

Flood risk area assessment in Patong Municipality, Kathu District, Phuket Province, Thailand

S Vongtanaboon¹, W Hancharoen² and S Homya¹.

¹ Environmental Science Department, Faculty of Science and Technology, Phuket Rajabhat University, Phuket., Thailand,

² Entrepreneur Department, Faculty of Social Science, Phuket Rajabhat University, Phuket, Thailand

Corresponding author: vongtanaboon@yahoo.com

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CORRESPONDING AUTHOR

*E-mail: vongtanaboon@yahoo.com

ABSTRACT

The objectives of this research were to evaluate risk factors and assess flood risk areas, including analyzing guidelines for flood risk area management in Patong Municipality, Kathu District, Phuket Province. Factors affecting flood were rainfall, slope gradient, soil permeability, land use, and water barrier. Weighting factors and rating factors were indicated and geographic information system for potential surface analysis and overlay analysis were applied. The results revealed that Patong Municipality had high risk area as 2.17 km² (11.39%). Flood risk area for moderate level accounted for 4.00 km² (20.99%) and low flood risk area accounted for 12.89 km² (67.62%). Guidelines for flood risk area management in Patong Municipality should focus on the principles of soil and water conservation, forest restoration and preservation in the upstream area, flow path and stream are management, land use management, ground cover planting to prevent soil erosion and maintain soil moisture.

1. INTRODUCTION

1.1. Research Background

At present, Thailand is experiencing a lot of natural disasters, especially flooding. From the study of flood factors, it was found that important factors that causing flood was the rainfall that fell in the area and neighborhood. There were additional factors that caused the flood problem in the area to become more severe such as slope of the area, distance of the community from the river, soil permeability, landuse and transportation [1-3]. In the analysis of the flood risk area, the geographic information system was applied together with spatial potential analysis by weighting method. Weighting and rating scores were determined by experts from relevant organizations [4,5].

Patong Municipality has a geography with beautiful natural resources. Patong Beach is a place that attracts both Thai and foreign tourists to visit the city of Patong, thus making it famous and well-known throughout the world and also a place where foreign tourists come to rest all year round. The beach is also equipped with facilities such as hotels, restaurants, water sport equipment stores resulting in the rapid expansion of the city along with the growth of tourism business [6,7]. However at present, Patong municipality often faces flooding problem after several hours of rain, causing the amount of rain to overflow in the canals and streets around Patong, whereas sea inundation results in the inability of water to drain into the sea immediately. Therefore, <https://doi.org/10.29165/ajarcde.v3i1.22>

there should be a study of flood risk factors in order to indicate the flood risk area in the Patong Municipality. The results of the study will allow people in the area to have knowledge and understanding in preparing for the flood situation.

1.2. Research Objective

The objectives of this research were to evaluate risk factors and assess flood risk area, including analyze guidelines for flood risk area management in Patong Municipality, Kathu District, Phuket Province.

2. MATERIALS AND METHODS

The method of flood risk area assessment in Patong Municipality, Kathu District, Phuket was as follows:

2.1. Flood risk factors evaluation

According to research papers related to flood risk factors, there were affecting 5 factors consisting of rainfall, slope of the area, soil permeability, land use and water barrier.

2.1.1. Rainfall.

The maximum daily rainfall in each year during the past 8 years (2001 - 2018) were gathered from the Southern Coast Meteorological Center. The return period was calculated [8] as well as the rainfall intensity and duration. Then the rainfall interpolation was estimated by using statistical processes and

mathematical equations [9].

2.1.1 Slope.

Elevation of the area was surveyed and contour data was interpolated into digital elevation model, then surface slope was analyzed [10].

2.1.2 Soil permeability.

Soil data were surveyed and soil permeability were tested and compared with soil characteristics and properties of the Land Development Department.

2.1.3 Landuse.

Landuse type and area were surveyed in the study area.

2.1.4 Water barrier.

Transportation routes were surveyed in the study area.

