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Intensity of Coastal Erosion in Sri Lanka: The Case of South Western Coastal Sector

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ABSTRACT:- Coastal erosion has been a problem in Sri Lanka for long period of time. Sea Level rise and reduction of supplying sediment load to coast intensified the shoreline erosion rate. Identifying the intensity of shoreline erosion has become an urgent requirement in Sri Lanka to fulfil two reasons. First one is to make due plans to combat coastal erosion. Second is to make aware general public and the respective authoritative personality about the gravity of the problem of coastal erosion relating to South West Coastal Sector of Sri Lanka (SWCS). SWCS is the one of most important coastal sectors in terms of geographical, socio-economic and other points of views. Current study paid attention on secondary sources of data. This source of data provides two types of information relating to this study. One is the collecting information on studies that paid attention on coastal erosion. Second is to make comparison across studies. Primary data was collected by using field observation and key informant interviews.

Studies show the short term erosion rate of the SWCS vary from 0.0- 3.0m/yr. Yet this figure may increase significantly by 2050 up to 4.0-11.0 m/yr and the average would be 7.0m/yr. This situation in 2100 will be from 10.0 -34.0m/y and the average figure will be 17.0-24.0m/yr. Results of the current study urge relevant parties to take immediate action to shift the existing cultural environment into suitable inland locations as soon as possible while discouraging constructions in the South Western Coastal Zone in Sri Lanka.

Key Words: Intensity, Coastal Erosion, Shifting Cultural Environment.

I. INTRODUCTION

Sea erosion has been a problem from time immemorial in Sri Lanka. Yet, this problem attracts only when it attacks human construction or livelihood (Dassanayake, 1928). This notion is not changed much even after nearly a hundred years in this country. Contrary to this explanation, recession coast has caused to immerge many other issues with several facets in the contemporary coastal zone of Sri Lanka (Bakker, 2018, Senevirathne et all, 2017, Lakmali, 2016, Maddumabandara, 1989 and CCD, 1986). Large number of complications relating to natural environment, socio-economic, cultural and political spheres particularly in the coastal zone have been surfaced by the process of coastal erosion in many coastal segments of the country. Intensity of such problems are significant in South, South West and Western coastal sector of the Island of Sri Lanka (CCCRMD, 2018). The coastal zone of Sri Lanka has become an important geographical region in this country in terms of environmental, socio-economic, cultural and many other aspects (Perera, 2017, Senevirathne et all, 2017, Lakmali, 2016). Therefore, respective authoritative personalities, institutions and general public in these areas are working hard to control the intensity of coastal erosion which lead to create multi-faceted issues in and around their own territory. Getting supports from general public and coastal zone users is important in controlling shoreline erosion problem. In order to achieve this goal, it has become a mandatory requirement to identify the intensity of the erosion process of the coast. The broad objective of this paper is set as to identify the visible impacts of coastal erosion and find ways to socialize their gravity and intensity. Such initiation would be very important even to general public to plan for the future.

Sri Lanka is relative to other countries is a small island country having a 65610Km^2 total land area. The island of Sri Lanka is situated southern tip of India and northern part of the Indian Ocean. Absolute location of Sri Lanka is $5^0 54^1$ and $9^0 52^1$ North Latitudes and $79^0 39^1$ and $81^0 53^1$ East Longitudes. Approximately 1620km long coastline including shoreline of bays and inlets but excluding lagoons is belong to this country (CCCRMD, 2018). People of the ancient world knew Sri Lanka as Ceylon, Heladiva and Serendib. The oldest world map

Multidisciplinary Journal

drawn by Ptolemy (circa 150) had named Sri Lanka as "Taprobane". Coastal zone is still a testimony the visit of ancient voyagers to Sri Lanka (Senevirathne, 2017). These monuments are also about to wash away by the process of intensified coastal erosion.

