GEOMORPHOLOGICAL CHANGES CAUSED BY THE 2004 TSUNAMI IN THE COASTAL ENVIRONMENT OF WELIGAMA BAY AREA IN SRI LANKA

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Abstract

The coastal area of Weligama bay was severely affected by the tsunami disaster on 26th of December 2004. It has caused thousand deaths in addition to the destruction of million rupees worth properties and also most of the geomorphological features have been changed severely. Therefore, this study was to examine how the tsunami waves have impacted on geomorphological environment of Weligama bay beach area.

Changes of geomorphological features were identified through the analysis of satellite images before 2004 and after in 2005. Arc view GIS software was used to hazardous mapping and damage analysis of the area. Pre and post tsunami map overlay technique of Arcview software can be used to determine the changes of geomorphological features.

The tsunami waves have caused to change coastal features by shrinking and spreading estuaries, eroding the coast and blocking the estuary. Such changes can be observed in the estuaries of Polwatta Ganga, Pemuyana and Rassamuna headlands, and Weligama bay beach. North of the Polwatta Ganga estuary was spreader in about 5 meters and the breath of sand spit of the estuary was increased in about two meters. The Tsunami waves attacked to the Pemuyana headland in the south of the bay occurring serious damaged to the Weligama town area and base of the headland was eroded about one Meter.

The Kapparatota natural harbor which was Located in the northern part of the bay has changed into a bay beach by sand deposition.

Keywords: Tsunami, Geomorpology, Estuary, Headland, Sand spit

Introduction

The coastal area of Weligama Bay is an attractive landscape because of its varieties of Landforms and ecosystems such as beaches, sand spits, estuaries, sea cliffs, headlands mangroves, Marshlands, and corals. Not only the esthetic value of the area, but also they were influenced to establish specific socio economic activities. With the influence of these geomorphological features, many economic activities such as fisheries, tourist and coir processing are located in this area. Landforms and ecosystems caused to control the natural disasters in to some extent, i.e. floods, storm waves. However, after the 2004 tsunami disaster, these geomorphological features in the area were seriously damaged and changed leading to imbalance of the coastal systems.

According to the records of coast conservation Department in 1997, three thousand seven hundred seventy six coastal habitats can be observed in Matara and Galle districts represented of this study area. Most of these resources were completely or partially damaged by the tsunami waves travelled up to 1 Km inland at certain places. It destroyed vegetation, changed landforms, created vast amounts of debris released pollutants and contaminated soils and fresh water supplies. Also, it has created many more environmental problems, such as, coastal pollution, coastal erosion, degradation of landforms and coastal habitats. With the occurrence of the tsunami, these environmental problems in the southern coastal zone have tremendously increased.

Even though, many studies have been paid many attention on examining the human and socio-economic impacts of tsunami, they are not yet satisfactorily addressed the problems concerning the entire environment of the coastal area. A few studies carried out so far have not been paid attention on these sectors in environmental aspects. As such, this has been analyzed the impact of tsunami on geomorphological features of Weligama coastal environment.

1.0 Objectives of the study

The main objective of this study was to examine how the tsunami waves have impacted on coastal geomorphological environment of Weligama bay area. In addition to above major objective, this study concerned on the following aspects,

(a) Identification of geomorphological features within the study area.
(b) Determination of tsunami wave process affected to the geomorphological changes.

(c) Analysis of coastal geomorphological changes on Weligama bay beach.

2.0 The area of study

The area of this study was conducted in the coastal area of Weligama bay stretching from Pemuyana headland to Rassamuna headland. This area represent the Weligama divisional secretariat and it is one of the worst damaged in Matara district. Among the twenty nine Grama Niladari divisions within this divisional secretariat, twenty two G.N.divisions were affected by tsunami.

