



**Predicting Coastal Vulnerability along Coast of Sampadi**

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Aquatic Resource Science and Management  
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## DECLARATION

I, Ahmad Hibbatul Hakimi B Azman, 34734 final year student of Aquatic Resource Science and Management hereby declare that this desiccation is my own work and effort with the guidance of my supervisor, Dr. Aazani Mujahid. No part of the desiccation has previously been submitted for any other degree, university or institution of higher learning.

.....

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**Dated:**

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## List of abbreviations

CIVAT	Coastal Integrity Vulnerability Assessment Toolkit
GPS	Global Positioning System
SIF	S Intrinsic Factors
FELDA	Federal Land Development Authority
VA	Vulnerability Assessment
CCA	Climate Change Adaptation
CTI CCA	Coral Triangle Initiative Climate Change Adaptation
TURF	Tool for Understanding Resilience Fisheries
ICSEA Cchange	Integrated Coastal Sensitivity, Exposure and Adaptive Capacity to Climate Change
AC	Adaptive Capacity
NE	Northeast

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# Predicting coastal vulnerability along coast of Sampadi

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## **Abstract**

The coasts that bordering South China Sea always experienced one of the monsoons known as Northeast monsoon. During this monsoon, the beaches will subject to erosion greatly. A study was conducted in coast of Sampadi which covers Sampadi beach and also Rambungan beach to predict its vulnerability towards exposure of monsoon period. The study was conducted using Coastal Integrity Vulnerability Assessment Toolkit (CIVAT) as one of the Coral Triangle Initiative Climate Change Adaptations (CTI CCA) toolkits which were done during and post Northeast monsoon. It showed that both of the beaches having erosion but differ during and after NE monsoons. Coastline also shows changes for the past 10 years which is about 48 meter per year for Sampadi beach and about 53 meter per year for Rambungan beach. Vulnerability level for Sampadi coasts were differed according to each beach which is medium vulnerability at Sampadi beach due to medium potential impact and adaptive capacity but high vulnerability at Rambungan beach due to high potential impact and medium adaptive capacity. Awareness levels at Sampadi coast are low as most of the community here are farmers and fishermen with low education backgrounds.

KEYWORDS: CIVAT, CTI CCA, coastal, vulnerability, Northeast monsoon

## **Abstrak**

*Kawasan pantai yang bersempadan dengan Laut Cina Selatan kerap kali mengalami salah satu musim monsun yang dikenali sebagai Monsun Timur Laut. Semasa musim Monsun Timur Laut, pantai akan terdedah dengan hakisan seterusnya. Satu kajian telah dijalankan di pesisiran pantai Sampadi yang meliputi Pantai Sampadi dan Pantai Rambungan bagi mengenal pasti kesan yang berlaku akibat terdedah kepada musim Monsun Timur Laut ini. Kajian telah dijalankan dengan menggunakan "Coastal Integrity Vulnerability Assessment Toolkit" (CIVAT) iaitu salah satu daripada kit "Coral Triangle Initiative Climate Change Adaptations" (CTI CCA) semasa dan selepas Monsun Timur Laut. Hasil kajian menunjukkan kedua-dua pantai mengalami hakisan tetapi dengan kadar yang berlainan semasa dan selepas Monsun Timur Laut. Pesisiran pantai turut mengalami perubahan bagi tempoh 10 tahun iaitu dengan kadar 48 meter setahun di Pantai Sampadi manakala di Pantai Rambungan dengan kadar 53 meter setahun. Tahap valnerabiliti untuk pesisiran pantai Sampadi adalah bergantung untuk setiap pantai di mana ianya adalah sederhana di Pantai Sampadi kerana mempunyai kadar impak dan kemampuan beradaptasi yang sederhana manakala di Pantai Rambungan adalah tinggi disebabkan kadar impak yang tinggi dan kemampuan beradaptasi yang sederhana. Tahap kesedaran di pesisiran pantai Sampadi adalah kerana kebanyakan penduduk adalah nelayan dan petani yang mempunyai latar belakang pembelajaran yang rendah.*

