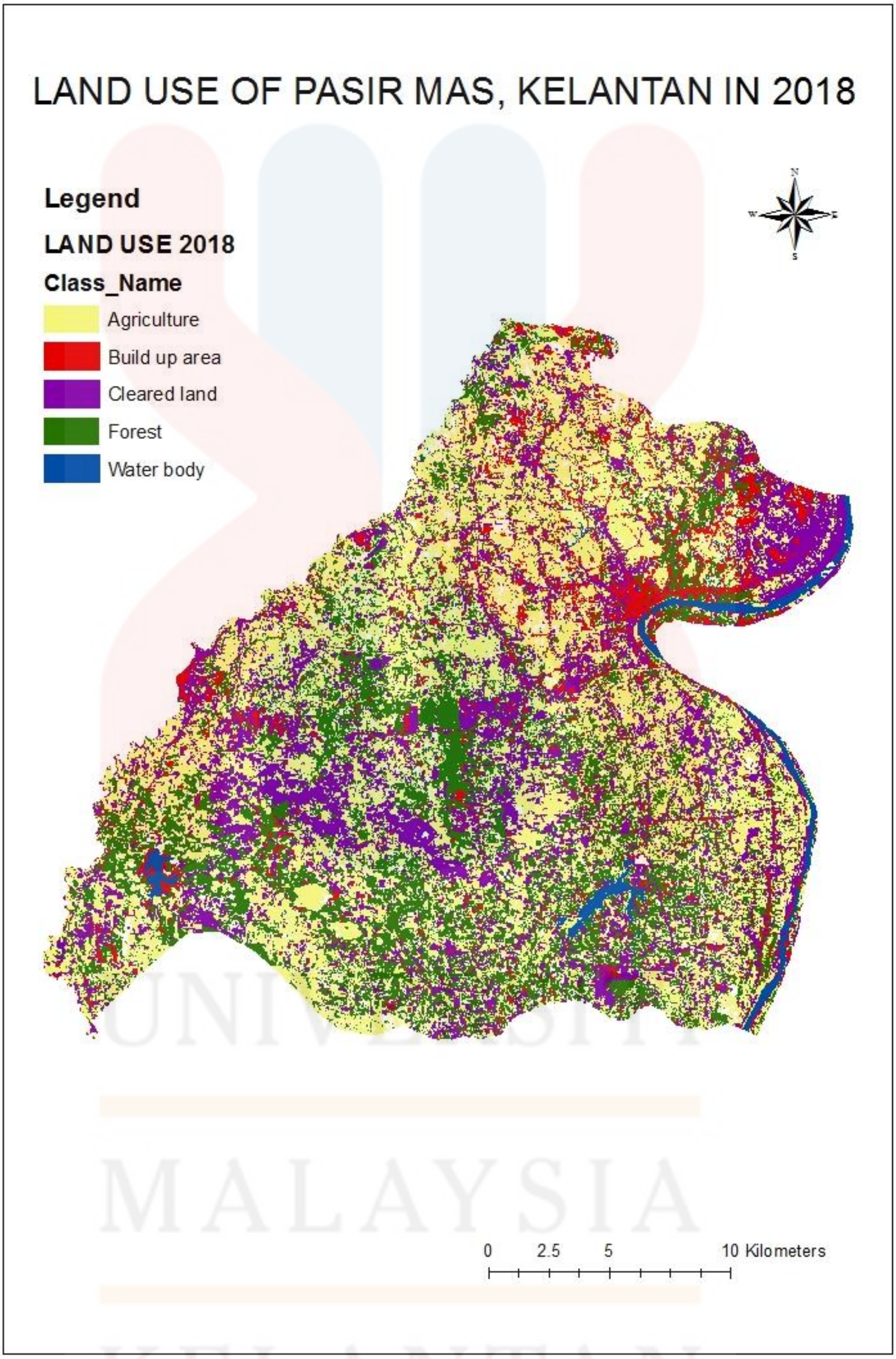

Figure 4.3: Land use map of Pasir Mas in 2018

Meanwhile, Figure 4.4 shows the spatial area change graphwith express in the form of percentages. Agriculture was the largest area for the three years compared to the other land use. In 2014, agriculture shows 52.64% lower compared to agriculture in 2016 which 55.03% and it continued to rise with 58.17%. This happened due to the main anthropogenic activities and main income in the Pasir Mas was agriculture. While, the build-up area was continuously increased from 2014, 2016 and 2018 with 10.46%, 10.51% and 11.22% respectively increases. The development of urban area raises every year corresponding with the raise population in Pasir Mas due to it one of the urban centres in Kelantan (Ismail, 2016). Similar to the cleared land, the percentage area was increased from 2014, 2016 and 2018 with respectively 10.30%, 10.75% and 10.86%.

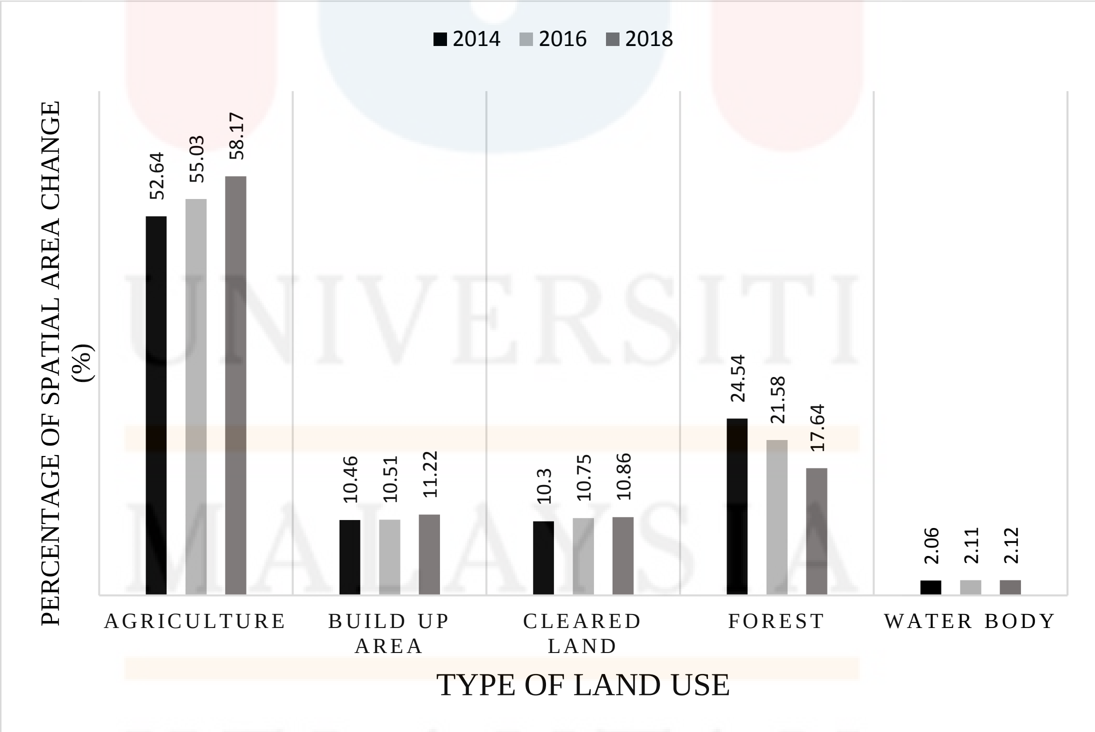

Figure 4.4: The spatial area change graph for 2014, 2016 and 2018

The next higher area beside agriculture was forest. In Kelantan there is more than 12,000 hectares of permanent forest reserves including in Pasir Mas. In 2014 the forest percentages were 24.54% while in 2016 showed 21.58% and 17.64% respectively in 2018. The results also show that water bodies were raised from 2.06% in 2014, 2.1% in 2015 and 2.12% in 2018. The water bodies important to indicated the drainage system that contributed to flooding events. The land use influences both the speed of surface runoff and water retention (Wu, Shen, & Wang, 2019). The trend of forest in the study area decreasing due to the urban expansion and the rate of deforestation in Kelantan raise every year (Economic Planning Unit, 2017). From here, the deforestation for development can alter the hydrological respond of the land and contributed towards the flood.

