Evaluation of Thunde Malaysia using Geographic Information System (GIS)

STENY CHIN LOONG

Thesis submitted in fulfilment of the requirements
for the award of the degree of
B.Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2015

ABSTRACT

Malaysia is one of the highest occurence of thunderstorm activity in the world. Situated close to the equator, the warm and humid tropical conditions are highly favourable for the development of thunderstorm.This related to its characteristics itself such as gust factor. Gust factor define as the ratio between a peak wind gust and mean wind speed over a period of time. For that reason, this study is conducted to investigate the characteristic of thunderstorm in Peninsular Malaysia.There are 12 meteorological stations in Peninsular Malaysia were used. Geographical Information System software were used in order to examine the thunderstorm event in Peninsular Malaysia. From the result it is shown thunderstorm were periodically repeated anually. Higher gust factor was favorably indentified during the Inter monsoon season. From the observation, the damage may frequently occured at higher gust factor area. It can be conclude that higher gust factor will increase the risk of particular area. This application will guide us to get the information about the location and to identify thunderstorm hazard potential.

ABSTRAK

Malaysia merupakan salah satu kawasan yang mempunyai kejadian aktiviti ribut petir yang paling tertinggi di dunia. Malaysia terletak berhampiran dengan garisan khatulistiwa dan mempunyai keadaan tropika yang panas dan lembap merupakan satu situasi pemangkin untuk pembentukan ribut petir. Salah satu ciri yang berkaitan dengan rebut petir adalah faktor kekuatan. Faktor kekuatan angin ini ditakrifkan sebagai nisbah antara satu tiupan angin puncak dan purata kelajuan angin pada masa satu tempoh. Atas sebab itu, kajian ini dijalankan untuk menyiasat ciri-ciri ribut petir di Semenanjung Malaysia.Terdapat 12 stesen kaji cuaca terdapat di Semenanjung Malaysia digunakan dalam kajian ini, "Geographical Information System" perisian telah digunakan untuk mengkaji peristiwa ribut petir di Semenanjung Malaysia. Berdasarkan daripada hasil kajian, dibuktikan bahawa ribut petir merupakan satu fenomenon yang berulang pada setiap tahun. Faktor kekuatan angin yang lebih tinggi dikenalpasti lebih kerap semasa pertukaran musim monsun. Dari pemerhatian, kerosakan sering berlaku di kawasan yang faktor kekuatan angin yang lebih tinggi. Kesimpulannya, faktor kekuatan angin yang lebih tinggi akan meningkatkan risiko kemalangan akibat daripada ribut petir anginpada kawasan tertentu. Kajian ini akan memberi petunjuk untuk mendapatkan maklumat tentang bahaya sesuatu lokasi dan untuk mengenal pasti ancaman bahaya ribut petir.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Km/h	Kilometer per hour

LIST OF ABBREVIATIONS

NE	North East
SW	South West
GIS	Geographical Information System
IDW	Inverse Distance Weighted

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In Malaysia, thunderstorms are a common phenomenon which occurs throughout the year but are most likely to happen during the inter-monsoon periods, namely April to May and October to November; frequently occur during the afternoon and early evening of the day over the sea. Despite their small sizes, all thunderstorms are very dangerous because of the present of gust wind which is defined as the sudden drastic increase in wind speed in a short period of time that will cause serious damages if not taken precautions.

Thunderstorm gusts can be severe and able to inflict major damage to high buildings and was caused by the downburst of wind emanating from thunderstorm cloud. By the definition of the World Meteorological Organization, thunderstorm is defined as one or more sudden electrical discharges, manifested with flashes of lightning and a sharp thundering sound. Thunderstorms are capable of producing hail, heavy rain, frequent lightning and strong gusty winds which can cause casualties such as lightning are responsible for many fires each year, heavy rain can lead o flash flooding and landslides, and strong straight-line winds which are capable of knocking down tress, power lines and mobile homes.

Thunderstorms are formed thru a convection process which is defined as the transport of heat energy, since because of the atmosphere is heated unevenly or unstable, an imbalance occurred which thunderstorms are attempting to correct. There

are three main stages within thunderstorms cycle: Cumulus stage, mature stage and dissipating stage.

Firstly, a cumulus stage is the starting point of the formation of thunderstorms. During the day, the earth's surfaces are constantly heats up the surfaces by the sun, the warm air from the surfaces will rise due to its lighter than cool air known as an updraft. If the air is moist, then the warm air will condenses into a cumulus cloud. The cloud will continue to grow as long as warm air below continues to rises.