Sri Lanka had been considered as the stepping stone of the Indian Ocean which links Western world with Eastern world through naval roots by ancient navigators (Cook, 1951). Since time immemorial, the coastal zone of Island of Ceylon was so busy with several kind of human activities. As a result of the importance of relative and absolute location as well as the serendipitous natural resources that concentrated into and around the coastal zone, coastal zone of Sri Lanka has become a most attractive geographical destination for the people belong to all social strata. Though, the Sri Lankan coastal region encompasses 24% of the country's total land area, 65% of the urbanized land area, 32% of the total population of the county, two third of the industrial contribution to GDP and main roads and railways lies with in the coastal zone in Sri Lanka (CCD,1997 and 2006). Contribution to Gross Domestic Product (GDP) from the DSDs of the coastal zone is significant when compared to other all DSDs situated in Sri Lanka. According to the Nayananda (2007), contribution to the GDP from coastal zone in 1994 is 44%. This is 9% increase from 1983. Among the all coastal sector, the highest share to the GDP comes from the South Western (SW) coastal zone and to take immediate action to control impacts that cause to jeopardize human activities. Coastal erosion in Sri Lanka has been already identifies as the root and main problem that led to create an array of problems in the coastal zone (CCD, 1986).

Coastal zone is the key geographical region that helps to maintain many segments of the biological chains. Breading places of many terrestrial and aquatic species of the marine and coastal wetlands sustain from the coastal zone with divers geomorphologic and biological systems. Food generating sources for them are also link with the coastal zone. Therefore, when the coastline is eroded, the fauna and flora species may get uprooted and destroyed. The density of fauna and flora population would decrease gradually leading to reduction of bio-diversity and bio- production. In order to protect this valuable geographical region, intensity of shoreline erosion should be identified first. Then the due strategies should be taken to control it. The main objective of this paper is to identify the later aspect.

II. MATERIALS AND METHODS

Available printed and digital books, reports published by government or private authors, conference proceedings and text books were referred to collect secondary data. Relevant scientists and coastal residents were interviewed to collect primary data and information. Field observations method was employed to update and to correct the available both qualitative and quantitative data gathered through questioner survey, case studies and interviews.

Topographical and geological maps, aerial photographs and satellite images were used to get data and information relevant to geographical data on the study area.

Study area

Intensity of shoreline erosion is high in SW coastal sector among others in Sri Lanka (Bakker, 2018, Swan, 1965, CCD, 1986). On the other hand, this coastal zone is the most important geographical area in terms of socio-economic, cultural and environmental point of views (CCCRMD, 2018). Accordingly, shoreline belong to the SW coastal sector in Sri Lanka has been selected as the ground area of the current study.

Coastal Zone extends from Colombo to Galle is defined as the Southwestern coastal sector (CCD,1986, Maddumabandara, 1989). Northern end of this coastal sector is Colombo Lighthouse and the Southern end marks by the Matara - Galle district boundary. Coastal zones of three districts namely, Colombo, Kaluthara and Galle of the Western Province comprised with the study area. The total length of the SW coastal sector is 155Kms. This is 10% out of total length of the Sri Lanka's coastline. There were 14 districts and 67 divisional secretariats covering the coastal region with maritime boundaries in Sri Lanka. South Western coastal sector comprised with three districts and 13 DSDs (Figure 01).

Use of resources of the SW coast has been increasing since foreign traders came from Arab in ancient times and particularly after occupation of Western rulers around 16th century. This trend has again been increasing after getting independence in 1948 from Western Rulers (CCD, 1990). Since then, the South Western coastal zone has captured the attention of development planners, policy makers, environmentalists and concerned authorities as well as researchers associated into many fields.



Figure 01

More than 90% out of total length of the coast line of the study area is used for any kind of human activities. Occupying foreign and local traders, residing foreign and local people along the South Western coast have been increased after constructing the Southern railway track and main road which are situated close proximity to and parallel to shoreline (Cook, 1952). Therefore, several stretches of shoreline belong to the current study area have been identified as the highest pressure exerted into coastal zone by human in Sri Lanka. Early 1980s, corral mining had identified as the main reason for coastal erosion of SW coast (Clark, 1996). But, in 2013s the main reason for increasing erosion has changed into reduction of sediment supply and altering the near shore wave climate by constructing structures along the coast. As the reducing sediment supply of the shoreline and construction activities are high along the densely populated, high concentrated region by industries, commercial centers and many other infrastructure facilities, the shoreline erosion rate is also high in such areas.