In Table 4.2 and 4.3, the transition area change for 2014, 2016 and 2018 was determined for area change within the same classes for different years. The transition area change for 2014 and 2016 of agriculture was 36.64%, while for build-up area show 51.93%, the cleared land represented 54.43%, 48.15% of area change for forest and 80.28% that determined for water bodies. However, in 2016 and 2018 the transition area changes were 31.55% for agriculture, 30.85% for build-up area, 37.93% for cleared land, 51.74% for forest and lastly 54.08% for water bodies.

Table 4.2: The transition area change for 2014 and 2016

The Transition Area Change for 2014 and 2016

2014 / 2016	Agriculture		Build up area		Cleared land		Forest		Water body		Grand total area (ha)
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	
Agriculture	6523	36.64	1031	12.45	1081	13.93	5477	25.78	68	11.20	14180
Build up area	3207	18.01	4301	51.93	1196	15.42	3051	14.36	6	1.05	11761
Cleared land	3516	19.75	1497	18.07	4221	54.43	1147	5.40	14	2.35	10395
Forest	3981	22.36	1083	13.08	874	11.27	10230	48.15	31	5.14	16200
Water body	577	3.24	371	4.48	461	5.95	1341	6.31	490	80.28	3240
Grand total area (ha)	17804		8283		7833		21246		610		55776

Table 4.3: The transition area change for 2016 and 2018

The Transition Area Change for 2016 and 2018

2016 / 2018	Agriculture		Build up area		Cleared land		Forest		Water body		Grand total area (ha)
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	
Agriculture	7773	31.55	2726	17.37	4337	28.39	3310	25.35	215	28.29	18361
Build up area	3336	13.54	4842	30.85	2828	18.52	1561	11.96	87	11.45	12654
Cleared land	6319	25.65	4663	29.71	5793	37.93	1416	10.85	15	1.97	18206
Forest	6644	29.97	3276	20.87	2270	14.86	6755	51.74	32	4.21	18977
Water body	566	2.3	189	1.2	46	0.3	14	0.12	411	54.08	1226
Grand total area (ha)	24638		15696		15274		13056		760		69424

4.1.3 Average Amount of Rainfall Distribution

The amount of rainfall occurring on a real-time basis which can help in indicate the severity and immediacy of the threat. From the determining the amount of rainfall, it able estimated the level of flood risk. This amount of rainfall can used for the present and future flood prediction. The average amount of rainfall has been show in Figure 4.5 in Pasir Mas, Kelantan. The rainfall map was analyzed using kriging analysis to produce a continuous raster rainfall data within and around the administrative boundary. Then it has been classified into five classes based in Figure 4.5 where each colour represented different average amount of rainfall.

The monsoon climate along with heavy rainfall able result in the flooding. Floods were connected with excess rainfall as well as water that cannot immediately percolate directly into the ground flows down slope as runoff. The amount of runoff was related to rainfall intensity. Water river level's increases because of heavy rainfalls. When the level of water increases above the river banks, the water began overflowing. Hence, the water spill over to areas connecting to the rivers resulting in floods. This make the area in water bodies and surrounded it become vulnerable to the flood.

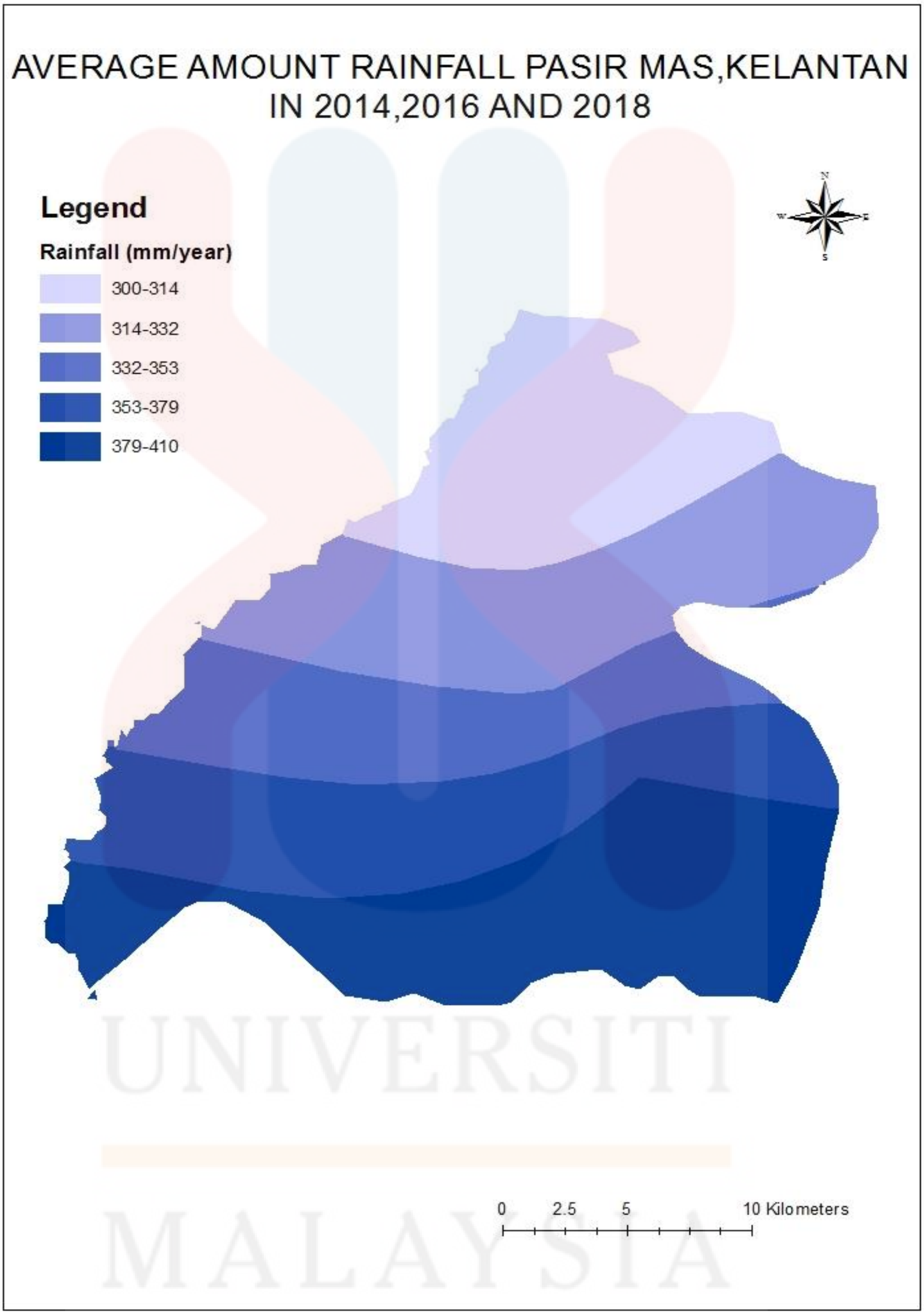

Figure 4.5: The average amount of rainfall map for 2014, 2016 and 2018

The flood event in 2014 that called "tsunami-like flood" was severe and its result was vulnerable. The heavy rainfall was one of the factor contribute to it happen. Based on Figure 4.6, the average amount of rainfall according to year. From the result, in 2014 was the highest with 409.85 mm/year. In 2016, the average amount of rainfall was 315.01 mm/year in 2014 and 300.47 mm/year in 2018. While high rainfall rate in both of the year 2016 and 2018. This happen due to Pasir Mas had been flooded around four episodes which around November to January in 2016 and 2017 (JPS, 2017). The heavy rainfall within a short period could contribute to the flooding. It had been proved because of the flood disaster on that year hit nearly 90% of Kelantan state which covered Pasir Mas because of maximal rainfall rate (MMD, 2017). The significant increasing trends of rainfall were observed and it been proved that heavy rainfall had contributed to the flood.