KATA KUNCI: CIVAT, CTI CCA, pesisiran pantai, valnerabiliti, Monsun Timur Laut

## 1.0 Introduction

Malaysia, with a land area of some 330, 000 km<sup>2</sup> and a coastline of some 4, 800 km sits on the geologically stable of Sunda Shelf. About half of the coastal areas are beaches and slightly less than half are covered by mangrove area (Abdullah, 1992). There are also about 30% of coastal area rocky coasts (Ong, 2002). The coastal areas are defined as the zone where land, sea and air are interacts (Birds, 2008). It is very important for the people to know about the coastal geomorphology especially the beach shape as most of the human activities are focusing at the coastal area. According to Ong (2002), it has been estimated that some 30% of the coastal areas of Malaysia are subject to varying degrees of erosion. Among the areas reported to seriously experience erosion are the coastal area that bordering South China Sea. The increasing incidences of coastal erosion had threatened the coastal population and some had loss their properties.

Very few coastal studies were done in Peninsular Malaysia except by Husain *et al.*, (1995) in Setiu, Terengganu and only one in Sarawak which is by Ezaimah Idris (2012) in Sematan but never in coastal area of Sampadi. The Coastal Integrity Vulnerability Assessment Toolkit (CIVAT) part of Coral Triangle Initiative (CTI) Climate Change Adaptation (CCA) was chosen in order for assessing coastal vulnerability to erosion towards wave and monsoon exposure. This toolkit was chosen for the study because extensive study was done in Philippines using this toolkit had successfully proven (Siringan *et al.*, 2005). Furthermore, the coastal habitats and local communities in Malaysia are mostly similar to Philippines hence it is most probable that this tools are also applicable to be use for this study.

According to Cuevas (2010), Global climate change can cause sea level to rise. As the sea level starting to rise, this will lead to increasing frequency of erosion. The erosion of natural processes such as storm tides, winds and regular wave action may change the shoreline shapes but, as the sea level rise, the situation become worst (Praseteya and Black, 2003). In Malaysia, most of the states that bordering South China Sea will experience Northeast monsoon. Northeast monsoon is also one of the factors that speed up the process of erosion in some part of Malaysia (Husain *et al*, 1995). Hence, the natural environment of the coastal areas such as coral reef, mangrove forest, sandy beaches and rocky shore can help to protect the coastal area from erosion as they act as natural barrier.

Therefore, the purpose of this study is to determine the level of coastal vulnerability towards exposure of Northeast monsoon period. It is very important to monitor the level of vulnerability along coastal area especially along coasts of Sampadi which is none before for future coastal managing by applying these objectives: (i) to determine the geomorphological changes along coasts of Sampadi during and after Northeast monsoon (ii) to obtain the vulnerability level of Sampadi coasts following criterion by CIVAT Toolkit (iii) to determine the awareness level among local communities about the important of coastal area.

## **2.0 Literature Review**

### **2.1 Sampadi Coast**

Sampadi is an area which located in Lundu district in Sarawak. These areas are located approximately 30 km away to the west of Kuching. Sampadi is actually one of the FELDA (Federal Land Development Authority) areas which still the status of this FELDA area is still disputed between being a settlement or plantation-only scheme (McAlister and Nathan, 1987). Local villagers who are hired to work here were not being given any of the lands provided, unlike their counterparts in West Malaysia. Sampadi coast cover a total of 20 km in length for coastline. The coastal include Sampadi Beach and Rambungan Beach.