Next is the mature stage, when the cumulus cloud becomes very large, the water in the cloud which hold by the rising warm air will eventually becomes too large and heavy, thus rain will started to fall. Meanwhile, cool air starts to enter the cloud and since cool air particles are heavier than warm air, the cool air will starts to descend in the cloud known as the downdraft. The downdraft pulls the heavy water in the cloud making it rain.

Lastly, after for awhile, the thunderstorms will start to dissipate. This stage is the dissipating stage. This only occurs when the downdraft of the cool air in the cloud begins to dominate over the updraft. Since the warm airs can no longer rise, cloud droplets can no longer form. The downdraft hitting the ground creates an outflow boundary. This can cause downburst which is defined as a rapidly descending of air beneath a small area of a thunderstorm. The strong winds can reach to a very high speed that can cause significant damages along its path and is extremely dangerous to aviation. A straight line wind will push debris in the same direction the wind is blowing hence the term straight line.

1.2 PROBLEM STATEMENT

Every year, severe thunderstorms affected communities across the Malaysia causing fatalities, crops and property destroyed, and disrupting businesses. Recently numbers of damages and injuries due to thunderstorms in the past few years had increases in Malaysia. Due to the lack of awareness among the public increases and the number of people who are involved with wind engineering activities in Malaysia are still inadequate.

The lack of information regarding thunderstorms hazards are needed in order to gain the initiative against preventing and reducing the risk factor causes by thunderstorm. There are very little emphasizes of design building structure such as roof and cladding to minimize wind-induced damaged to buildings. Several factors are found which said to be contribute to the damage to the building component, one of it is said the failure of the lack on consideration to wind effect during design stage.

Thus, a gust factors are needed to be obtain throughout within Peninsular Malaysia as to get the estimation of the strength of wind within the proximity of area and the relation of the thunderstorms with any recent cases to prove. Continuously design of buildings while not considering the potential gust factors accordingly to area may cause damages or hazards in the future.

1.3 OBJECTIVES

The objectives of the research are as follows:

i) To investigate and analyse the thunderstorms gust factor all over Peninsular Malaysia.
ii) To determine the relationship between the damages and thunderstorm events.

1.4 SCOPE OF STUDY

The scope of this study is to identify and analyze the thunderstorm events from a dozen numbers of meteorological stations from all over of Peninsular Malaysia. Gust factor and the frequency of thunderstorms in year 2013 and 2014 are analyzed by using spatial distribution wit Arcgis software.

The study area is limited to peninsular Malaysia while East Malaysia which consists of Sabah and Sarawak are not included in this study.

Figure 1.1: Peninsular Malaysia Map

Source: http://www.mymalaysiabooks.com/malaysia/Malaysia_states.htm (2015)

1.5 SIGNIFICANT OF STUDY

The reason for this research study is because of the lack of information regarding thunderstorm events in Malaysia. A significant amount of database is needed in order to mitigate any kind of hazard risk posed by thunderstorm events. As an example, a place with a history of high number of hazard cases due to strong gusty wind, the reason is because the building around the area did not consider the risk of the gust factor when designing the structure.

1.6 THESIS STRUCTURE

This thesis is divided into five chapters:

i)	Introduction	: This chapter includes the overview of the studies, problem statement, objectives, and scopes of study, the significance of the study and study area.
ii)	Literature Review	: This chapter is the previous study material related to objectives.
iii)	Methodology	: The flow of the thesis from data collection to production of the result.
iv)	Discussion	: Discuss the result obtained based on the case study.
v)	Conclusion	: Conclusion of the discussion based on the thesis result and provides the future suggestion.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Many researchers have conducted a similar study such as this and many theories have been proposed to explain the phenomenon of thunderstorms. Although the literature covers a wide variety of such theories, this chapter of literature review will focus on major aspects which emerge throughout this study.

Malaysia is one of the countries who have the highest number of thunderstorm activity occurrence in the world. This is because Malaysia is located very close to the equator, the warm and humid tropical conditions which is highly favourable for the development of the thunderstorms.

Figure 2.1: Malaysia close to the Equator line

Source: http://www.worldatlas.com/webimage/countrys/asia/my.htm (2015)

2.2 CLIMATES IN MALAYSIA

Due to the global climate changes in the world, a significant increase in number of thunderstorm occurrences in Malaysia due to its location is close to the equator. In general, the climates in Malaysia are mostly affected by the two monsoon seasons and inter–monsoon thunderstorms.

The approaching wind characteristics are largely controlled by the roughness of the upwind fetch over which it had blown. (Choi, 2009)

The north eastern monsoon blows from November to March, usually accompanied by heavy rainfall, thus this monsoon is known as the wet season. Around late May to September, the wind blows from the south western direction comparing to northeast monsoon, southwest monsoon are drier and more tranquil.