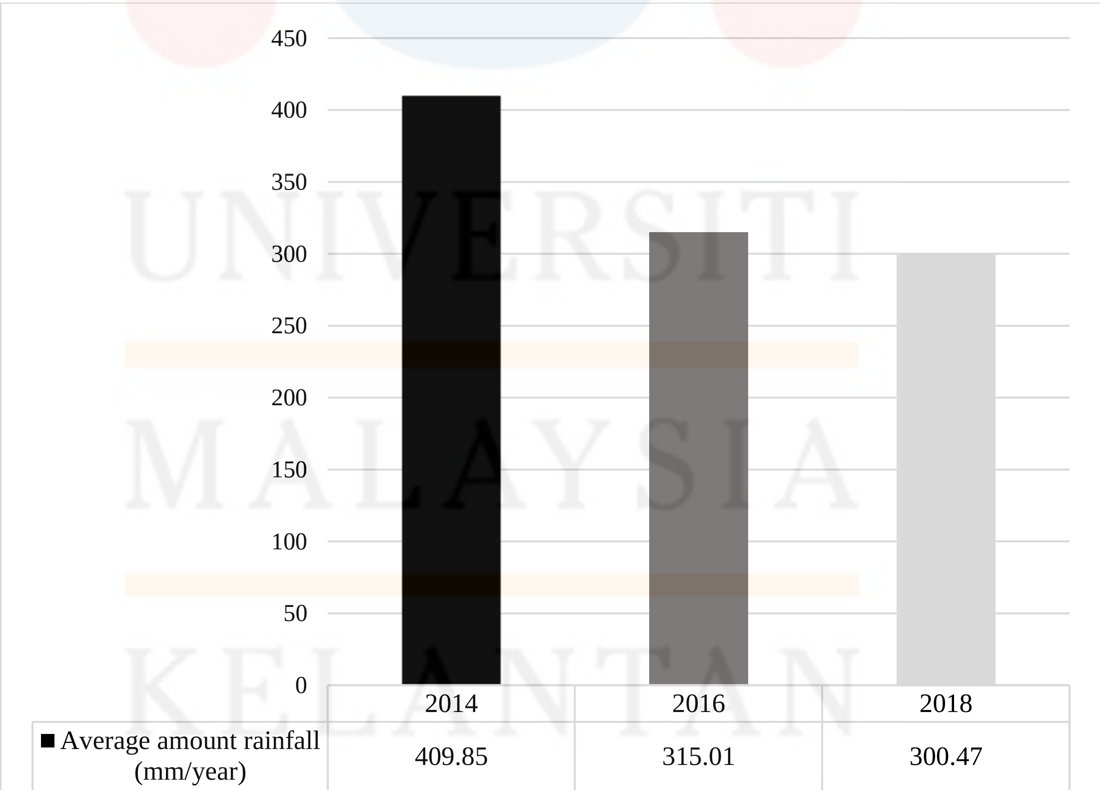

Figure 4.6: The average amount of rainfall for 2014, 2016 and 2018

4.1.4 Slope and DEM

The slope map simultaneously displays the slope which it steepness of continuous surface such as terrain represented in digital elevation model (DEM). Figure 4.7 shows the slope degree map while Figure 4.8 show the Digital Elevation Model (DEM) values in meter. Both of results show that most of the area has low level degree or in low land area. The low slope area represented with the green colour, which unfortunately is where development is possible and where the build up area is located. Elevation and slope act as a main role in controlling the stability regarding a terrain. The slope affected the direction of and measure of surface runoff or subsurface drainage reached a site.

Slope contribute to the main effect on the contribution of rainfall to river flow. It dominates the period of overland flow, infiltration and subsurface flow. Combination of slope angles essentially outlined the production of the slope and its relationship with the lithology, structure, type of soil and the drainage (Obidzinski et al., 2012). A lower land made the water to flow rapidly and this become disadvantage and causing the flood. The higher surface roughness is able to reduce the flood impact. Steeper slopes contribute to more vulnerable to surface runoff and the flat terrains lead vulnerable to water logging.