### **2.2 Coastal Geomorphology**

Most of the world's population's lives in coastal region and many of them visit the coast frequently. Coastal geomorphology deals with shaping of coastal features such as the process that work on them and also the changes that taking place (Bird, 2008). According to Mclachlan and Brown (2006), the coast is actually a zone of varying width including the shore and near shore zone from supralitoral zone to the waves break. In other words, the coast is the zone where the land, sea and air meet and interact. This will include the process of tectonic movements of the land margin, changes in sea level, effects of tides, waves and currents in the sea and variations in temperature, pressure and wind action at atmosphere. Most of the coasts have being shape by erosion and others by deposition (Cutter, 1996).

For this study, beach profiling and shoreline tracing were used in order to measure the changes that happened along the coasts. This method is one of the many ways available to obtain information about beach shape and slope. The Emery method which is the profiling was used for

detection of angle of elevation on the beach due to wave exposure (WHOI, 2011) while the shoreline tracing was used for detection of any changes along the coasts. In addition, the shoreline tracing is important as it gives information that can be use for coastal management, environmental protection and for development planning.

### **2.3 Beach erosion**

Beach is an accumulation on the shore of generally loose, unconsolidated sediment, ranging in size from very fine sand up to pebbles, cobbles and occasionally boulders that often with shelly material (Bird, 2008). According to Short (1999), beaches fringe about 40 per cent of the world's coastline and generally consist of unconsolidated deposits of sand and gravel on the shore. Some are long and gently curved and others might be shorter. Most of the beaches are exposed to the open ocean or stormy seas while some of the others are sheltered in bays or behind the islands or reefs. Beach systems deal with the interactions between beaches and the processes – waves, tides and winds that work on them. In general rule, the smaller the size of sand, the flatter the beach (Brander, 2007).

Coastal erosion or beach erosion is the wearing away of land and the removal of beach or dune sediments by wave action, tidal currents, wave currents, and drainage or high winds (Oldale, 2009). The loss of sand causes the beach to become narrower and lower in elevation. Waves, generated by storms, wind, or tides, can lead to beach erosion, which may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments. Erosion in one location may result in accretion nearby (McPherson, 2013). Softer areas become eroded much faster than harder ones. Despite the differences in erosion potential, there has been a dramatic increase in coastal and beach erosion over the last two

decades and this expected to continue as sea level rise and severity of storm and big waves (Saito, 2008). Erosion will lead to significant effect to coastal habitats which trigger social and economic impacts on coastal communities. As for the coastal economies, it is related to fisheries, shipping, tourism, recreational, agricultural and others. With the reduction of coastal habitats and ecological services they provided, coastal communities will experience more frequent and destructive flooding, compromised water supplies and fewer beaches.

Based on Abdullah in The National Coastal Erosion study, 1992, coastal erosion or beach erosion can be divided into three categories;

- (1) 145 km of critical erosion areas where shore-based facilities are in danger soon (category 1)
- (2) 246 km of significant erosion areas where the facilities are expected to be endangered within 5 to 10 years if no prevention action is taken (category 2)
- (3) 975 km of acceptable erosion areas that are generally undeveloped with consequent minor economic loss if coastal erosion continues untreated (category 3)

**Table 1:** Distribution of eroded coastal area of Malaysia (adapted from Abdullah, 1992)

<b>Area</b>	<b>Total length of coastal area (km)</b>	<b>Category 1</b>	<b>Category 2</b>	<b>Category 3</b>	<b>Total length of eroded coastal area</b>
<b>Peninsular</b>	1972	131	213	651	995 (73%)
<b>Sabah</b>	1802	6	10	310	326(24%)
<b>Sarawak</b>	1035	8	23	14	45(3%)
<b>Total</b>	4809	145	246	975	