It is apparent that the environmental degradation of the coast has been increasing due to over use of coastal resources and artificial human intervention to control shoreline erosion. Growth of the economy of Sri Lanka, high demand from tourism industry along with the impact of sea level rise have led to increase the use of coastal resources and build shoreline protection walls. Accumulative result of these activities causes to increase shoreline erosion owing to reduction of sediment supply (Swan, 1965, Maddumabandara, 1991). Among vast array of problems, coastal erosion has become the disastrous phenomenon that has caused to create several other problems mainly in the SW coastal Sector in Sri Lanka.

Data collection methods

Mainly three methods were employed to gather data for the current study as;

- 1. Literature Survey
- 2. Field survey
- 3. Case studies

Field survey was comprised with four types of data collecting methods. Questionnaire survey, informal discussion with general public, interviews of community leaders and participatory observation method were also used to gather data and information.

Stratified sampling method was employed to select ground locations to collect primary data. General public of the coastal zone or coastal dwellers and coastal zone users as well as policy implementers were selected with the help of random sampling method to collect data.

Data Analysis techniques

Collected data was analyzed and presented with the help of basic statistical methods. Total, mean and average of the numerical data series were used to draw graphs, maps and find patterns and trends.

III. RESULTS AND DISCUSSION:

Intensity of Shoreline erosion in South Western Coastal Sector

Shore line erosion or recession of land refers to loosing land due to shoreline erosion in this study. Loosing land have been calculated in two ways as net erosion in meters per year (m^2/y) and net loss of land in square meters per year (m^2/y) . Intensity of coastal erosion varies both spatial and temporal dimensions (Kahavita and Mylvaganum, 1953 and Swan, 1983).

All kinds of original sources of data produced by the authoritative institutes and researches were taken into consideration in this study. According to the available literature, studies carried out to find intensity of shoreline erosion can be categorised into to as,

- 1. National level studies
- 2. Local or spot level studies

National level comprehensive studies on shoreline erosion had been conducted from 1986 in Sri Lanka. Main two such studies are

- 1. Paranathala, W.E. 1954, "Some thoughts on the Organization of Sea Erosion Studies and the Development of Coast Protection Works in Ceylon", Transaction for 1954, The Engineering Association of Ceylon.
- Master Plan –Coast Erosion Management- Vol. I and II (1986), conducted by the Coast Conservation Department (CCD) & Danida- Danish Hydraulic Institute, New Secretariat, Maligawatta, Colombo 10.
- 3. Bakker, Paul J. J. 2018, Future Coastline Recession and Beach Loss in Sri Lanka- Master of Science (MSc) graduation thesis, University of Twente. Available at

There are several many other studies on selected coastal sector, for a spot or small length of coast line in Sri Lanka which provided shoreline erosion rates. For instances, following studies can be taken into this latter category.

- 1. Maddumabandara-1992
- 2. Amarasinghe A.G. 2001
- 3. Coastal Zone Management Plan of Sri Lanka -2006

Quantitative figures on the intensity of the coastal erosion of the study area given by the above mentioned sources are summarised in the following paragraphs.

Master Plan –Coast Erosion Management of Sri Lanka, published by the Coast Conservation Department in 1986 had been estimated as the net land erosion per year varies from 0.0 - 0.3 m/y. Net loss of land area in varies from 0.20000 m²/y (Table 01).

A study conducted by the Amarasinghe A.G. (2001) in 1988 to cover South Western Monsoon period showed that the intensity of erosion vary from 0.97- 2.35m/yr from place to place. Net erosion rate may be less or high after operating North East Monsoon period at the same year.