This area is a densely populated with concentration of many socio-economic activities. As a result of heavily impacted of tsunami on this area, over 282 people lost their lives and 2466 families have been displaced. Five hundred forty three houses completely damaged and also most of the socio-economic activities were vastly damaged. (Ministry of women's Empowerment and social welfare, 2005) In addition there were drastic destructions on coastal landforms and ecosystems of Weligama coast of Sri Lanka. Hence, Weligama coastal zone is selected as the study area covering these specific aspects.

The study area stretching from Pemuyana headland to Rassamuna headland, which is demarcated by mean sea level in the west and tsunami affected boundary line (TABL) in the east. (See fig 01)

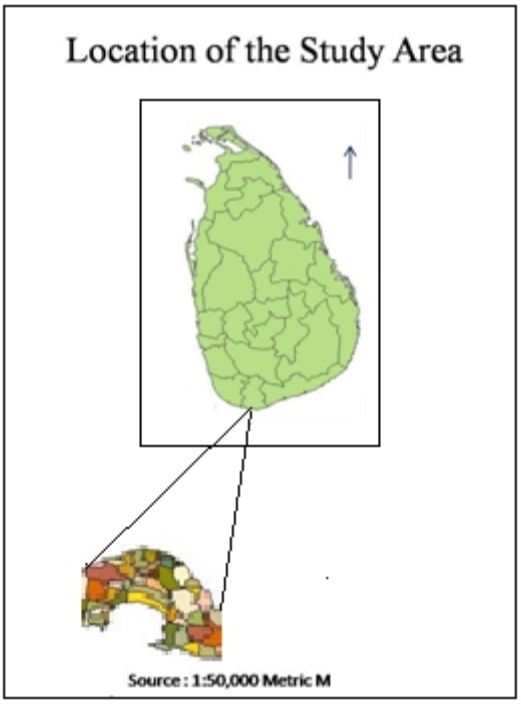


Fig 01-Distribution of the Study Area from Mirissa headland to Rassamuna Headland

3.0 Methodology

Required data for this study have been collected from available primary and secondary sources. For the identification of socio-economic damages in the study area, secondary data was collected from Weligama district secretariat office, Disaster Management Center and senses department in Sri Lanka. To make above mentioned study successful several methods were used to collect the primary data. Tsunami mapping, Questioner survey, target group discussion and field observation were used to relevant data collection.

The magnitude of affected geomorphologic features and ecosystems were identified through the analysis of satellite images before 2004 and after tsunami in 2005. Arcview GIS software was used to hazardous mapping and damage analysis in the area. Pre and after tsunami maps overlay technique of the Arc view software can be used to determine the changes and damages of geomorphological features. Using these data, a tentative geomorphological map was constructed to demarcate the damages and changes of geomorphological units and this was verified through the field works.

4.0 Geomorphological changes of Weligama coastal environment

Weligama bay area which is situated in southern Sri Lanka is very important in geomorpologically and ecologically. This area consists of coastal landforms originated by various kinds of processes. They are bay beaches and allied features, bay and headlands, estuary, beach rocks, alluvial plains, Fluvio-marine plains, denudational hills and planation surfaces. (See fig. 02) These are originated with the influence of marine, fluvial, Fluvio-marine and denudational processes.

Sea is the major agent in landform formation in the study area. It consists of number of marine agents such as waves, currents and tides. In addition, short term and long term sea level changes have affected to form landforms. Sea beaches, bay, islets, sand spits, sea cliff, headlands can be observed within the area originated by marine process.

The fluvial process is the dominant process in creating landforms next to marine process (weerakkody,1990). Polwatta River is the main source of formation of landforms and bringing sediment material to the coast. The amount of material brought through the polwatta ganga, deposited to form to landforms. As a result of these depositions alluvial plains, spits, flood plains are originated.

Some landforms have been originated as a result of admixing marine and fluvial processes. They categorized as flurio-marine process (swan,1983) Fluvio-marine and lagoons are the major fluvio-marine land forms.