## 2.4 Waves, tides and monsoon

Waves are created from wind fetch at the ocean while tides are created by the influenced of gravitational of moon and sun (Brown *et al*, 1999). Waves occur when wind transferring its energy to the water creating a rise of water level over normal condition which may travel over long distance (Natarajan *et al.*, 2003). There are two major waves' namely constructive waves and destructive waves. The strong moving waves may cause vigorous erosion on the shore. Combination of winds and waves along coastal area can erode the rock and lead to sedimentation to occur. According to Natarajan *et al.* (2003), as sea level rise, the water depth will increase and causes waves to reach the coast with high energy. The high energy of waves can erode and transfer large quantity of sediments into that area. Meanwhile, tides are also considered as waves cause by gravitational pull of moon and sun but vary depending on where the moon and the sun are in relation to the oceans as the earth rotate at its axis (Brown *et al.*, 1999). Some shorelines experience two almost equal high tides and two low tides each day, called a diurnal tide. Some locations experience only one high and one low tide each day, called a diurnal tide. Some locations experience two uneven tides a day, or sometimes one high and one low each day. This is called a mixed tide. The times and amplitude of the tides at a locale are influenced by the alignment of the Sun and Moon, by the pattern of tides in the deep ocean, by the amphidromic systems of the oceans, and by the shape of the coastline and near-shore bathymetry (Natarajan *et al.*, 2003).

Monsoon is defined as seasonal reversing wind accompanied by corresponding changes in precipitation also may defined as a seasonal changes in atmospheric circulation and precipitation associated with the asymmetric heating of land and sea (Trenbeth *et al*, 2000). Monsoons are caused by land-sea temperature differences due to heating by the sun's radiation.

Monsoon in Malaysia are categorized by two monsoon regimes which are Northeast Monsoon from November to March and Southwest Monsoon from May to September. Generally, Malaysia are experienced Northeast Monsoon which facing heavy rainfall during the period particularly at east coast of peninsular Malaysia and western Sarawak. Southwest monsoon are relatively dry weather. However, the Northeast monsoon which the weather systems develop in conjunction with cold air originating from China and north pacific will bring heavy rain. According to Husain *et al.* (1995), during northeast monsoon the wind and waves are larger than usual that cause the beach to become coarser and steeper. The effect of large waves may lead to severe flooding along east coast of Peninsular Malaysia and in Sarawak. In other words, monsoon is likely to have a significant effect on Malaysia, increasing sea levels and rainfall, increasing flooding risks and may lead to erosion (Marshall, 2008).

## **2.6 Coastal Vulnerability**

Vulnerability is a measure of the degree to which a human or natural system is unable to cope with adverse effects. In addition, vulnerability is also defines as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (McCarthy *et al.*, 2001). Hence in the context of this studies, coastal vulnerability may be define as a function of character, magnitude, and rate of climate change and variation to which a coastal is exposed, its sensitivity, and its adaptive capacity. The indicators to indicate vulnerability are exposure, sensitivity and adaptive capacity. Sensitivity and Exposure may be taken together to yield Potential Impact, while Potential Impact and adaptive capacity may be taken together to yield Vulnerability (Allison *et al.*, 2009). Refer Table 2 for description of vulnerability indicators.

**Table 2:** Description of vulnerability indicators (adapted from Allison *et al.*, 2009)

<b>Vulnerability indicators</b>	<b>Description</b>
Exposure	Quantify the intensity or severity of physical environment conditions driving changes in the present state of biophysical systems
Sensitivity	Describes the present state of the system, regarding specific properties that respond to exposure factors arising from climate change
Adaptive capacity	The ability of the system to tolerate with impacts associated with changes in climate

## **2.7 Vulnerability Assessment (VA)**

Vulnerability assessment was introduced by the government using CCA (Climate Change Adaptation) toolkit as one of the step to reduce the impacts of climate change and to ensure the existence of Coral's Triangle (Malaysia, Indonesia, Philippines, Timor Leste, Solomon Islands and Papua New Guinea) coastal and marine species (US Coral Triangle Initiative Support Program, 2012). The assessment is mainly to help coastal communities and government to take early actions in order to protect the coastal area. The VA tools were designed according to the framework suggested by Intergovernmental Panel on Climate Change where VA is a function of three elements which are exposure to climate change effects, sensitivity and adaptive capacity (Fernando and Yvaine, 2011). In these studies, the 'Coastal Integrity Vulnerability Assessment Toolkit' was used in order for predicting the vulnerability of coastal area. Various studies were done using this toolkit in Philippines which were proved to be successful.