Table 01 Intensity of Coastal Erosion and Accretion in South Western Coastal Sector in Sri Lanka (Estimated figures of the Coast Conservation Department of Sri Lanka in 1986)						
Coastline in Km	Erosion % of coast	Erosion rate	Accretion % of coast	Accretion rate	Net Erosion	Net loss 1000m ² /vr
in iun	70 01 Cou se	m/yr	70 01 Cou st	m/yr	m/yr	1000111791
40	40-50	0.0-0.1	N.A*.	N.A.	0.0-0.1	0-5
40	70-80	0.1-0.5	20-30	0.0-0.1	0.0-0.4	10-20
75	70-80	N.A0.3	0-10	0.0-0.1	0.2-0.3	10-20
	tensity of C stimated fig Coastline in Km 40 40 75	tensity of Coastal ErosionStimated figures of the CCoastline in KmErosion % of coast4040-504070-807570-80	tensity of Coastal Erosion and AccresStimated figures of the Coast ConserCoastline in KmErosion % of coastErosion rate m/yr4040-500.0-0.14070-800.1-0.57570-80N.A0.3	tensity of Coastal Erosion and Accretion in South Stimated figures of the Coast Conservation DeparCoastline in KmErosion % of coastAccretion % of coast4040-500.0-0.1N.A*.4070-800.1-0.520-307570-80N.A0.30-10	tensity of Coastal Erosion and Accretion in South Western CoastAccretionSouth Western CoastAccretionSouth Western CoastCoastlineErosionAccretionin KmFrosionErosionAccretion% of coastm/yrMof coastratem/yr0.0-0.1N.A*.N.A.4040-500.1-0.520-300.0-0.17570-80N.A0.30-100.0-0.1	tensity of Coastal Erosion and Accretion in South Western Coastal Sector in Setimated figures of the Coast Conservation Department of Sri Lanka in 1980Coastline in KmErosion % of coastAccretion rate m/yrAccretion % of coastNet Erosion m/yr4040-500.0-0.1N.A*.N.A.0.0-0.14070-800.1-0.520-300.0-0.10.0-0.47570-80N.A0.30-100.0-0.10.2-0.3

(Source: CCD,1986), N.A*.- Not Available

Coastal Zone Management Plan published by the Coast Conservation Department of Sri Lanka in 2006 reported the annual rate of coast erosion of the highest eroding segment of the South Western Coastal sector varies from 0.0 - 3.0 m/yr (Table 02).

Table 02 Overview of Critical Erosion Areas and Erosion Rates along the SouthWest Coast of Sri Lanka- (As in the Unpublished sources up to 2002)				
Main Area	Erosion rate- m/yr			
Moratuwa- Koralawella	Neutral			
Wadduwa	0-2			
Kalu Ganga- Payagala	1 -3			
Beruwala -Bentota	1 -2			
Hikkaduwa	0-2			
Galle North	0-1			

(Source: CZMP: 2006)

Paul Bakker (2018) has estimated the intensity of coastal erosion with paying attention many factors that can influence to the process of erosion in South Western coastal sector. Impact of Sea Level Rise that trigger with the climate change had been taken into consideration in his study. Bakker has forecasted the coastal erosion rate particularly in the year 2050 and 2100 in meters for four scenario as in the Table 03.

Table 03 Average 2050 and 2100 coastline recession estimates for theSouth Western Coastal Sector in Sri Lanka						
	2050		2100			
Climate Change Scenario	Mean [m]	Likely range [m]	Mean [m]	Likely range [m]		
RCP2.6	7	4:10	17	10 - 26		
RCP4.5	7	4:11	22	11 - 33		
RCP6.0	7	4:11	24	13 - 34		
RCP8.5	7	4:11	24	13 - 34		

(Source: Bakker, P., 2018)

These studies and figures shows that intensity of annual coastal erosion in South Western coastal sector vary form 0.0- 7.0m/yr. When considering long term recession in some areas in the South West coast is much higher. Old survey plans of the Kaluganga river mouth area shows that net loss of coast is 60m of land in the period from 1934 to 1986 giving an annual loss of 1.15m (Maddumabandara, 1991).

IV. DISCUSSION

Information and data reported in the literature shows that the shoreline erosion in South West Coastal sector is in serious level. Impact of shoreline recession is not only a loss of land. It paves the way to destroy natural and physical characteristics of the shore along with livelihood and quality of the life in and around the coastal zone. Such situation can lead to create critical issues as the coastal zone has become an important geographical region in terms of economic, cultural, political, administrative and environmental aspects (CCD, 1987). Changing global climate at present poses a various ways to increase the impact of coastal erosion (IPCC, 2014). Meteorological events such as hurricanes, tropical cyclones, and sea level rise are particularly harsh on coastal areas, often resulting in damages from high winds, storm surge, flooding, and shoreline erosion.