Generally, rocks are weathered by chemical, physical and organic action under the influence of climate, relief and morphology. Weathered material transported by water, wind and waves and ultimately deposited in lowlands. They have been caused to erosion and denudate of the surface topographic features (Bird,1976). The denudational landforms consist of denudational hills. planation surfaces and rock out crops.

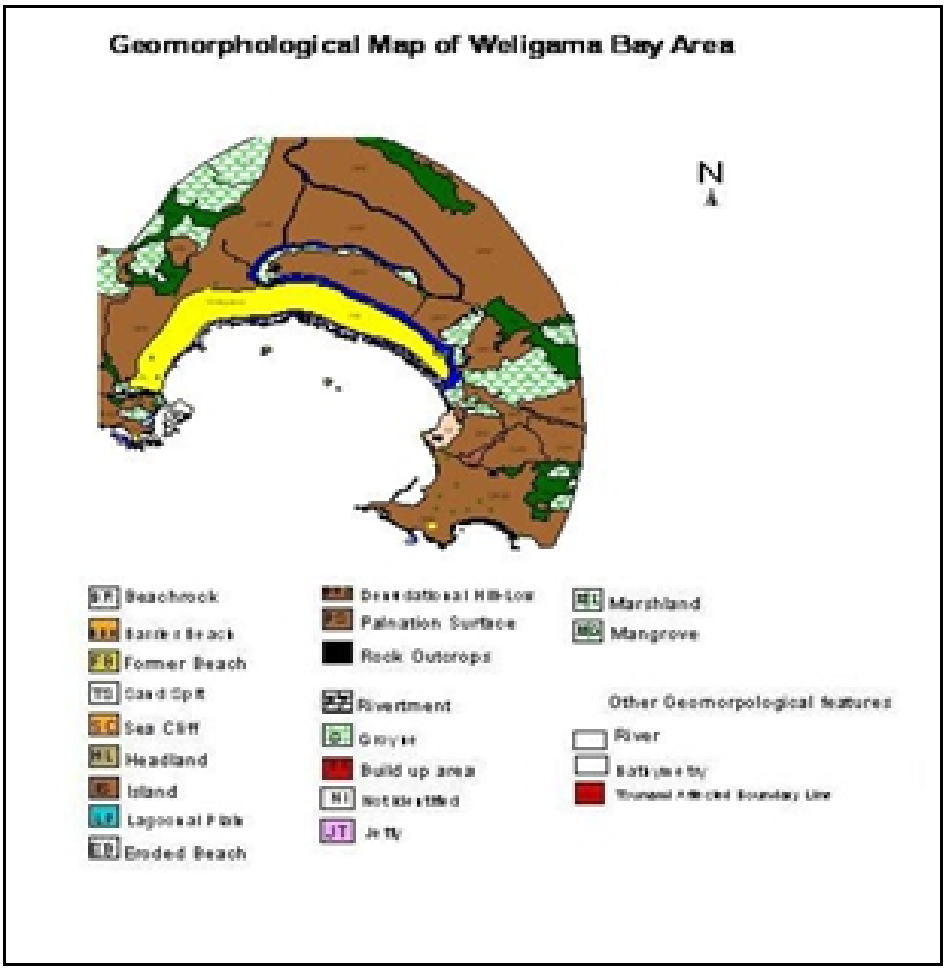


Fig 02-Tsunami affected coastal features in Weligama Bay area.

Human activities have affected on the changes of landforms in the coastal area similar to natural processes. The changes made by engineering constructions are prominent among human activities. Revetments and Groynes are some examples of manmade landforms. Especially eroded coastal area is the Kapapratota best example in the area. They are useful to preserve the coastal environment.