The currently available VA tools are;

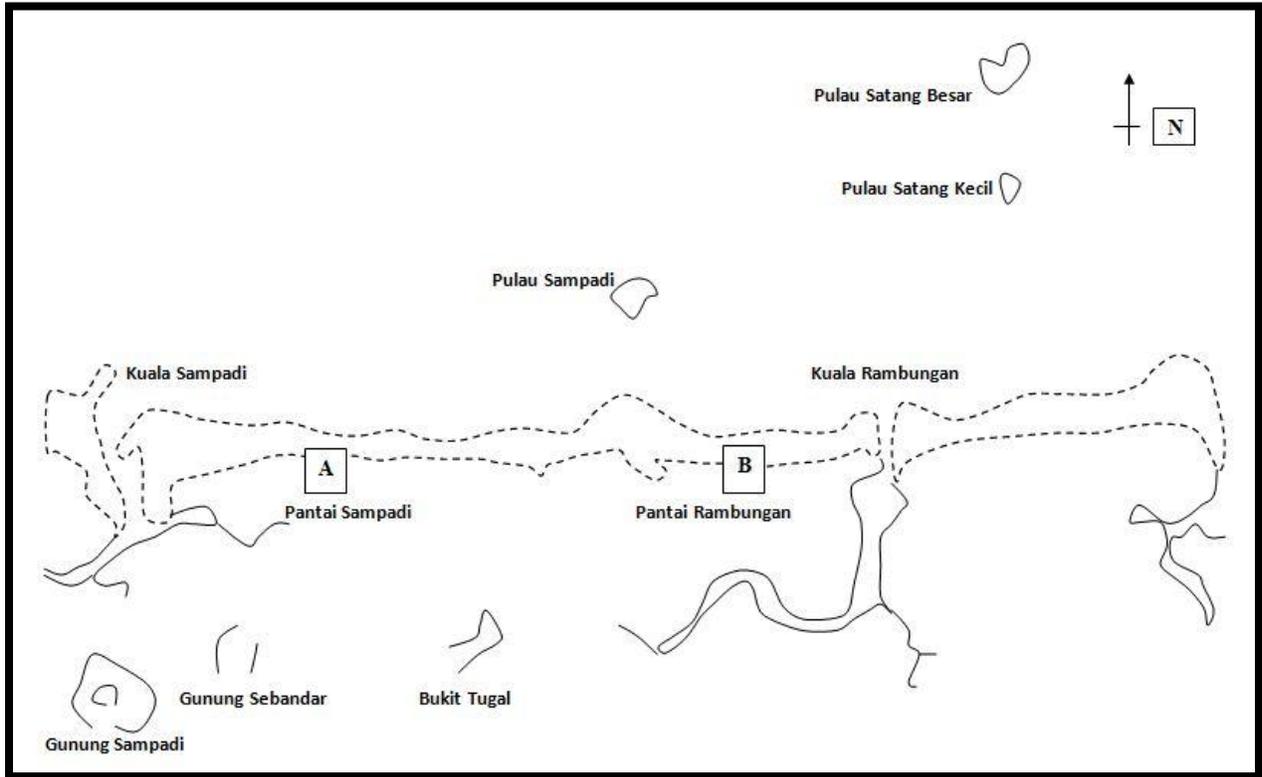
- (1) Integrated Coastal Sensitivity, Exposure and Adaptive Capacity to Climate Change (ICSEA CChange)
- (2) Coastal Integrity Vulnerability Assessment Toolkit (CIVAT)
- (3) Tool for Understanding Fisheries Resilience (TURF)

**Table 3:** Showing available tools for assessing vulnerability at coastal area (adapted from Vulnerability Assessment Tools for Coastal Ecosystem: A guide book)