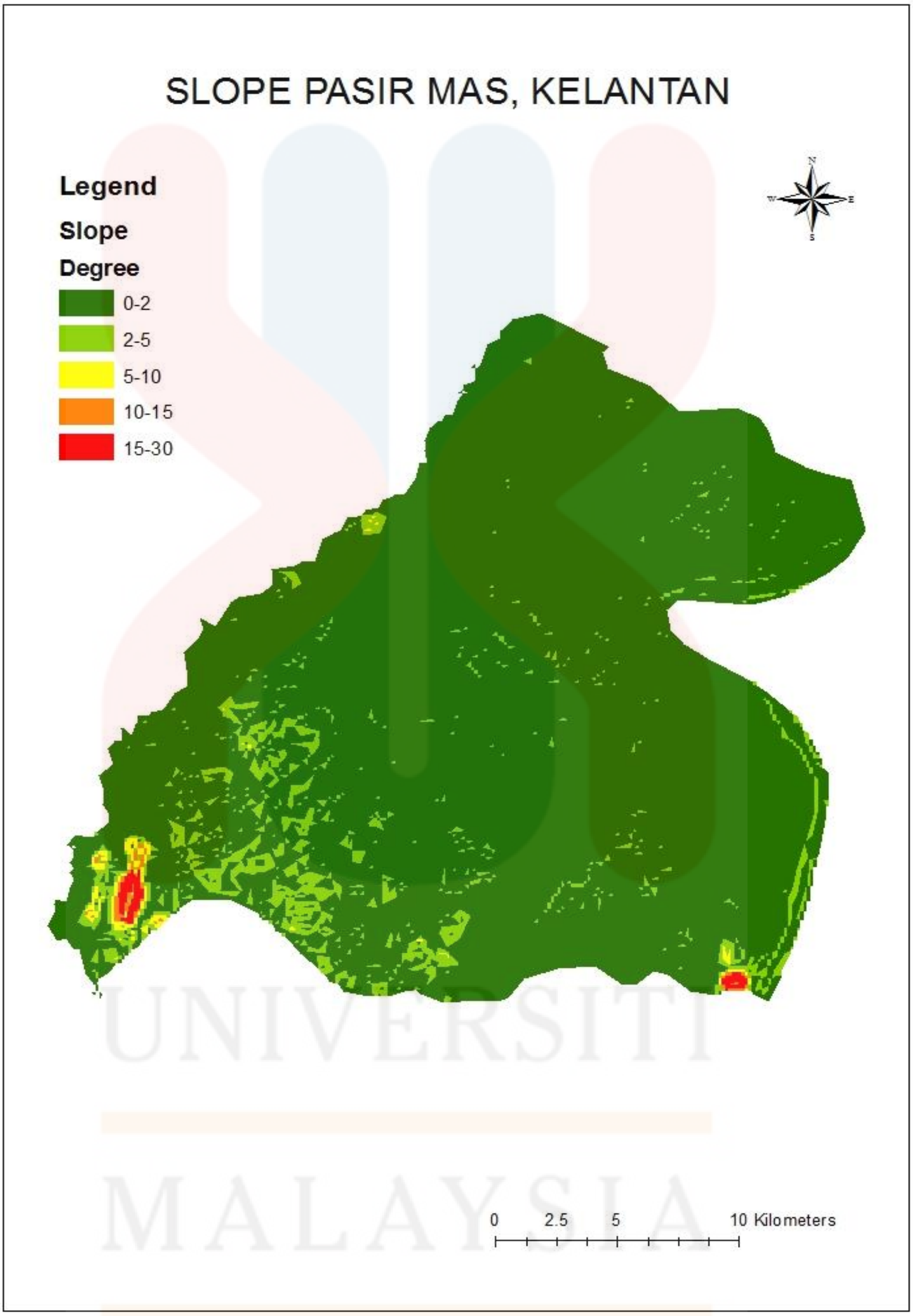

Figure 4.7: The slope degrees map in Pasir Mas

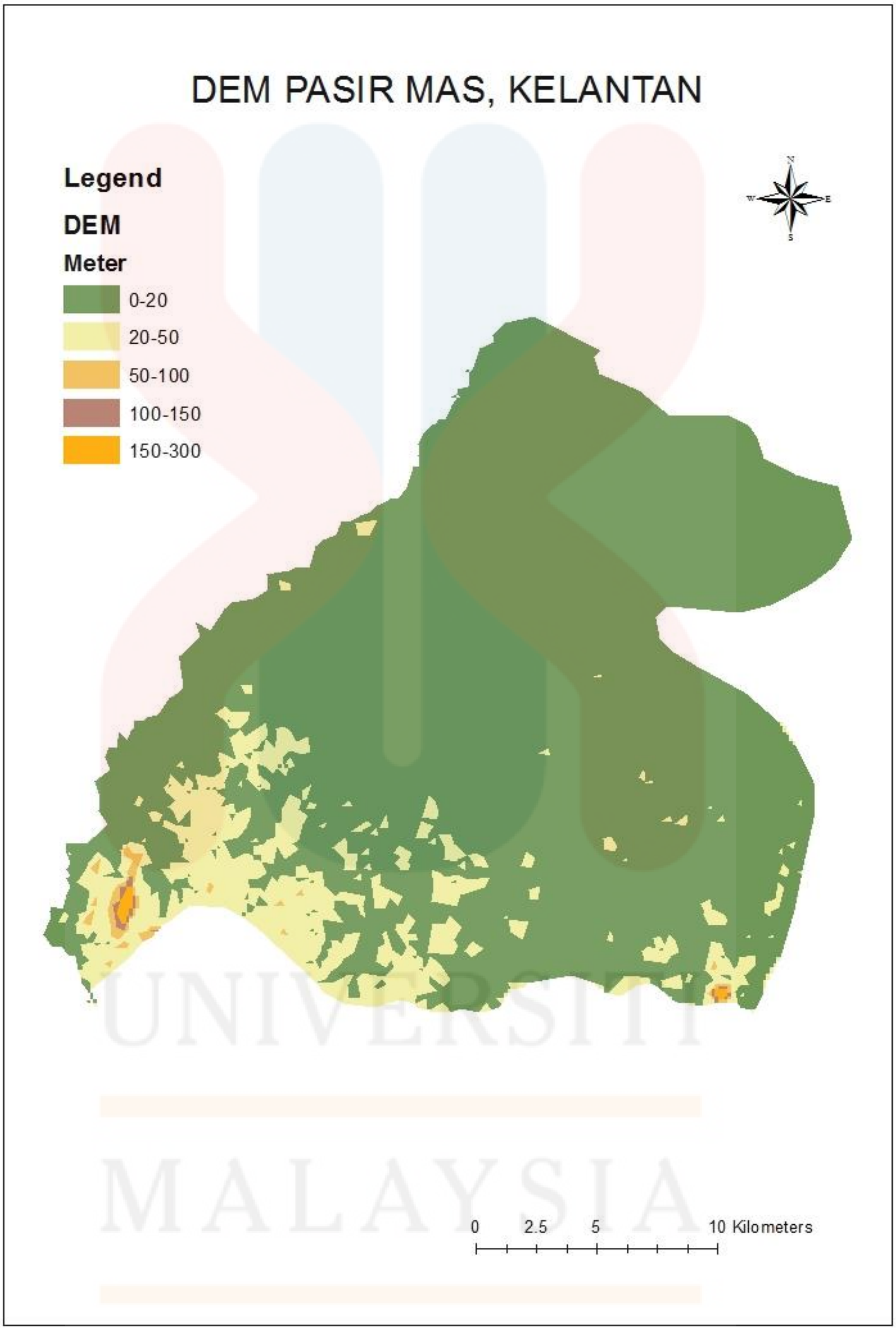

Figure 4.8: The Digital Elevation Model (DEM) map in Pasir Mas

Table 4.4 shows the slope degrees was been reclassified into five degree of slope which from 2014 to 2018. Based on the result, the highest slope degrees was 92.76% which is the flat area or very gentle slope. Low slopes degree assign for highly vulnerable to flood happen in contrast to high slope degree. Rainfall or excessive water came from the river usually form in the area where the low slope degree located. Areas with high slope degree has low flow accumulation of water and reduce risk flooding. The slope class with the least value was classified higher scale as well as most of the flat terrain while the class which the maximum value was assigned as a lower scale because of its comparatively high runoff (Daniela Rincon, 2018). The outcome shows that most study area is based on a low slope. Hence, it proved that slope act as one of the predominant factors in the scale of hazard and risk classes.

The elevation of topography in the study area was also divided into different elevation values. The highest elevation value which 87.24% that between 0-20 m based on Table 4.4. This happened due to most of the study area was the lowland area. Flat land areas were concentrated at the highest area on Pasir Mas with little hills. This happen due to the elevation level from the river has possibly considered with the lower elevation than the surrounding area and make it more vital. This implies which the means that the elevation referred with risk was vital.

Table 4.4: The slope and Digital Elevation Model (DEM) of Pasir Mas

Physical factors	Values	Percentage (%)	Terminology
Slope degrees (°)	0-2	92.76	Very gentle slope
	2-5	6.16	Gentle slope
	5-10	0.53	Moderate slope
	10-15	0.22	Moderate steep slope
	15-30	0.33	Steep slope
Digital Elevation Model (DEM) classes (m)	0-20	87.24	Very gentle slope
	20-50	12.04	Gentle slope
	50-100	0.46	Moderate slope
	100-150	0.13	Moderate steep slope
	150-300	87.24	Steep slope

4.1.5 Flow Accumulation

Based on Figure 4.9, show the flow accumulation classes. The black colour which no flow accumulation was dominant compared to the others. While the highest value with yellow colour show only several possible stream channels in an event of water runoff. Drainage was a main ecosystem controlling the risks as its densities denote the essence of the soil and also its geotechnical characteristics. Flow accumulation was an indirect method of identifying drainage areas and raise perpetually from the drainage split to the outlet and stream channels. Accumulated flow sums the water moving down-slope into cells of the output raster and a weight of 1 was implemented to each cell if there no weight raster was given which consider as no possibility for vulnerable area (Osinska, 2016).