Although these landforms contribute to preserve existing coastal environment, specific landforms were badly damaged completely or partially. Most of them were changed by 2004 tsunami waves. Seventy five percent of total landforms were heavily damaged. Marine landforms of them were highly damaged by the tsunami waves. Bay beach, estuary, sand spits, beach rocks, headlands, sea cliffs and coastal structures are the specific coastal landform which was heavily damaged and changed by tsunami. They

could be identified by the interpretation of pre and post tsunami satellite images using Geographical Information System (GIS) and also they compiled into Geomorphologic maps.(see fig 02)

The tsunami waves have caused to change coastal features by shrinking and spreading of estuaries, eroding the coast and blocking the estuaries. Such changes can be observed in the estuaries of Polwatta ganga, Pemuyana and Rassamuna headlands and Weligama bay beach. The changes of these areas have been studied under the three sections as mentioned below.

(a) Changes of headlands in Weligama bay area
(b) Changes of Polwatta river mouth and sand spits
(c) Changes the coastline of the bay beach

4.1 Changes of headlands in Weligama bay area

The headlands which are located both side of the Weligama bay, are the main geomorphological features affected to the origination of Weligama bay beach. The concave area which is stretched between Pemuyana headland in the south and Rassamuna headland in the north is identified as Weligama bay. The height of these two headlands is 15-30m and they are the main morphological features to change the process of Weligama bay beach. The sea waves which flow into the bay area knocked against these two headlands and it may cause to reduce wave velocity and coastal erosion. Also, it has been a cause to form a broad beach in the area. The location of these headlands has caused to change the tsunami process as well as the normal sea wave process. Although the weligama area had been severely damaged by tsunami, the damaged may be increased further if there were not these two headlands.

The tsunami wave, attacked to the pemuyana headland in the south and it has refracted towards the northwest and north of the bay occurring serious damages to the Weligama town. Also, That is the main reason for the highest damages on Weligama bay beach area. But, there was not highly damage on Pemuyana headland because it is highly mountainous area with 30m in height and it is made of granites rocks. But, base of the headland was eroded about one meter above the sea level and the headland was narrowed because of the erosion of 300 meters of the headlands.

Rassamuna headland in the north of Weligama bay was eroded more than Pemuyana headland. The basement of the sea cliff on Galbokka pocket beach and Gurukanda have been eroded in 15 meters above the sea level because tsunami wave came from westward and waves refracted from the south of the bay, attacked to this headland. The waves which attacked to this headland and they turned into the Galbokka marshland and it was expanded

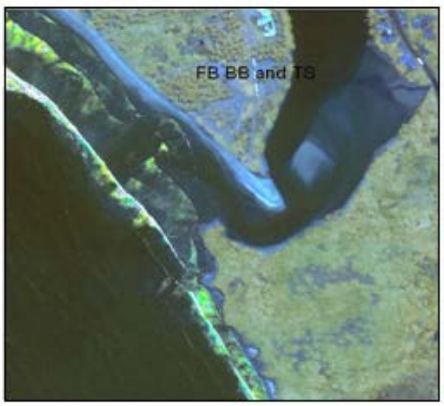
because of stagnant water. However comparing of other geomorphologiacal features, changes of the headlands was not so much.

4.2 Changes of the Polwatta Ganga estuary and sand spit

Polwatta Ganga is the major river flowing across the Weligama bay beach. This river flowing with meandering towards the north of the coastline approaches into the sea, closed to the Pemuyana headland. Estuary, sand spit, sea cliff, mangrove, former beach and beach rocks are the distributed around the Polwatta Ganga estuary and most of them were impacted by the tsunami. Because of the tsunami waves, the estuary was affected with less change. North of the estuary, the breadth was increased in about 5 meters and also, the breadth of sand spit of the estuary was increased in about 2 meters. During the 5000-6000 years Bp, the Holocene sea level went up in 1 meter and created river meanders as a upward movement of the river. (Weerakkody, 1990) Not only has such long-term sea level risen, caused to the coastal changes. According to that, tsunami waves in 2004 have caused to change the Polwatta Ganga estuary.