<b>VA Tools</b>	<b>Description</b>
<b>ICSEA CChange</b>	<ul style="list-style-type: none"> <li>• Integrated vulnerability of coastal area (ex: fisheries, coastal integrity and biodiversity vulnerabilities to synergistic climate change exposure)</li> <li>• Scoping and reconnaissance</li> <li>• Highly participatory and engaging local stakeholder knowledge</li> <li>• Lower resolution of analysis</li> <li>• Cannot provide specific adaptation options</li> <li>• Can be used to compare general vulnerabilities across sites</li> <li>• Assesses available data and information for use in CIVAT and TURF</li> </ul>
<b>CIVAT</b>	<ul style="list-style-type: none"> <li>• Vulnerability of coastal integrity to sea level rise and waves exposure</li> <li>• High resolution of analysis</li> <li>• Requires geologist to help interpret data and guide data collection</li> <li>• Can identify specific adaptations options to improve coastal integrity</li> </ul>
<b>TURF</b>	<ul style="list-style-type: none"> <li>• Vulnerability of fisheries to wave exposure, sea surface temperature, and sedimentation</li> <li>• High resolution of analysis</li> <li>• Requires fisheries expert to interpret data and guide data collection</li> <li>• Can identify specific adaptation options to reduce fisheries vulnerability to climate change</li> </ul>

### 3.0 Materials and Method

#### 3.1 Study site



**Figure 1:** Study site along coast of Sampadi, Lundu

The study was conducted along the coastal area of Sampadi (Figure 1) which comprise of two beaches namely Sampadi beach (A) and Rambungan beach (B). From observations being made, most of communities in Sampadi were fishermen and some were farmers that work on agriculture activities such as oil palm and orchard. Field sampling was conducted twice which were during Northeast monsoon (end of November) and post Northeast monsoon (end of February).

## **3.2 Sampling procedure**

### **3.2.1 CIVAT**

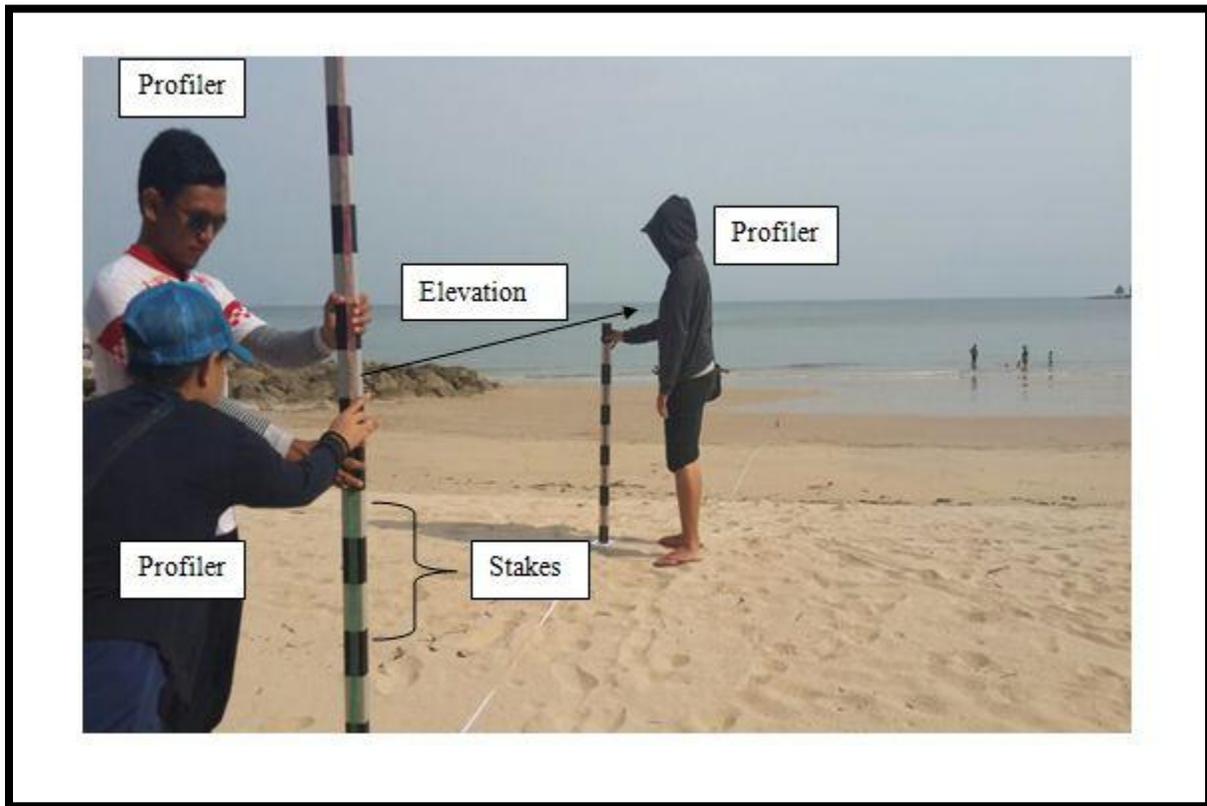
This study was carried out using CIVAT as it provide high resolution of data analysis for assessing coastal integrity. In addition, CIVAT has been designed to promote ecosystems-based management of the coast. The ecosystem of the coast includes mangrove area, reef area, sea cliffs, and sand dune which was included in CIVAT was used as indicator for vulnerability assessment. According to Siringan *et al.* (2013), this tool also included processes such as waves action and sea level changes and both intrinsic (geomorphology, shoreline trends) and extrinsic (beach mining and coastal structure) factors for analysis.