In generally, shoreline erosion spawns secondary hazards such as floods, intrusion of salt (brine) water to fresh water source and damaging private and public properties. When taken into consideration these factors, impacts of coastal erosion can be categorized broadly into four categories as follows,

- 1. Environmental Impacts
- 2. Economic Impacts
- 3. Social Impacts

Environmental Impacts of shoreline erosion

The disappearing the equilibrium of coastal environment is the main accumulative environmental problem of shoreline erosion. This happens mainly from five processes and their cumulative effects. Five

Multidisciplinary Journal

processes can be mentioned as changing morphological features, degradation of coastal aquatic and terrestrial ecosystems, the decline the quality of estuarine-dependent habitat and reduction of near shore water quality and change its volume. These are also surfacing as the main environmental problems associated with the process of increasing shoreline erosion in the South Western Coastal sector (Senevirathne, 2016). Apart from these issues or negative impact, entire marine environment and the terrestrial environments of the adjacent coastal zones also influenced in many ways to alter or destruct the balance of the wetland and other terrestrial environment.

Altering the existing relief features of the coastal zone is the main visible phenomenon of the shoreline erosion process. Three significant impacts could be traced by the increasing shoreline erosion as follows,

- 1. Shifting shoreline land wards and inundation land area by the sea water
- 2. Increasing the slope angle of the near shore area
- 3. Accretion and moving shoreline seaward.

The first two phenomenon had influenced to wash away the surface soil, vegetation cover along with habitable environment of the land and aquatic animals. Recession of land has made changes of the coastal biosphere in losing bio-diversity and bio-production. The intensity and the rate of change of these two phenomenon regulate from several factors. Main such factors are listed in the Table 04 below. All these impacts cannot be measured.

Factors that regulate the intensity of the shoreline erosion process and the rate of horizontal movement of the shoreline Table 04.

Main Factor that	Description (situation that help to erode coastline)	
cause to change		
	If the bed rock is not out cropped in the shore and the fractures and cleavages are	
Rock type & structure	more of the available boulders and wave action is high.	
Sediment budget	Supply of sediment does not equal to demand, or receiving does not equal to loss.	
Relief features of the	The coastline is not made up with parallel mountain or high relief features	
shore		
Relief features of the	Slope of the continental self is high. Near shore area of the sea is not shallow.	
continental self		
Wave direction	Waves hit the shore with an angle not equal to 90°	
Wave height and	Wave height is high. High wave action continues throughout seasons or so.	
intensity		
Vegetation cover	There is not thick vegetation cover that helps to protect shore from wave action.	
Human activities	Removing sediments, clearing vegetation and construction that influence to alter	
	wave action is significant.	
Sea Level	Sea level is rising. Change of sea level daily is also significant.	

Shoreline erosion had paved the way to loss bio- diversity of coastal environments such as wetlands, coral reefs, sea grasses beds and biological environment of the shoreline, estuaries and adjoining water bodies of the coast. The decline of estuarine-dependent fish and shellfish populations and their associated fisheries, declining near shore water quality and had changed the volume, quality, and pulsing of freshwater inflows to estuaries. These are the direct environmental impacts of shoreline erosion. Therefore, coastal zone dwellers explained the coastal ecosystems are more valuable per unit area than other marine or terrestrial ecosystems.

Visible and measurable impacts of shoreline erosion are losing land. Reduction of biodiversity and bio production is visible yet difficult to measure exactly. Yet this study found the intensity and gravity of these two aspects. Concise discussions over these two matters are as in the following paragraphs.

V. CONCLUSION

According to the results of the studies carried out by the CCD in 1986 and 2006, Bakker in 2018, it can be concluded that the South Western Coastal sector in Sri Lanka is a recession shoreline. This situation would continue even up to year 2100.

Erosion rate of the shoreline may be vary from time to time. According to the calculation of CCD in 1986 and 2006 the intensity of shoreline erosion vary from 0.0 -3.0m/yr. This figure will increase up to 7m/yr in 2050 and 22m/yr in 2100 (Bakker, 2018). This shows that the intensity of shoreline erosion in short term is small compared to long term.

Shoreline erosion can totally destroy the natural and physical characteristics of the shore. It is obvious that such situations lead to create critical issues as the coastal zone has become an important geographical region in terms of economic, cultural, political, administrative and environmental aspects (CCD, 1987). Changing global climate poses a various ways to increase the impact of coastal erosion (Bakker, 2018). Meteorological events such as hurricanes, tropical cyclones, and sea level rise are particularly harsh on coastal areas, often resulting in damages from high winds, storm surge, flooding, and shoreline erosion.