During the inter change between the two monsoon, thunderstorms are frequently occurs during this season periods. The intensity of the thunderstorms during inter-monsoon is relatively stronger and more turbulent than those in the northeast monsoon and southwest monsoon seasons.

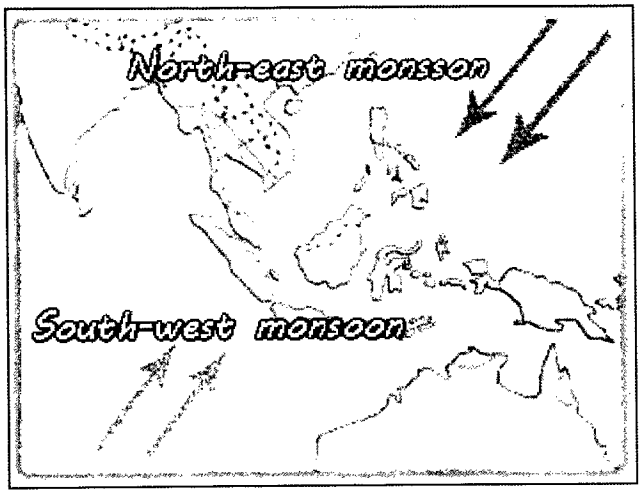

Figure 2.2: Monsoon direction map

Source: http://durianinfo.blogspot.com/p/durian-seasons-in-durian-production.html (2015)

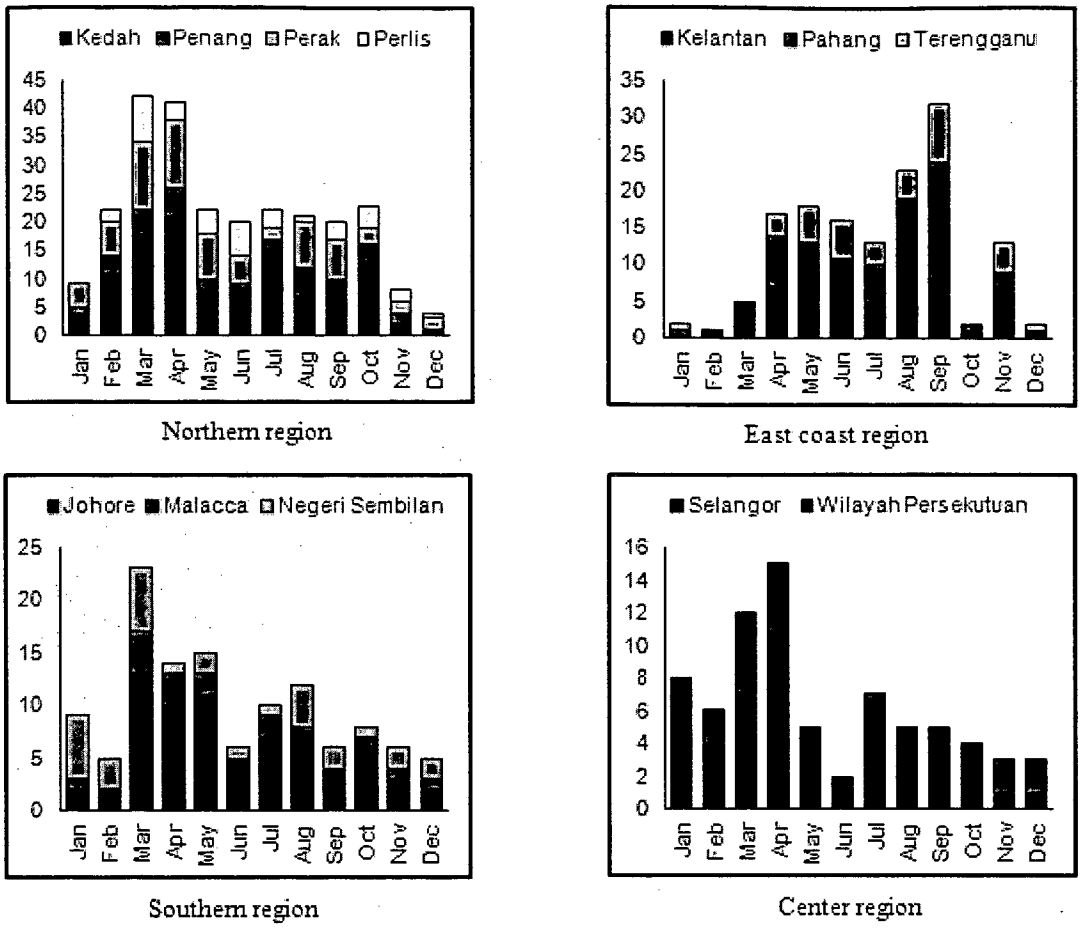

Figure 2.3: Thunderstorms occurrence in year 2010 – 2012

(Mohd Fairuz Bachok et. al., 2012)

2.3 THUNDERSTORM IN MALAYSIA

Storm is a hydro meteorological hazard and defines as an atmospheric disturbance manifested during strong winds accompanied by rain, snow or any other precipitation and capable of inflicting significant damages along its path. A sudden increase of wind speed in a short period of time is called as Gust Factor.

