Review of Impacts on Coastal Zone Due to Poor Riverine Flood Controlling Mechanism: A Case Study in Kalutara Coastal Zone, Sri Lanka

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Abstract: *Sri Lanka has attractive coastal zone that contributes to the economic value of the country by promoting tourism-related activities. In addition, due to the existence of natural coastal features, the coastal areas of the country have become the main obstacle to the natural coastal hazards as Tsunami. However, the coastal area of Kalutara is currently facing serious problems due to the anthropogenic activities. Kalutara is also highly vulnerable area for riverine flood of Kalu Ganga. In May 2017, a considerable portion of naturally formed sand barrier at Kalu Ganga River outfall was removed as a strategy to risk reduction process of flooding. The focus of this study is to review the negative impacts of this risk reduction process. To achieve this objective, the bathymetric profiles and the Google Earth satellite images from 2013 to 2019 were collected and analysed. The review data is shown a chronological variation of the sand barrier at the river outfall. Also erosion in the Kalutara coastal region is accelerating after May 2017. Moreover, from the questionnaire survey, salt water intrusion identified as a serious problem in the region. When applying risk reduction process for any disaster, first have to identify the best possible mechanism and it should be applied in proper manner for appropriate location. If not, other hazards may generate as side effects of the poor risk reduction strategies by developing harmful effects for the society and the environment.*

***Keywords*: Bathymetric profile, Disaster, Erosion, Risk reduction, Satellite image**

I. INTRODUCTION

The coastal zone is one of the main sources for multiple uses of a country. The coastal zone of Sri Lanka is about 1700 km long and it is the main part of the landscape of country (Lakmali et al., 2016). The economic value of the country can be increased by promoting coastal related activities such as tourism, fisheries development (Koralagam, 2008), recreational enhancement and so on. Furthermore, the use of coastal areas has produced more than 40% of the country's gross domestic product (Nayanananda, 2007).

Different natural coastal features such as sand spit bars, lagoons, estuaries, etc. are available along the coastal zone in Sri Lanka. The shapes and the formation of these features are governed by the natural coastal dynamics mainly hydrodynamics and sediment transport patterns. In addition, due to the existence of natural coastal features, the coastal areas of the country are in safe because these natural coastal features have become the main obstacle to the natural coastal hazards as Tsunami. The erosion and accretion are take place along coastal zones due to natural coastal process and the quickness of these processes are governed by the monsoon seasonal effects.

However, considerable amount of coastal zone in Sri Lanka has faced to serious issues mainly due to human activities since many people in the country live in coastal areas (Ratnayake et al., 2018). The coastal erosion identified as one of the main issues around Sri Lanka is accelerated in considerable amount and the valuable natural coastal features and manmade features are harmfully affected from this erosion. But the Length of Sri Lanka's coastline is not uniformly subjected to intensive erosion (Lakmali et al., 2016).

Coastal areas with natural or artificial geomorphological conditions, which provide enough shelter, breaking the high wave energies, are favorable for accretions. Kalutara coastal zone was one of coastal areas in Sri Lanka which was having positive hydrodynamic and sediment dynamic patterns with geomorphologic conditions for accretion process before May, 2017. However, the coastal area of Kalutara is currently facing serious problems due to the human activities. Not only natural coastal features but also coastal zone is disappearing in Kalutara and it is the

considerable issue for the country in economically and environmentally.

Also Kalutara is highly vulnerable area for riverine flood of Kalu Ganga (Samarasinghe et al., 2010) and riverine flood is most common natural disaster in Sri Lanka. As well, it is one of weather related hazard and high amount of rainfalls are act as main factor for riverine flooding. Sri Lanka is in the path of two monsoons and topographical features of the country are strongly affect the spatial patterns of winds, seasonal rainfall, temperature, relative humidity and other climatic elements, particularly during the monsoon season (Hemachandra, 2010).

In present, the frequency of riverine floods in the country is considerably increased with climatic changes and Southwest monsoon is brought heavy rains (Ampitiyawatta and Guo, 2009) and strong winds to Sri Lanka. Kalu Ganga, Gin Ganga, and Nilwala Ganga are main rivers which are faced to flood hazard and considerable amount of population and agricultural areas are inundated due to the flood hazard. Different types of flood controlling strategies are applied as mitigation and risk reduction processes by the responsible organizations (DMC act, 2005).

In the month of May, 2017 flash flood was affected to towns, villages, and agricultural areas which are located in the border of the Kalu Ganga. In some areas, the water levels reached 6m high and remained for 4-10 days period affecting urban and rural dwellings, small and medium enterprises, micro businesses, education and health services and public and private infrastructure (DMC act, 2005). To control this vulnerable situation of Kalutara area, a considerable portion of naturally formed sand barrier at Kalu Ganga outfall was removed near the part where spit is connected to the land. Although, maintenance of canals, and river outfalls is one of strategies for flood controlling mechanism and it should be applied in proper manner (DMC act, 2005). However, due to the poor mechanism of flood risk reduction strategy, different types of negative impacts have occurred in the coastal zone in Kalutara. The main focus of this study is to review these negative impacts using bathymetric profiles before and after demolition of sand spit bar and Google earth images from 2013 to 2019. Before applying risk reduction process for any disaster, first have to identify the best possible mechanism and it should be applied in proper manner for appropriate location.