The method involved in tools were Emery method (1965) of beach profiling and also shoreline tracing. Besides, the observations of the coastal criteria following the rubrics were also being included for vulnerability assessment. In addition, pilot questionnaires also had being distributed among the local communities in order to determine the level of awareness regarding the importance of coastal area.

### **3.2.2 Beach profiling**

The beach profiling method was adapted from Emery method (1965) to determine the steepness of the beach gradient by determine the changes of height elevation of the beaches. The method used measuring tapes and two stakes as shown in Figure 2. A permanent structure was chosen as a marker and was marked as starting point. Then, a straight transect was line perpendicular to the beach from starting point or maker up to breakwater. There were 3 profiling being carried out in Site A (Table 4) and also 3 profiling in Site B (Table 4). The profiling was done during low tide in order to get the possible longest profile. During profiling, the horizontal

view must be cleared in order to make the reading. While conducting the profiling, observation also being made regarding the sediment type and any objects found along the transects. The data collected from beach profiling were computed into Microsoft excel and profile graph showing the gradient of the beach were plotted.



**Figure 2:** The Emery method of beach profiling.

**Table 4:** Stations, coordinates and total length of profiling

<b>Stations</b>	<b>Coordinates</b>	<b>Total length of transects (meter)</b>
<b>Station 1:</b> <b>Sampadi beach</b>	N 01° 41' 55.3" E 110° 01' 26.4"	255 meter
<b>Station 2:</b> <b>Sampadi beach</b>	N 01° 41' 56.3" E 110° 01' 32.3"	240 meter
<b>Station 3:</b> <b>Sampadi beach</b>	N 01° 41' 56.4" E 110° 01' 31.6"	150 meter
<b>Station 4:</b> <b>Rambungan beach</b>	N 01° 41' 55.1" E 110° 06' 07.7"	200 meter
<b>Station 5:</b> <b>Rambungan beach</b>	N 01° 41' 55.9" E 110° 05' 54.2"	207 meter
<b>Station 6:</b> <b>Rambungan beach</b>	N 01° 41' 53.0" E 110° 04' 06.1"	180 meter

### 3.2.3 Shoreline tracing

The shoreline tracing method was adapted from Morton *et al.* (1993) were carry out in order to determine the position of shoreline during sampling and indicates the changes happened. This method was done using Global Positioning System (GPS) which was shoreline position of latitude and longitude was taken every 50 steps distance. Any variations of remarks such as sediment type and size, location of man-made structure or any structure encroaching on the foreshore, tide level and any sign of erosion and accretion were also recorded. The shoreline

position of latitude and longitude was then key in into Google Earth application to get the current shoreline position. The position then was overlayed with 2004 map to determine the changes happened.