Gust factor is defined as the ratio of the maximum gust/wind speed of duration, to the average of wind speed for an averaging period of T and the formula is as shown below:

$$\text{Gust Factor} = \frac{\text{Maximum Gust Speed Km/h}}{\text{Mean Wind Speed Km/h}}$$

Figure 2.4 Gust factor formula

"Maximum Gust speed km/h is the maximum of the running average wind speed over t seconds and mean wind speed km/h is the wind speed averaged over T seconds. Generally, t=3s and T=10 or 60 min are used to calculate the gust factors". (Choi and Hidayat, 2002)

2.4 THUNDERSTORMS RISK ASSESSMENT

Thunderstorms hazards is the risk aspect when a property or object failed to sustain due to the strong wind inflicted on it. Risk is something that happens to everyone everyday to deal with. The aim of risk assessment is to remove or reduce the level of the hazard risk by adding precaution and control measures when necessary.

"Risk assessment is all about risk management. The only reason you do an assessment is because somebody has to make a risk-management decision" (Smith, 2005).

Currently, thunderstorm related hazards are not being given priority in Malaysia due to the shortage of awareness and wind expert among Malaysia. Cases such as property damages and deaths have been reported and publicizes in daily Newspaper and television News. According to most of the reported news, northern region on Peninsular Malaysia has the highest damage occurs yearly.

2.5 GEOGRAPHICAL INFORMATION SYSTEM (GIS)

In term of thunderstorm hazards assessment, Geographical Information System (GIS) is software or technology field which described, explained, and predicted the outcome of the patterns and processed it at a geographic scales.

GIS is a science, a technology, a discipline and an applied problem solving methodology (Longley, 2005).

GIS has several components, computer systems and software which helps analyze the data of the procedure. By using these tools, GIS are able to succeed in producing the required result outcome.

2.5.1 Data Management

An amount of information must be gathered and managed in advance in order to be prepared for the input of data into GIS. By linking the thunderstorms occurrences, the hazards, and the information of gust factors together in term of geographic region, GIS were able to establish a full situational awareness on the potential risk of thunderstorms gust factor with a zoning map.

2.5.2 Inverse Distance Weighted (IDW)

The exact coordination of each weather station are taken as an XY data and added into ArcGis 9.3 for the data to be interpolated. A raster surface from points are interpolated using inverse distance weighted (IDW) technique as shown in Figure 2.5.

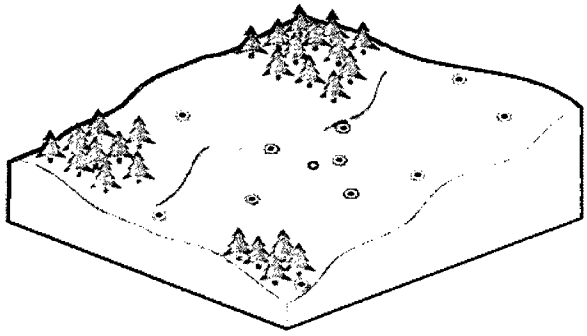

Figure 2.5: IDW Neighbourhood for Selected Point

Source: http://help.arcgis.com (2015)

Inverse distance weighted (IDW) interpolation determines cell values by using a linearly weighted combination of a set of sample points. The surface being interpolated should be that of a location dependent variable.