2.2. Determination of flood risk weighting factors and rating factors

Flood risk weighting factors and rating factors were determined based on research papers related to flood [5], [11], [12], [13], [14], [15], [16], [17] including the field survey and observation. (Table 1).

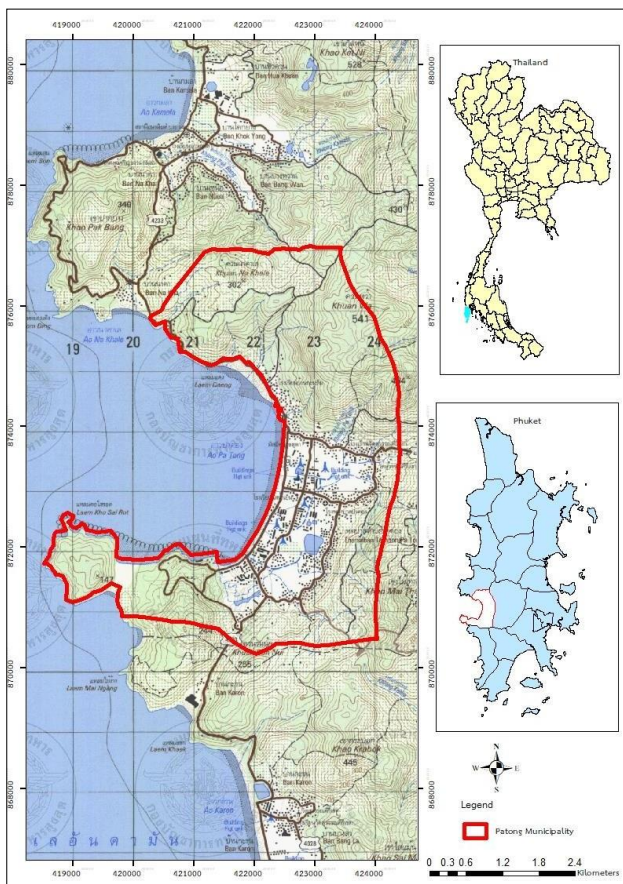


Figure 1. The study area of Patong Municipality, Kathu District, Phuket Province

2.3. Assessment of flood risk area

Flood risk factors were overlaid and analyzed to classify the flood risk area with the following equation : $S = (R_1W_1) + (R_2W_2) + (R_3W_3) + (R_4W_4) + (R_5W_5)$

The flood risk area analysis was carried out according to statistical methods which was divided into 3 levels: high risk level, moderate risk level and low risk level [13] using the mean value and the standard deviation to determine the width of each range for the risk level. The volume of biogas was monitored and recorded every day; the cumulative gas measured based on the results that noted from daily gas generated. Every 3 days produced gas was collected in the gas sampling bag with 1 L working volume (Tedlar PVF - PTFE valve, China) and was stored in dry storage and the continuous temperature range from -70°C to 100°C. The volume of gas used for checking components was 400ml – 1000ml.

3. RESULT AND DISCUSSION

Assessment of flood risk area in Patong Municipality, Kathu District, Phuket Province could be summarized and discussed as follows:

3.1. Municipality, Kathu District, Phuket Province

In the study of flood risk factors in Patong Municipality, five flooding factors: rainfall, slope of the area, soil permeability, landuse and water barriers had been compiled to analyze flood risk area [2], [17].

3.1.1. Rainfall

Maximum. Daily rainfall during the year 2001- 2018 in Patong municipality were gathered. It was found that the average daily rainfall in the period of 18 years was 144.1 mm. The maximum rainfall was 211.9 mm in August 2011 due to the monsoon trough which was quite strong across the upper Thailand almost throughout the month. By the beginning of the month, the monsoon trough had spread across the northern and northeastern regions, then moved down across the lower northern, central and eastern regions, together with the moderate to strong southwest monsoon covering the Andaman Sea. Such characteristics caused Thailand to heavily rain throughout the month, causing continuous flood in many areas for the southern region. Most of the rainfall was in the middle and late month, especially at the end of the month, the southwest monsoon was strong, causing more rain, resulting in heavy to very heavy rain in many areas of the west side of the southern area [18].