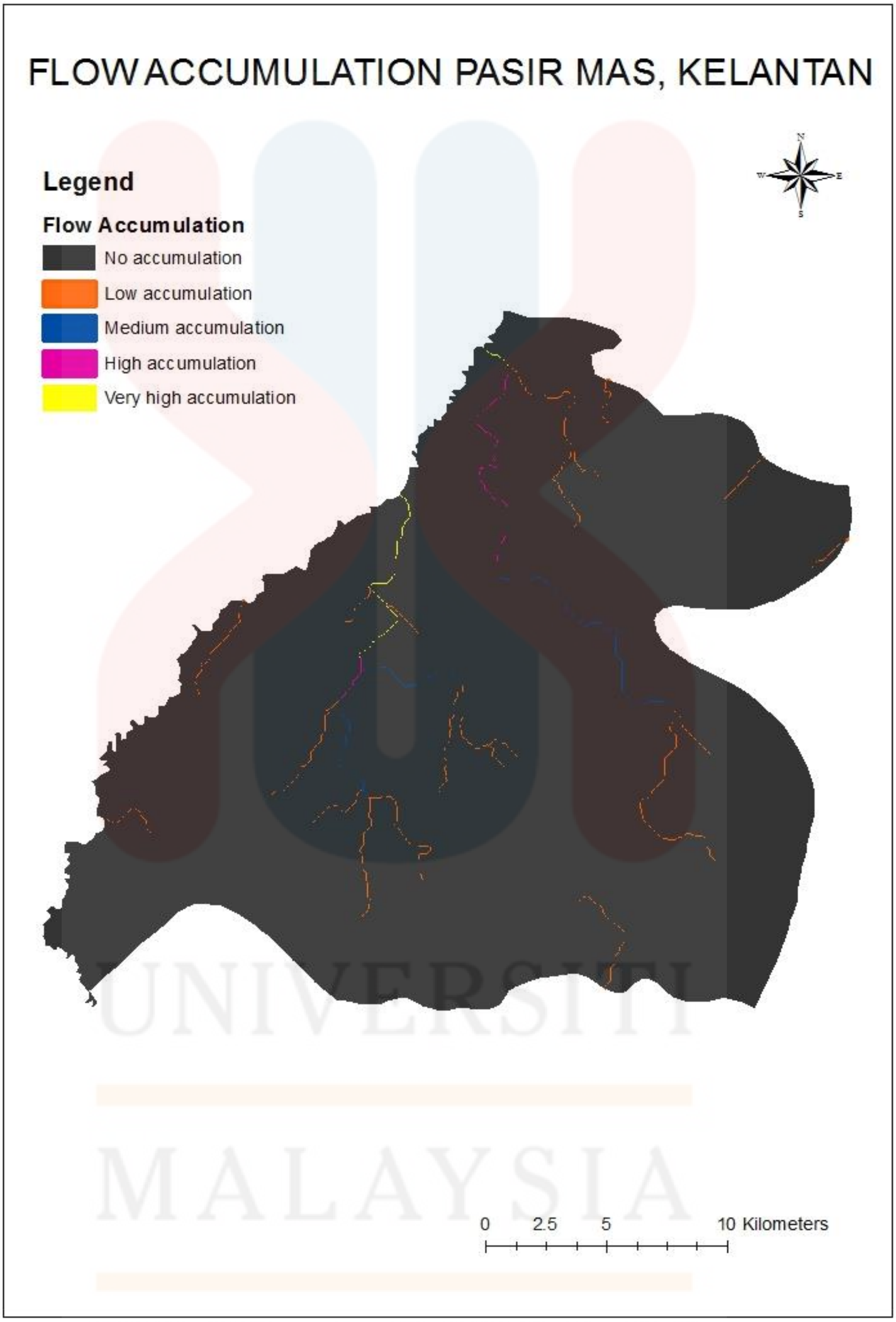

Figure 4.9: The flow accumulation map of Pasir Mas

Based on Table 4.5, it shows the flow accumulation that represented in pixel. 129,797 to 239,843 pixel was represented for very high flow accumulation while 0 to 10,346 pixel correspondingly to no flow accumulation. Each flow accumulation classes had their level of vulnerable which the high values flow accumulation of an area able causing in higher flood vulnerability result. The flood intensifying condition that has more drainage was contribute to face environmental disaster potential (Caldas et al., 2018). Hence, flow accumulation was a main factor in expressing flood vulnerability.

Table 4.5: The flow accumulation of Pasir Mas

Physical factor	Values (pixel)	Description	Weighted of features
Flow accumulation	0-10,346	No accumulation	1
	10,346-45,146	Low accumulation	2
	45,146- 90,293	Medium accumulation	3
	90,293-129,797	High accumulation	4
	129,797-239,843	Very high accumulation	5

4.2 Flood Vulnerability

4.2.1 Introduction flood vulnerability in Pasir Mas

Pasir Mas is one of the location listed on the flood area every year and experienced extreme flood event in 2014. In December 2014, Pasir Mas was hit by flood event that causes the severe on records based on depth and level of flood in addition to the percentage of properties damages. Meteorological and hydrological records proved that the main river in Pasir Mas which is Kelantan River usually overflows during monsoon season. This happens because of heavy rainfall, affect nearly annual repetition of floods every year.

Uncontrolled land use changes such as land use changes such as deforestation, raise rainfall intensity and other factors such as slope, elevation and drainage network were possible causes for flood vulnerable area. The flood vulnerability means as a measure of area vulnerability to damages (Rezaul Rakib, 2017). The flood vulnerable mapping was needed pre-requisite for wide range flood risk management plans.

4.6.2 Flood vulnerability analysis

Based on Figure 4.10 show the flood vulnerable area in Pasir Mas, Kelantan. The flood vulnerability also presents areas of high vulnerability in the surroundings of the rivers and the other location which mostly has the water body that represented in red colour that based on Figure 4.10. The moderate vulnerability was represented as orange colour that several locations that had been vulnerable to the flood. While reasonable vulnerability in yellow colour and low vulnerable in blue colour were dominated, some areas close to the river has high vulnerability and a few regions have moderate vulnerability.

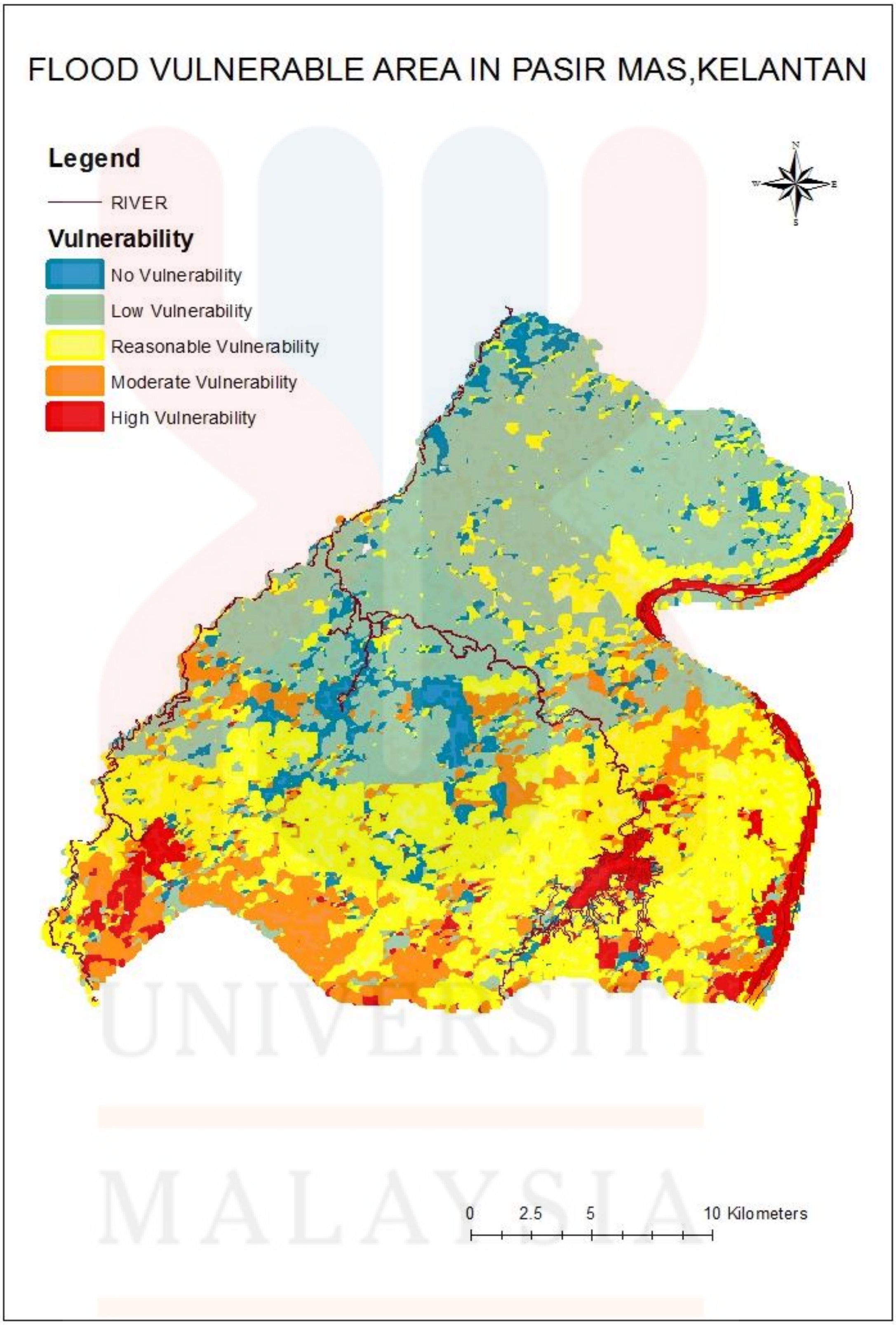

Figure 4.10: Flood vulnerable area map in Pasir Mas

Based on Table 4.6, it show the weighted overlay flood vulnerability in Pasir Mas, Kelantan. In this study, the weight analysis were been used for measure each flood vulnerability factor and developed the flood vulnerable map as shown in Table 4.6. Each of flood indices were examined which include land use, amount of rainfall, slope, DEM and flow accumulation and then it reclassify in form of scale that represented the level of vulnerable in the study area which 1(no vulnerability), 2 (low vulnerability), 3 (reasonable vulnerability), 4 (moderate vulnerability) and 5 (high vulnerability).

The finding show that the area located at the water bodies recorded high vulnerable compared to the others. This happen due to water bodies store the water. When surface water run-off from the surrounding area exceeds the level of water bodies, it increases the flow capacity of the water and cause the flood. From here, it make the water bodies and area surrounded it more vulnerable. The flood vulnerable area from reasonable to high area mostly within the build up area or development area. Hence, this defined the human activities give a great contribution to flood danger. The ability of map flood vulnerable area had been done by using GIS successfully and it map was used for evaluating the impacts of floods. Hence, it been proved that the flood vulnerable mapping able serve as input for integrating of flood risks management strategies and spatial planning in the study area.