The disappearing the equilibrium of coastal environment through changing morphological features, degradation of coastal aquatic and terrestrial ecosystems, the decline the quality of estuarine-dependent habitat and reduction of near shore water quality and change its volume have been identified as the main environmental impacts of the process of increasing shoreline erosion. This is significant in the South Western Coastal sector. Apart from these issues or negative impact, entire marine environment, terrestrial natural ecosystems and socio-economic cultural environments of the near shore and adjacent coastal zones also influenced in many ways to alter or destruct their equilibriums.

LIST OF REFERENCE

- [1]. Amarasinghe A.G. 2001, <u>Shoreline Denudation: Spatial and Temporal Variation of Sea Erosion in</u> <u>South West Coastal Sector in Sri Lanka</u>, Unpublished Thesis submitted to the Faculty of Arts, University of Peradeniya.
- [2]. Bakker, Paul J. J. 2018, Future Coastline Recession and Beach Loss in Sri Lanka- Master of Science (MSc) graduation thesis, University of Twente. Available at
- [3]. CCCRMD, 2018, Coastal Zone Management Plans. Coast Conservation and Coastal Resources Management Department (CCCRMD), New Secretariat, Maligawatta, Colombo 10. Available at, http://coastal.gov.lk/images/pdf/acts/czcrmp_2018_gazette_2072_58_e.pdf
- [4]. CCD. (1986) <u>Master Plan Coast Erosion Management</u>. Vol. I,II, Coast Conservation Department (CCD) & Danida- Danish Hydraulic Institute, New Secretariat, Maligawatta, Colombo 10.
- [5]. CCD. (1990, 1997, 1982, and 2006) Coastal Zone Management Plan. Coast Conservation Department (CCD), New Secretariat, Maligawatta, Colombo 10.
- [6]. Clark, John R. 1996, Coastal Management Hand Book, Lewis Publishers, Boca Raton, Florida, 33431.
- [7]. Cook, L. C.K. 1951, Ceylon: Its Geography, Its Resources and Its People.
- [8]. Dassanayake S. W. 1928 "Coast Erosion In Ceylon". <u>Transaction Engineering Association of Ceylon</u>, Colombo. Pp. 55-73.
- [9]. IPPC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group II to the Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrendrea, and L.L. White (eds.)]. Cambridge University Ores, Cambridge, United Kingdom and New York, NY, USA, 1132pp.
- [10]. Kahavita, D.W.R. & Mylvaganam T. (1953). "A Problem in Beach Erosion, Its Investigation and Solution". <u>Transactions for 1953</u>, Engineering Association of Ceylon.
- [11]. Lakmali, E.N., et all, 2016, "Long Term Coastal Erosion and Shoreline Positions of Sri Lanka" Proceedings of ERE 2016, https://www.researchgate.net/publication/307301862
- [12]. Maddumabandara, C. M. 1989. <u>Coastal Changes of Crow Island and its environs</u>. Coast Conservation Department(CCD), New Secretariat, Mligawaththa, Colombo 10,Sri Lanka.
- [13]. Maddumabandara, C.M. 1991, "Case Studies in Shoreline Trends in South West", <u>Proceedings of the Seminar on Coastal Erosion in Sri Lanka: Colombo 9 -11 Feb. 1991</u>, CCd/GTZ Project, New Secretariat, Maligawatta, Colombo 10.
- [14]. Nayanananda O.K. 2007, The Study of Economic Significance of Coastal Region of Sri Lanka in the Context of Environmental Changes of Pre and Post Tsunami, Coast Conservation Department and The Ministry of Environment and Natural Resources, New Secretariat, Mligawaththa, Colombo 10,Sri Lanka.
- [15]. Paranathala, W.E. 1954, "Some thoughts on the Organization of Sea Erosion Studies and the Development of Coast Protection Works in Ceylon", Transaction for 1954, The Engineering Association of Ceylon.
- [16]. Perera, M.D.N.D. et all, 2017, "Risk of Seawater Intrusion on Coastal Community of Bentota River Basin Sri Lanka", Procedia Engineering 212 (2018) 699–706, ELSERVER.Com/ Locate / Procedia., Available online at <u>www.sciencedirect.com</u>.