3.1.2. Slope of the area.

The slope of Patong Municipality was found that the area with the slope greater than 15% was 11.60 square kilometers or 60.86% of the area and it was covered with forest. The area with the slope of 5-15% was 4.43 square kilometers or 23.24% which was an agricultural area. The area with the slope less than 5% was 3.03 square kilometer or 15.90% which was community and residential area (Table 2).

Whereas S = area risk or potential
 R_i = rating factors of flood
 W_i = weighting factors of flood

Table 2. Slope of the area in Patong Municipality, Kathu District, Phuket Province.

Slope	Weighting	Rating	Area	
			square kilometer	percent (%)
Slope 0 - 5 %	0.15	3	3.03	15.90
Slope 5 - 15 %		2	4.43	23.24
Slope > 15 %		1	11.60	60.86
Total			19.06	100

The slope factor was the second factor that affected the flood following the maximum daily rainfall factor. This was consistent with the study of flood factors to determine the risk area with geographic information systems in the Songkhla Lake sub-basin in Phatthalung Province which was found that the additional factors that caused flooding in the study area following the amount of rainfall was the slope of the area [1]. In addition, the application of geographic information systems to determine the flood risk area in Angthong Province was found that geographic characteristics were important factors affecting flood [5].

3.1.3. Soil permeability.

Characteristics and properties of soil series in Patong Municipality consisted of Alluvial Complex, poorly drained (AC - pd), Ban Thon series (Bh), Estuaries (EC), Khok Kloi series (Koi), Thai Muang series (Tim) and slope complex (SC). The soil permeability in Patong Municipality was found that the area with high permeability was 12.78. square kilometers or 67.05% as slope complex (Sc) area consisting of rock fragments, rocks or rocky surfaces scattered everywhere. Most of them were covered with forests due to the high slope of the area. The area with moderate permeability was 3.89 square kilometer or 20.40% as Ban Ton series (Bh) and the mixed soil series of Khok Kloi and Thai Muang (Koi & Tim) with a moderate slope in the granite hillslope area and loamy sand or sandy clay soil. The area with low permeability was 2.39 square kilometer or 12.55% as Alluvial Complex (AC) and Estuaries (EC) with poor drainage and silty clay soil (Table 3).

Table 3. Soil permeability in Patong Municipality, Kathu District, Phuket Province

Soil water permeability	Weighting	Rating	Area	
			square kilometer	percent (%)
Low permeability	0.06	3	2.39	12.55
Medium permeability		2	3.89	20.40
High permeability		1	12.78	67.05
Total			19.06	100

In the study, soil permeability factor was the fourth factor affecting flooding in accordance with the application of geographic information systems to assess flood risk area in Si Racha District, Chonburi province [19], which was found that the fourth factor causing flood was soil permeability.

3.1.4. Landuse.

In the study of landuse factor, it was found that the forest area and natural water area was 7.60 square kilometers or 39.87%,

agricultural area was 3.31 square kilometers or 17.37%, urban area and residential area was 8.15 square kilometers or 42.76% (Table 4).

Table 4. Landuse type in Patong Municipality, Kathu District, Phuket Province.

Landuse	Weighting	Rating	Area	
			square kilometer	percent (%)
Communities and residences	0.04	3	8.15	42.76
Agricultural area		2	3.31	17.37
Forests and natural water sources		1	7.60	39.87
Total			19.06	100

Landuse of Patong Municipality that caused the most flooding was communities and residential area, such as Suwannakhiriwong temple, Ban Sai Nam Yen school, Ban Kalim school, Patong hospital, Patong police station, mosque, Patong municipal office and various hotels. When areas were developed to be communities or residences, land was filled and adjusted to build roads and various structures causing water basins, marshes and canals to be completely destroyed. Within the community area that did not establish a proper and effective drainage system, therefore the heavy rainfall could cause flooding for a long time and lead to subsequent damage.