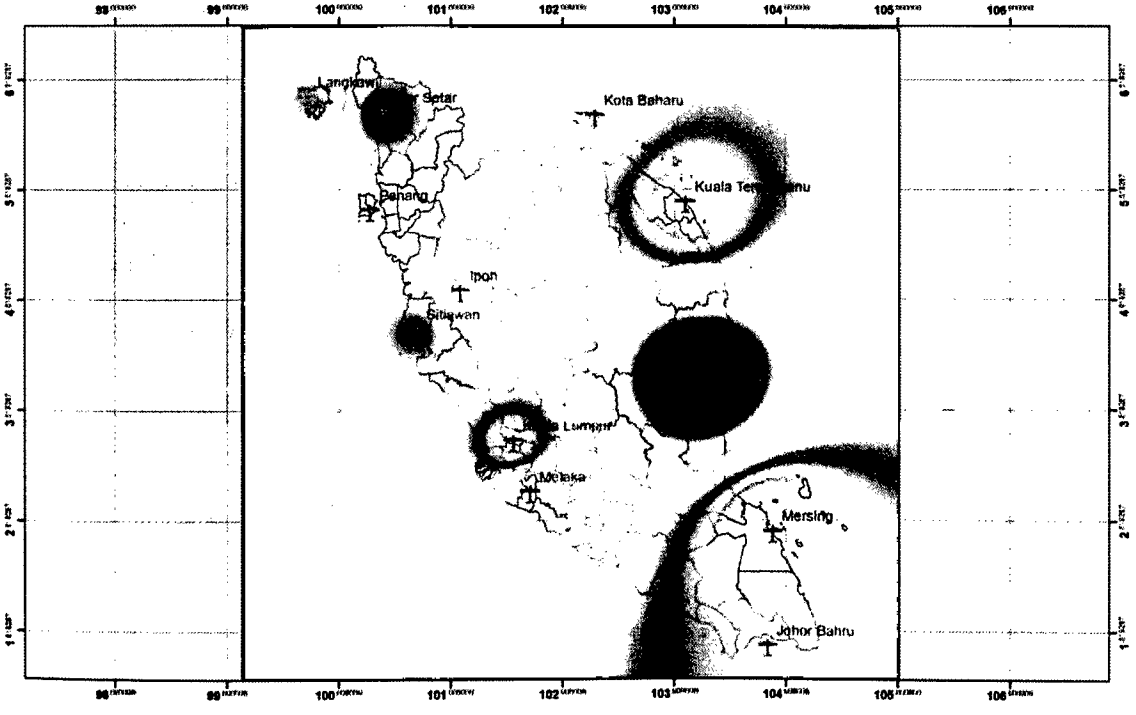

Figure 2.6: Inverse Distance Weighted (IDW) Interpolation

2.6 SUMMARY

Overall, previous studies stated that the gust factor has the potential to damage any manmade structural building and natural environment such as trees. Since Malaysia is located on near to the equator of the earth, every year Malaysia has to face the annual four seasons; the northeast monsoon, southwest monsoon, and the two inter-monsoons in between. As a result from these phenomenon's, many hazards related to the sudden increase of gust wind have been identified and took noticed as the risk of the hazard could pose danger to the public safety.

On top of that, GIS software were use to analyze these phenomenon. When using GIS, it reduced the time of data processing and also allows making prediction easily to be made thru a simple mapping which is easily visualizing the intensity of the information. The data collection requires skills and knowledge to be used as the complexity of the GIS software are quite hard, thus, cooperation and communication among organization are encouraged to reduce the difficulty of data processing.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter is more on the method for preparation for the process of collecting the data and inputting the data to get the results. This chapter will start with the flow of methodology. The main purpose of this chapter is to achieve the objectives of this study. This study is primarily consists of 4 phases, which are:

i)	Data collection	: Thunderstorm hazard related cases in Peninsular Malaysia from 2013 to 2014 and the gust factors of the surrounding area around the weather stations.
ii)	Preparation	: The collected data are to be readied in Microsoft Excel table
iii)	Data Processing	: Data are input into Geographical Information System software (GIS)
iv)	Results	: Thunderstorm hazard maps

3.2 DATA COLLECTION

Data collection is an important aspect of any type of research study. The process of data gathering and measuring information on the aspect of variables which is in interest are then evaluated and analyzed to produce suitable results. However, an inaccurate data collection may cause the results of a study to be a failure.

The data for this study are mainly taken from reliable sources from the internet. Examples are such as the news websites (New Strait Times, Harian Metro, The Star Online, and The Malaysian Insider) and Malaysia Meteorological Stations.

3.2.1 Thunderstorm Hazard Disaster Data

Any hazards cases regarding to thunderstorms that are reported in news website are collected, the data taken are then tabulated according to several aspect such as dates, locations, and damage type/losses. The tabulated data were then recorded in Microsoft Word for future references. A total of 18 cases were recorded in year 2013 and year 2014 is collected from the news websites.

Table 3.1 shown below is an example of some of the thunderstorm hazard cases:

Location	Date	Damage Types
Kedah (Kulim)	13 Mar 2013	30 Houses
Penang	13 Jun 2013	100 Houses, 2 Death
Penang	13 Jun 2013	25 –storey UMNO Building
Ipoh	7 Dec 2014	57 Houses

Table 3.1: Thunderstorm Hazard Cases