II. RESEARCH DESIGN

A. Study Area

The coastal area in Kalutara district was selected as study area which is located in Western province in Sri Lanka (Figure 01). The Kalutara is important city having several famous landmarks mainly Kalutara Bhodiya and Calido beach. The Calido beach connected to Kaluganga outfall is very popular among local and international tourists for recreational activities. Kalu-Ganga River watershed covers 2,658 square kilometres and water flow from high of about 2250m above mean sea level. The annual rain fall in the area is about 4000mm and the length of Kaluganga river course is about 129km from the central hilly area.

Figure 1. Kalutara Coastal Area

B. Methodology

Google Earth Satellite images were extracted form Google Earth Pro online software to monitor the changes of in Kalutara coastal zone from 2013 to 2019. In addition, the bathymetric profiles were collected before and after the flood event in 2017. Bathymetry data in Kalutara coastal area before and after the demolition of sand spit bar at Kaluganaga river outlet was obtained from the Coast Conservation and Coastal Resource Management, Sri Lanka. Moreover, the questionnaire survey was done to examine the salt water intrusion on Kalu Ganga and 60 house-holders were selected to conduct these surveys that are living around river-side.

II. RESULTS

The summary of the questionnaire survey which was done for identify the salt water intrusion changes in Kalutara area is shown on the table 1. The output of the questioner survey was categorized by considering the age ranges. Majority of the study area said that salt water intrusion along Kaluganga was increased after year 2017.

Table 1. Statics of salt water intrusion changes after year 2017

Salt Water Intrusion	Age (Range)		
	20 - 40	40 – 60	≥ 60
Increased	78%	92%	88%
Normal	22%	8%	12%
Decreased	-	-	-

The figure 2 is shown the example Google Earth image comparison before and after demolition of the sand spit bar on 2015-01-07 and 2018-01-16 respectively. The several comparisons were examined using extracted Google Earth images from Google Earth Pro online software from 2013 to 2019. Generally, most variation of the sand spit bar and adjacent area in Kalutara coastal indicates after the May, 2017.

Figure 2. Before and after demolition of sand spit bar

The bathymetric profiles at nine locations compared in Kalutara coastal area before and after demolition of the sand spit bar and figure 3 is shown the bathymetric profiles at river outlet regarding separate time durations. After examine all the bathymetric profiles before and after demolition of sand spit bar, It is observed that the water depths were increased after demolition sand spit bar (deepened the sea bed)

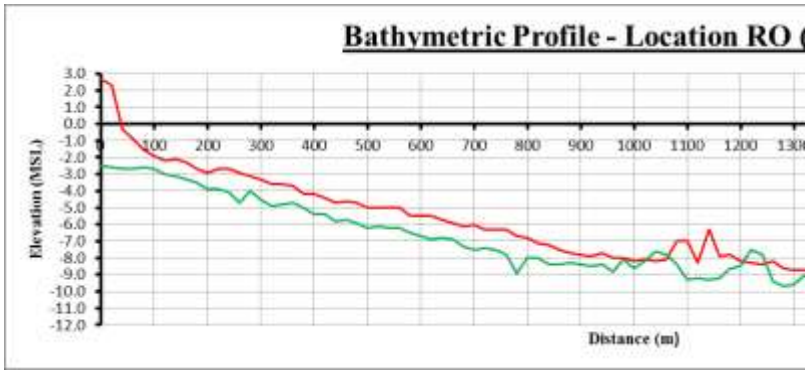

Figure 3. Bathymetric profiles at river ou

IV. DISCUSSION

The beach morphology variation was observed by means of Google earth images extracted from Google Earth Pro online software from 2013 to 2019. After 2017, it is indicated that new sand spit bar created in different location within the same area. It is because variation of hydrodynamic and sediment transport pattern after the incident in May 2017. Moreover, the severe erosion is shown in the place where old sand spit bar connected to the land. The less supply of sand and energetic wave impact on beach face are the reasons for severe erosion at the place where old sand spit bar connected to the land.

The salt water intrusion along Kaluganga was increased after year 2017 and it was a serious problem in the region. So drinking water problem can be arise as another problem in this area. It shows that the application of poor management strategies for disaster risk reduction is contribute to uplift the other disaster.

The comparison of bathymetric profiles was indicated deepening of sea bed at the area. Such deepening in the nearshore zone can cause the sea waves to break very near to the coastline. This might also lead to generate new diffraction patterns resulting differential coastal accretion and erosion scenarios. Then, the erosion is accelerated in the area after May, 2017.

V. CONCLUSIONS

This study highlights the harmful effects for the natural structure of the Kalutara beach area due to unplanned disaster management process. When managing any disaster, the disaster management cycle should be followed systematically, continually, and consistently. It shows different kind of activities which should be prepared before, during, and after the disaster event. So when applying any kind of activity from this cycle, we should have perfectly planned the relevant activity.

Maintenance of canals and river outfalls is one of mitigation process and it should be applied as a pre disaster management activity. On the other hand, canal cleaning before monsoon period commence, widening the canals, removing blockages, maintenance of river outfall are some of preparedness activities to mitigate the impacts of floods. But the disturbances for naturally formed structures are not a proper disaster management activity.

The effective disaster management process should have rich with information about the appropriate location and possible time period.When applying mitigation process for any disaster, first have to identify the best possible mechanism and it should be applied in proper manner for appropriate location. If not, new hazards may generate as side effects of the poor mitigation strategies by developing harmful effects for the society and the environment.

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