3.1.5. Water barriers

The study was found that the area with water barrier less than 0.30 km/sq km was 17.54 square kilometers or 92.03%. The area with water barrier between 0.30-0.60 km/sq km was 0.56 square kilometers or 2.94%. The area with water barrier greater than 0.60 km/sq km was 0.96 square kilometers or 5.03% (Table 5).

Table 5. Water Barrier in Patong Municipality, Kathu District, Phuket Province.

Water barrier (km/sq km)	Weighting	Rating	Area	
			square kilometer	percent (%)
Water barrier > 0.60	0.11	3	0.96	5.03
Water barrier 0.30 - 0.60		2	0.56	2.94
Water barrier < 0 - 0.30		1	17.54	92.03
Total			19.06	100

The routes that blocked the canal included Pak Bang canal,

Pak Lak canal, Wang Khi On canal, Bang Ton Khao canal. When comparing with the application of geographic information systems in determining flood risk area in Suphan Buri Province [4], it was found that most areas were covered with more than 0.60 km/sq km of water barrier in Suphan Buri Province.

3.2. Assessment of flood risk area in Patong Municipality, Kathu District, Phuket province

For the flood risk assessment in Patong Municipality, the flood risk levels were divided into 3 levels which could be summarized as follows (Table 6 and Figure 2).

3.2.1. Low flood risk area.

The area with low flood risk was 12.89 square kilometers or 67.62% of the total area in Patong Municipality. Most areas were very steep slopes with high soil permeability. Landuse type was mostly forest. This low risk area was found in Ron Nui hill, Nakalay hill, Wa hill and Khao Maitao Sibsong mountain.

3.2.2. Moderate flood risk area.

The area with moderate flood risk was 4.00 squarekilometers or 20.99% of the total area. Most areas had relatively low slope with moderate soil permeability. Most landuse was agricultural land and community. There were some transportation routes obstructing the water flow and drainage. This moderate risk area was found at Kalim school, Suwannakhiriwong temple, Patong Municipality and Patong Department of Disaster Prevention and Mitigation.

3.2.3. High flood risk area

The area with high flood risk was 2.17 square kilometers or 11.39% of the total area. Most areas were floodplain with very low slope and low soil permeability because of its landuse type as community and residential area. There were transportation routes that hindered the water flow and drainage when heavy rain occurred. This high risk was found at Ban Sai Nam Yen school Patong hospital, Patong police station, Nanai roadand Rat Uthit 200 Years road, which was consistent with the past flooding records in 2017 and 2018.

Table 6. Flood risk levels in Patong Municipality, Kathu District, Phuket Province.

Risk level score	Flood risk level	Area	
		square kilometer	percent (%)
> 1.90	High flood risk	2.17	11.39
1.54 - 1.90	Medium flood risk	4.00	20.99
<1.54	Low flood risk	12.89	67.62
Total		19.06	100

From the study of [20], it was found that the high flood risk area was usually due to heavy rainfall, floodplain area, short distance from stream, landuse of community and residential area and poor soil permeability. According to the previous study [1], it was found that the rainfall amount was the main reason and the most important factor effecting flood followed by topography and landuse. However, the nature of flooding was mainly caused by overflowing of water from the stream. Based on the assessment and survey of the flood risk area in Patong Municipality, it was able to analyze the guidelines for flood management, prevention and mitigation, including landuse planning which should integrate various measures, including engineering structures and non-structure measures which consisted of soil and water conservation and forest reservation [5].

4. CONCLUSION

The pretreatment of solid-state with alkali pretreatment for 3 days and concentrations substrate could effect on the common reed with a significant change of lignocellulose content and metabolism. The substrates of anaerobic digestion with 2% NaOH-pretreated common reed produced 49% more biogas when compared to the untreated with 70.1% methane and yield of co-substrate 362.26 ml CH₄ /g VS. The changes of chemical structures were contributed to the improvement of biodegradability, accessibility of microorganism and the enrichment of biogas production.

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