Table 4.6: Weighted overlay flood vulnerability

Factors affecting flooding	Values	Scale	Interpretation
Land use	Forest	1	No vulnerability
	Agriculture	2	Low vulnerability
	Cleared land	3	Reasonable vulnerability
	Build up area	4	Moderate vulnerability
	Water body	5	High vulnerability
Amount of rainfall (mm/year)	300-314	1	No vulnerability
	314-332	2	Low vulnerability
	332-353	3	Reasonable vulnerability
	353-379	4	Moderate vulnerability
	379-410	5	High vulnerability
Slope (degrees)	0-2	5	High vulnerability
	2-5	4	Moderate vulnerability
	5-10	3	Reasonable vulnerability
	10-15	2	Low vulnerability
	15-30	1	No vulnerability
DEM (meters)	0-20	5	High vulnerability
	20-50	4	Moderate vulnerability
	50-100	3	Reasonable vulnerability
	100-150	2	Low vulnerability
	150-300	1	No vulnerability
Flow accumulation	No accumulation	1	No vulnerability
	Low accumulation	2	Low vulnerability
	Moderate accumulation	3	Reasonable vulnerability
	High accumulation	4	Moderate vulnerability
	Very high accumulation	5	High vulnerability

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, it is difficult to minimize the event of natural disasters, which include floods. The result sought to determine the flood vulnerable area on physical and climatic factors. The factors represented land use, amount of rainfall, slope and DEM and flow accumulation were applied to predict affected area of flooding. Each of these factors has been analyzed in details and taking into account to identify its level of contribution to the flood vulnerable area in Pasir Mas, Kelantan. The result shows that the physical and climatic factors had affected in determine the vulnerability of the area to floods.

Secondly, the result sought to develop flood vulnerable map based on five physical and climatic factors. From the flood vulnerable map, it can be observed that most of the area in Pasir Mas, Kelantan was falling under reasonable to high vulnerability classes. This study has been conducted to assess the area that was vulnerable to flooding using integrated approaches of remote sensing and GIS. The GIS can provides timely, cost effective and accurate information. Therefore, assessing area vulnerable to flooding disasters is one of the parameters in creating a flood vulnerable map. It can be used for disaster mitigation and urban planning besides to reduce the risk of life and properties losses due to the flood.

5.2 Recommendations

There are many coping strategies that able intends to use against floods. Of all this, GIS provide a wide coverage application which not only for flood mapping used but also able used for many types of analyzing task. Firstly, geospatial data infrastructure technologies need to be using along with disaster management plan. This is used to facilitate informed analysis and decision making (Ahmed & Kranthi, 2018). Additionally, it can provide sharing and convey of geospatial data, in advance for effective pre and post flood measures. Access by the communities and concerned authorities to such geospatial data must be created through the use of online of digital technology. Hence, it can be helpful in emergency situations in reducing the damage properties and human life.

Hence, the flood vulnerable map able serve as a valuable reference material for future studies and stimulate more interest in the used of GIS and remote sensing. It has the potential to promote the development and use of hybrid approaches to further enhance flood forecasting and management procedures. The number of published producing on flood vulnerable map seem minimal in comparison to other integrated mapping approaches. This is despite the sizeable volume of articles on flood and related natural hazards published globally. With the projected increase in flood catastrophe in coming years, it is expected that more researches will be undertaken using GIS and remote sensing and other analysis tool for optimal flood forecasting and management. Afterwards, further research may well be conducted at identifying the impacts of the potential flood towards socio-economic activities in Pasir Mas using GIS. Here it able estimate the flood impacts and produce much proposed mitigation for the future.

REFERENCES

Adeoye, N. O. (2009). Climate change and menace of floods in Nigeria Cities: Socio-economic implications. *Advances in Natural and Applied Sciences,* 369-377.

Aggarwal, P. K. (2009). Remote Sensing and Gis Applications in Flood Management. *International Journal of Geoinformations, 5*(2), 11-23.

Alaghmand, S. B.-A. (2010). GIS-based river flood hazard mapping in urban area: A case study in KayuAra river basin, Malaysia. *International Journal of Engineering Technology, 2*(4), 488-500.

Barroca, L. (2010). Indicators for identification of urban flooding vulnerability. *National Hazards Earth System, Science, 6*(1), 535-561.

Behanzin, D. I., Thiel, M., Szarzynski, J., & Boko, M. (2016). GIS-Based Mapping of Flood Vulnerability and Risk in the Bénin Niger River Valley. *International Journal of Geomatics and Geosciences, 6*(3), 1653–1669.

Caldas, A. M., Cristina, T., Cristina, R., Cartaxo, F., Neto, R., Zanata, M., … Pacheco, L. (2018). Conflicts , and Conservation of Soil and Water : A Study in the Batatais SP Municipality , Brazil, *8*, 22–34.

Daisy, D. a. (2006). Environmental Aspects of Integrated Flood Management. *World Meteological Organization (WMO), Vol 9*(4), Pg. 34-55.

Daniela Rincon, U. T. (2018). Flood Risk Mapping Using GIS and Multi-Criteria Analysis in Greater Toronto Area Case Study. *Education Geoscience,* 275-289.

Dano, U., Balogun, A.-L., Matori, A.-N., Wan Yusouf, K., Abubakar, I., Said Mohamed, M., Pradhan, B. (2019). Flood Susceptibility Mapping Using GIS-Based Analytic Network Process in Perlis, Malaysia. *Water,* 615.

Dem, M., Li, J., Li, J., & Yao, K. (2018). Inundation Analysis of Reservoir Flood Based on Computer Aided Design (CAD) and Digital Elevation, *10*(5), 2–17.

DID. (2017). The Department of Irrigate and Drainage : Environment. *Annual Flood Report of 2016/2017, 9*(2), 1-81.

Dihn, Q. B. (2012). Climate change impact on flood hazard, vulnerability and risk of the Long Xuyen Quadrangle in Mekong Delta. *International Journal River Basin Management, 10*(2), 103-120.

Dixon, J. E. (2014). Spatial Interpolation of Rainfall Data Using ArcGIS: A Comparative Study. *Geo-Spatial Analytics Lab, 6*(1).

Economic Planning Unit. (9 May, 2019). *Sustainable Development Goals Malaysia*. Retrieved from https://sustainabledevelopment.un.org/content/documents/15881Malaysia.pdf

Ejenma, E. S. (2014). Mapping Flood Vulnerability arising from Land Use/Land Covers Change along River Kaduna, Kaduna State, Nigeria. *Journal of Humanitie and Social Science, 19*(7), 155-160.

Ejeta, L. T. (2018). Community's Emergency Preparednessfor Flood Hazards in Dire-dawa Town, Ethiopia: A Qualitative Study. *US National Library of Medicine Natonal Institutes of Health*, *12*(3), 210-216.

Elsheikh, R. F. A., Ouerghi, S., & Elhag, A. R. (2015). Flood Risk Map Based on GIS, and Multi Criteria Techniques (Case Study Terengganu Malaysia). *Journal of Geographic Information System*, *07*(04), 348–357.

ESRI. (8 June, 2017). *What is ArcMAp?* Retrieved 8 March, 2019, from Environmental Systems Research Institute (ESRI): http://desktop.arcgis.com/en/arcmap/10.3/main/map/what-is-arcmap-.htm

Ferris, E. (2010). Natural Disasters, Human Rights and The Role of National Human Rights Institutons. *The Brookings Institutional, 4*, 34-55.

Forkuo, E. (2011). Flood hazard mapping using Aster image data with GIS. *International Journal of Geomatics and Geosciences*, *1*(4), 932–950.

Gabriel de Oliveira, E. C. M., Gabriel de Oliveira, Elisabete C. Moraes, Nathaniel A. Brunsell, Yosio E. Shimabukuro, Nathaniel A. Brunsell, Y. E. S., Luiz E.O.C. Aragão, G. A. V. M. and, Santos, G. A. V. M. and T. V. dos, Santos, T. V. dos, & Ava, A. information is. *Intech Open*, *2*, 64.

Goel, N. K. (2015). Flood Hazard Mapping in the lower part of Chindwin River Basin , Myanmar. *International Conference on Innovation Advances and Implementation of Flood Forecasting Technology, Tromso, Norway,* 103-120.

Haghroosta, W. R. (2018). Extreme weather and floods in Kelantan state, Malaysia in December 2014. *Research in Marine Sciences, 3*(1), 231-244.

Hashim, M. S., Hassan, S., & Bakar, A. A. (2015). Developing a Household Flood Vulnerability Index : A Case Study of Kelantan, *3*(11), 55–65.