Tsunami waves have flown 500 meters along the Polwatta Ganga and river meandering obstructed the further flow of water towards the upper areas. Because of this area of river banks sedimented with marine deposits and it damaged the mangroves about the 5 meters breadth along the both river banks.

Sand spit of estuary was developed by tsunami and sand accumulated on flood plain of the both sides of the river banks about in 2 feet thickness. Sand spit was spread in two meters and north of the estuary was broadened in two meters and deepened in one meter. By this time, landscape of the river outfall has become into the former condition, by the redevelopment of sand barrier. But, basement of the sea cliff has been eroded in 15 meters in height, because the tsunami wave attacked on the cliff base. However, the damage of the estuary was less than Weligama bay area as a result of refracted tsunami waves from the Pemuyana headland.



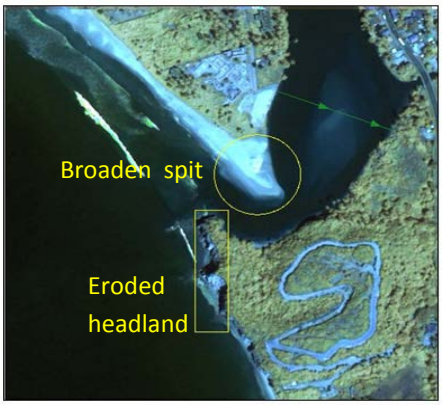


Fig. 03-Polwatta
Ganga estuary-before tsunami

Fig. 04-Changes of Polwatta
Ganga estuary-after tsunami

4.3 Changes of the coastline in the Weligama bay

Weligama coastline stretched from Pemuyana headland to Rassamuna headland is the bay beach area. This coastline with concave shape is a broad flat terrain area. The depth of the coastline sea floor is less than 5 meters and the height of the coastline is not more than 1 meter. This area with flat terrain was severely affected by the tsunami and eroded the coastline in two meters towards the land area, and also the coastline was polluted with accumulation of debris. Buildings and properties were also highly damaged.

The bay was geomorphologically changed because of sand deposition on the north part of it. Tsunami wave refracted towards the north-west of the bay, and the northern part of the bay beach was formed further with beach materials transported by the tsunami waves from south to north direction. It has caused to develop a broaden beach at about 15 meters in width and former offshore coast had changed into a sandy beach now. As a result of this, it is clear that the Kapparatota natural harbor has changed into a bay beach area. (See fig 04 and 05)

Fig. 04-Progradaded beach after tsunami by accumulation of Sand-Kapparatota

Fig. 05-Collected sand deposits from Kapparatota harbor

5.0 Conclusions

The coastal landscape of Weligama has been created with Varity of coastal landforms, originated from processes of marine, fluvial, flurio-marine, winds and denudation. But 75% of them have been impacted by the 2004 tsunami. The bay beach and its allied features such as, headlands, sand spits, sea cliff, marshlands and estuaries were the mostly damaged and changed landforms of the area.

A part from the damages, lots of changes of geomorphologic features could be identified. The changes were broadening, narrowing and blocking of river outfall, broadening and sedimentation of marshlands and sand spits. Such changes can be observed in the estuaries of Polwatta Ganga, Pemuyana and Rassamuna headlands, and Weligama bay beach.

North of the Polwatta Ganga estuary was spreader in about 5 meters and the breath of sand spit of the estuary was increased in about two meters. The Tsunami waves attacked to the Pemuyana headland in the south of the bay occurring serious damaged to the Weligama town area and base of the headlands was eroded about one Meter and they were narrowed because of the erosion of 300 meters of the headlands. Rassamuna headland in the north of Weligama bay was eroded more than Pemuyana headland.

The bay was geomorphologically changed because of sand deposition on the north part of it. As a results of this the Kapparatota natural harbor which was Located in the northern part of the bay has become into a bay beach by sand deposition.

Most of these geomorphologic features were severely changed and very extensive changed has occurred on bay beach, river outfall, sand spits, marshland and headlands.

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