### 3.2.4 Vulnerability assessment

Vulnerability assessment was done using the criteria provided in the CIVAT toolkit. The criteria involved were sensitivity, exposure and adaptive capacity. Refer Table 5 for example of the criteria involved. The criteria then were scored based on the observation rate. For points 1 and 2, it will consider as low, 3 and 4 consider as medium and 5 are the highest. To obtain the vulnerability of this area, Cross tabulation approach was used as suggested by Allison *et al.*, (2007). Formulas used to obtain the vulnerability were as follow:

$$\text{Exposure} \times \text{Sensitivity} = \text{Potential Impact}$$

$$\text{Potential Impact} \times \text{adaptive capacity} = \text{Vulnerability}$$

After all the scaling was done, a table showing the degree of potential impact by cross tabulation between exposure and sensitivity were made for comparison. Refer appendix 1 for calculation of vulnerability assessment. The final score were grouped into 3 which were 1-10 points as low, 11-20 points as medium, and 21-30 points as high. When all the calculation and scoring had being obtained, comparison then being made using the potential impact and vulnerability table.

**Table 5:** Example of criteria observed provided from CIVAT indicators (adapted from VA Tools for Coastal Ecosystem: A Guide Book)

Sensitivity criteria		Low	Moderate	High
		(1-2 points)	(3-4 points)	(5 points)
<b>Intrinsic Factor</b>	Coastal landform and rock type	Rocky, cliff coast, beach rock	Low cliff (<5m), coble or gravel beach, fringed by mangrove	Sandy beaches, deltas, muddy/sand flat
	Seasonal beach recovery	Net accretion	Stable	Net erosion
	Slope from the shoreline to 20m elevation (landward slope)	>1 : 50	1:50 – 1: 200	<1:200
	Width of reef flat or shore platform (m)	>100 m	(50,100) m	<50 m
	Beach forest/vegetation	Continuous and thick with many creeping variety	Continuous and thin with few creeping variety	Very patchy to none
	Lateral continuity of reef flat or shore platform	Greater than 50%	(10-50)	Less than 10%
	Coastal habitat	Coral reef, mangroves, and sea grass or coral reef and mangroves are present	Either coral reef or mangrove is present	None
	If habitat assessment is possible, the following rubrics are to be evaluated: <ul style="list-style-type: none"> <li>➤ Coral reef as sediment source</li> <li>➤ Mangrove as sediment trap</li> <li>➤ Sea grass as sediment source and stabilizer</li> <li>➤ Mangrove as wave buffer</li> </ul>			
<b>Extrinsic factor</b>	Coastal and offshore mining (includes removal of fossilized corals on fringing reef and beach)	None to negligible amount of sediments being removed	Consumption for household use	Commercial use
	Structures on the foreshore	None; one or two groins <5m	Short groins & short solid based pier; seawalls	Groins and solid based pier >10m ; seawalls

### **3.2.5 Questionnaires**

A target of 30 sample questionnaires was distributed among the local villagers of Kampung Sampadi and Kampung Rambungan. The objective of these questionnaires was to obtain the awareness level among the local villagers about the importance of coastal area. As mentioned by Abdullah (1992), there is a need to understand not only the biophysical environment but also their demographic factor and socio-economic environments in order to get a proper and effective awareness of the coastal areas. A part from distributing questionnaires, interviews were also carried out in order to get more information regarding the activities that had been done along the coast of Sampadi. Refer appendix 4 for questionnaire sample.