Hassan, A. G. (2006). Development of flood risk map using GIS for Sg. Selangor Basin. *Universiti Sains Malaysia*, *1*(1), 51-70.

Heywood, I. C. (2008). An introduction to geographical information systems in third editions. *Exxes, England: Prentice Hall, 3*(2), 111-134.

Hua, A. K. (2018). Adaptation and mitigaion towards moonsoon floods in Pasir Mas, Kelantan. *Department of Geography, Faculty of Art and Social Science, University of Malaya*, *2*(1), 24-66.

Hussain, T. N. (2014). The level of satisfaction towards flood management system in Kelantan. *Pertanika Journal of Social Science and Humanities*, 257-269.

Ibrahim, N. F. (2016). Identification of Vulnerable Areas To Floods in Kelantan River Sub-Basins By Using Flood Vulnerability Index. *International Journal of GEOMATE*, (March).

Ibrisam, W., Bin, F., & Wan, H. (1996). Urban Growth Determinants for the State of Kelantan Opinions of the State's Policy Makers, (3), 176–189.

Ishaya, S., Ifatimehin, O., & Abaje, I. (2009). Mapping Flood Vulnerable Areas in a Developing Urban Centre of Nigeria. *Journal of Sustainable Development in Africa*, *11*(4), 180–194. Retrieved from http://www.jsd-africa.com/Jsda/V12NO2_Winter2009_B/Pdf/Mapping flood vulnerable

Areas in a Developing urban centre of Nigeria.pdf

Ismail, W. I. (2016). Urban Growth Determinants for State of Kelantan: Opinions of the State's Policy Makers. *Academic Engineering and Sciences Geoinformation*, *3*, 176-189.

Jayasselan, A. (2011). Drought and floods assessment and monitoring using Remote Sensing and GIS [Electronic Version]. *Satellite Remote Sensing and GIS Application in Agricultural Meteorology, 1*(6), 291-313.

Jeb, D. N. (2010). Flood inundation hazard madeling of the River Kaduna, using remote sensing and geographic infoemation system. *Journal of Applied Sciences Research*, *4*(12), 1822-1833.

Jeong, S., & Yoon, D. K. (2018). Examining vulnerability factors to natural disasters with a spatial autoregressive model: The case of south Korea. *Sustainability (Switzerland), 10*(5), 1–13.

Jodaki, M. A. (2015). Geographical Information System (GIS) Application in Flood Crisis Management. *2nd International conference on Innovative Engineering Technologies (ICIET'2015)*, 1-4.

Jonkman, S. N. (2012). Issues and challenges in flood risk management. *Editorial for the Special Issue on Flood Risk Management, 4*(6), 785-792.

JPS. (2017). MODUL ALAM SEKITAR, *5*(1), 1–110.

Kenneth, E. a. (2015). Geographic informationsystem as an integrating technology: Context, concepts and definitions. *The Geographer's Craft Project, Department of Geography. The University of Colorado at Boulder*, *4*, 22-31.

Korah, P.I.&López, F.M.J. (2015). Mapping Flood Vulnerable Areas in Guatemala using GIS. *Journal of Environmental and Earth Science*.

Kourgialas, N. N., & Karatzas, G. P. (2011). Flood management and a GIS modelling method to assess flood-hazard areas—a case study. *Hydrological Sciences Journal*, *56*(2), 212–225.

Lawal, D. U., Matori, A. N., Yusuf, K. W., Hashim, A. M., & Balogun, A. L. (2014). Analysis of the flood extent extraction model and the natural flood influencing factors: A GIS-based and remote sensing analysis. *IOP Conference Series: Earth and Environmental Science, 18*(1).

Lyu, H., Wang, G., Shen, J. S., Lu, L., & Wang, G. (2016). Analysis and GIS Mapping of Flooding Hazards on 10 May 2016, Guangzhou, China, *3*(6), 1–17.

Malaysia Coordinates. (8 January, 2019). *GPS Coordinates of Pasir Mas, Malaysia*. Retrieved 13 March, 2019, from Latitude. to: https://latitude.to/map/my/malaysia/cities/pasir-mas

Martina, Z., Blistan, P., & Purcz, P. (2016). Flood Vulnerability in Bodva River Basin in Slovakia, *21*(4), 42–56.

Mohd, M. S., Daud, D., & Alias, D. B. (2006). GIS Analysis for flood Hazard Mapping : Case Study ; Segamat , Johor, West Malaysia. *Seminar Nasional: GIS Application for Mitigation in Natural Disaster*, 1–15.

MMD, M. M. (2017). Determination of Z-R Relationship and Inundation Analysis for Kelantan River Basin. *Ministry of Science, Technology and Innovation (MOSTI), 2*, 1-51.

Muhammad Rezaul Rakib, M. N. (2017). Flood Vulnerability Mapping to Riverine Floods: A study of the Old Brahmaputra River. *Current Research in Geoscience*, *7*(2), 47-58.

Muhammed, I. a. (2013). Application of remote sensing and geographic information systems in flood vulnerability mapping: Case study of River Kaduna. *International Journal of Geomatics and Geosciences, 3*(3), 618-627.

Nelson, S. A. (2018). Natural Hazards and Natural Disasters. *European Journal of Scientific Research*, *4*(1), 212-234.

Nerantriz Kazakis, L. K. (2015). Assessment of flood hazard areas at a regional scale using an index-based approach and Analytical Hierarchy Process: Application in Rhofope-Evros region, Greece. *Science of The Total Environment*, 555-563.

NIDM. (2014). Malaysia National profile disaster risk profile institutional setup initiatives, *2*(4), 12.

Nuur Fatihah, M. K. (2017). Flood Management Using Data Driver Index: A Case Study in Kelantan, Malaysia. *International Journal of Academic Research in Business and Social Science, 7*(11), 2222-6990.

Obidzinski, K., Andriani, R., Komarudin, H., & Andrianto, A. (2012). Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. *Ecology and Society*, *17*(1), 81–98.

Okpokwu, J. (2016). MSc Proposal on Flood Vulnerability Assassement of Anambra State Using Flood Stimulation Model. *International Journal of Water Resources and Environmental Engineering*, *6*(1), 89-101.

Ologunorisa, E. (2009). Flood Risk Assessment and Management in Nigeria: Perspective from the Niger Delta. *Selfers Educational books*, *2*, 291-313.

Osinska, M. W. (2016). Identifying urban ares prone to flash floods using GIS-preliminary results. *Hydrology and Earth System Sciences*, *2*(18), 5-18.

Osti, R., Tanaka, S., & Tokioka, T. (2008). Flood hazard mapping in developing countries: Problems and prospects. *Disaster Prevention and Management: An International Journal*, *17*(1), 104–113.

Ouma, Y. O., & Tateishi, R. (2014). Urban Flood Vulnerability and Risk Mapping Using Integrated Multi-Parametric AHP and GIS: Methodological Overview and Case Study Assessment, *2*(4), 1515–1545.

Pengairan, J., & Saliran, D. A. N. (2017). Dan Alam Sekitar. *Laporan Banjir Tahunan Tahun 2016/2017*, *9*(2), 1–81.

Pradhan, B. S. (2009). Maximum flood prone area mapping using RADARSAT images and GIS: A case study of Kelantan River Basin. *International Journal of Geoinformatics*, *5*(2), 11-23.

Prakash, A. (2002). Geographical Information Systems - An Overview. *Indian Institute of Information Technology*, (98004), 6-15.

PTJPM. (20 March, 2019). *Pejabat Tanah dan Jajahan Pasir Mas*. Retrieved 21 March, 2019, from Profil Setiap Daerah Pasir Mas: http://www.ptjpm.kelantan.gov.my/index.php/my/mengenai-kami/profail-setiap-daerah-pasir-mas

Rahman, H. A. A., Ibrahim, N. A., Abdul Hamid, A. A., & Abdul Hamid, T. H. T. (2018). Effect of 2014 massive flood on well water qualities: A case study on Kelantan River basin. *Journal of Water and Land Development*, 127–136.

Rimba, A., Setiawati, M., Sambah, A., & Miura, F. (2017). Physical Flood Vulnerability Mapping Applying Geospatial Techniques in Okazaki City, Aichi Prefecture, Japan. *Urban Science*, *1*(1), 7.

Roslee, R., Tongkul, F., Simon, N., & Norhisham, M. N. (2017). Flood Potential Analysis (FPAN) using Geo-Spatial Data in Penampang area, Sabah. *Malaysian Journal of Geosciences*, *1*(1), 1–6.

Schwarz, B., Pestre, G., Tellman, B., Sullivan, J., Kuhn, C., Mahtta, R., Hammett, L. (2018). Mapping Floods and Assessing Flood Vulnerability for Disaster Decision-Making: A Case Study Remote Sensing Application in Senegal. *Earth Observation Open Science and Innovation*, 293–300.

Sri Legowo, I. K. (2019). Application of digital elevation method (DEM) for flood estimation of upstream Ciliwung River, West Java, Indonesia. *International Journal of Geomate, 17*(59), 154-165.

Thilagavathi, G. T. (2011). Application of GIS in Flood Hazard Zonation Studies in Papanasan Taluk, Thanjavur District, Tamilnade. *Advances in Applied Science Research, 2*(3), 574-585.

Udika, R. (2010). Flood Management : an examination of mitigation measures for flooding in urban areas in Trinidad. *Natural Hazards Review*, *4*(1), 1–12.

United Nation, U. (1982). Proceedings on Flood Vulnerability Analysis and on the Principles of Floodplain Management for Flood Loss Prevention. *UN Guidelines*, 111-189.

WMO. (2011). Integrated Flood Management Tools Series Flood Emergency Planning. *World Meteorological Organization: Associated Programme on Flood Management*, *11*, 1-29.

Wu, Z., Shen, Y., & Wang, H. (2019). Assessing Urban Areas ' Vulnerability to Flood Disaster on Text Data : A Case Study in Zhengzhou City, *11*, 45-48.

Zakaria, S. F., Zin, R. M., Mohamad, I., Balubaid, S., Mydin, S. H., & Mdr, E. M. R. (2017). The development of flood map in Malaysia. *AIP Conference Proceedings*, *9*(5), 138–148.

Zikri Muhamad, B. T. (2017). Property destruction, human losses and economic paralysis: Impact flood in Kelantan. *American Scientific Publisher,* 108-119.

APPENDICES

Appendix A: Tables

Table A1: The class confusion matrix land use of Pasir Mas, Kelantan in 2014

Overall Accuracy = (27351/29916) 91.4260%
Kappa Coefficient = 0.8529

Class	Ground Truth (Pixels) Water body	Build up area	Forest	Agriculture	Cleared land
Unclassified	227	13	108	1130	19
Water body [B	11113	0	0	0	0
Build up area	4	254	16	530	14
Forest [Green	0	3	1156	51	0
Agriculture [	304	6	27	14504	8
Cleared land	4	14	4	83	324
Total	11652	290	1311	16298	365

Class	Ground Truth (Pixels) Total
Unclassified	1497
Water body [B	11113
Build up area	818
Forest [Green	1210
Agriculture [	14849
Cleared land	429
Total	29916

Class	Ground Truth (Percent) Water body	Build up area	Forest	Agriculture	Cleared land
Unclassified	1.95	4.48	8.24	6.93	5.21
Water body [B	95.37	0.00	0.00	0.00	0.00
Build up area	0.03	87.59	1.22	3.25	3.84
Forest [Green	0.00	1.03	88.18	0.31	0.00
Agriculture [	2.61	2.07	2.06	88.99	2.19
Cleared land	0.03	4.83	0.31	0.51	88.77
Total	100.00	100.00	100.00	100.00	100.00

Class	Ground Truth (Percent) Total
Unclassified	5.00
Water body [B	37.15
Build up area	2.73
Forest [Green	4.04
Agriculture [	49.64
Cleared land	1.43
Total	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Water body [B	0.00	4.63	0/11113	539/11652
Build up area	68.95	12.41	564/818	36/290
Forest [Green	4.46	11.82	54/1210	155/1311
Agriculture [	2.32	11.01	345/14849	1794/16298
Cleared land	24.48	11.23	105/429	41/365

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
Water body [B	95.37	100.00	11113/11652	11113/11113
Build up area	87.59	31.05	254/290	254/818
Forest [Green	88.18	95.54	1156/1311	1156/1210
Agriculture [	88.99	97.68	14504/16298	14504/14849
Cleared land	88.77	75.52	324/365	324/429

Table A2: The class confusion matrix land use of Pasir Mas, Kelantan in 2016

Overall Accuracy = (13118/14873) 88.2001%
Kappa Coefficient = 0.8175

Class	Ground Truth (Pixels) Water body	Build up area	Cleared land	Agriculture	Forest
Unclassified	604	31	43	499	48
Water body [B	6838	3	0	68	0
Build up area	7	406	60	40	15
Cleared land	5	38	582	86	0
Agriculture [	162	3	2	4460	15
Forest [Green	0	5	2	19	832
Total	7616	486	689	5172	910

Class	Ground Truth (Pixels) Total
Unclassified	1225
Water body [B	6909
Build up area	528
Cleared land	711
Agriculture [	4642
Forest [Green	858
Total	14873

Class	Ground Truth (Percent) Water body	Build up area	Cleared land	Agriculture	Forest
Unclassified	7.93	6.38	6.24	9.65	5.27
Water body [B	89.78	0.62	0.00	1.31	0.00
Build up area	0.09	83.54	8.71	0.77	1.65
Cleared land	0.07	7.82	84.47	1.66	0.00
Agriculture [	2.13	0.62	0.29	86.23	1.65
Forest [Green	0.00	1.03	0.29	0.37	91.43
Total	100.00	100.00	100.00	100.00	100.00

Class	Ground Truth (Percent) Total
Unclassified	8.24
Water body [B	46.45
Build up area	3.55
Cleared land	4.78
Agriculture [	31.21
Forest [Green	5.77
Total	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Water body [B	1.03	10.22	71/6909	778/7616
Build up area	23.11	16.46	122/528	80/486
Cleared land	18.14	15.53	129/711	107/689
Agriculture [	3.92	13.77	182/4642	712/5172
Forest [Green	3.03	8.57	26/858	78/910

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
Water body [B	89.78	98.97	6838/7616	6838/6909
Build up area	83.54	76.89	406/486	406/528
Cleared land	84.47	81.86	582/689	582/711
Agriculture [	86.23	96.08	4460/5172	4460/4642
Forest [Green	91.43	96.97	832/910	832/858

Table A3: The class confusion matrix land use of Pasir Mas, Kelantan in 2018

Overall Accuracy = (23442/25611) 91.5310%
Kappa Coefficient = 0.8478

Class	Ground Truth (Pixels) Water body	Forest	Agriculture	Build up area	Cleared land
Unclassified	213	39	1075	21	33
Water body [B	8656	2	6	1	3
Forest [Green	7	580	163	6	1
Agriculture [	232	28	13641	10	7
Build up area	6	5	232	256	8
Cleared land	2	0	57	12	309
Total	9116	654	15174	306	361

Class	Ground Truth (Pixels) Total
Unclassified	1381
Water body [B	8668
Forest [Green	757
Agriculture [	13918
Build up area	507
Cleared land	380
Total	25611

Class	Ground Truth (Percent) Water body	Forest	Agriculture	Build up area	Cleared land
Unclassified	2.34	5.96	7.08	6.86	9.14
Water body [B	94.95	0.31	0.04	0.33	0.83
Forest [Green	0.08	88.69	1.07	1.96	0.28
Agriculture [	2.54	4.28	89.90	3.27	1.94
Build up area	0.07	0.76	1.53	83.66	2.22
Cleared land	0.02	0.00	0.38	3.92	85.60
Total	100.00	100.00	100.00	100.00	100.00

Class	Ground Truth (Percent) Total
Unclassified	5.39
Water body [B	33.84
Forest [Green	2.96
Agriculture [	54.34
Build up area	1.98
Cleared land	1.48
Total	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Water body [B	0.14	5.05	12/8668	460/9116
Forest [Green	23.38	11.31	177/757	74/654
Agriculture [	1.99	10.10	277/13918	1533/15174
Build up area	49.51	16.34	251/507	50/306
Cleared land	18.68	14.40	71/380	52/361

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
Water body [B	94.95	99.86	8656/9116	8656/8668
Forest [Green	88.69	76.62	580/654	580/757
Agriculture [	89.90	98.01	13641/15174	13641/13918
Build up area	83.66	50.49	256/306	256/507
Cleared land	85.60	81.32	309/361	309/380