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Coastal morphodynamics associated natural hazards: a case study of Oluvil area in Ampara district, Sri Lanka

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ABSTRACT

The tidal action is one of the most significant forces of the littoral changes. This study mainly focuses on coastal morphodynamics associated hazards which are caused by the natural phenomena. The study area, which is covered about 16 km in length, is rich by coastal resources and has an abundance of natural biodiversity. The objectives of this study (a) to identify the coastal morphodynamics associated hazards by the waves in the study area and (b) to detect coastal morphodynamics using time series data from 1981 to 2015 and to show the intensity of shoreline changes with the aid of Geo Spatial Technology. For this study, Aerial photograph in 1981 and satellite images of 2001 and 2015 used to identify the costal morphodynamics of the study area and they were subjected to the analysis with the aid of GIS 10.5 software. This study is concluded that the coastal morphodynamics associated hazards have been identified heavily in the study area due to the severe wave action.

***Keywords*:** Tidal action, biodiversity, littoral change, morphodynamic, natural hazard, GIS

1. INTRODUCTION

Shoreline or coastline, the boundary between land and sea, keeps changing its shapes and position continuously due to dynamic environmental conditions [4]. It is the most dynamic part of seascape since its shape is affected by different factors, such as hydrography,

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geology, climate, and vegetation [5]. The focus of the present study is in the Oluvil area, south of Oluvil harbor (Figure 1).

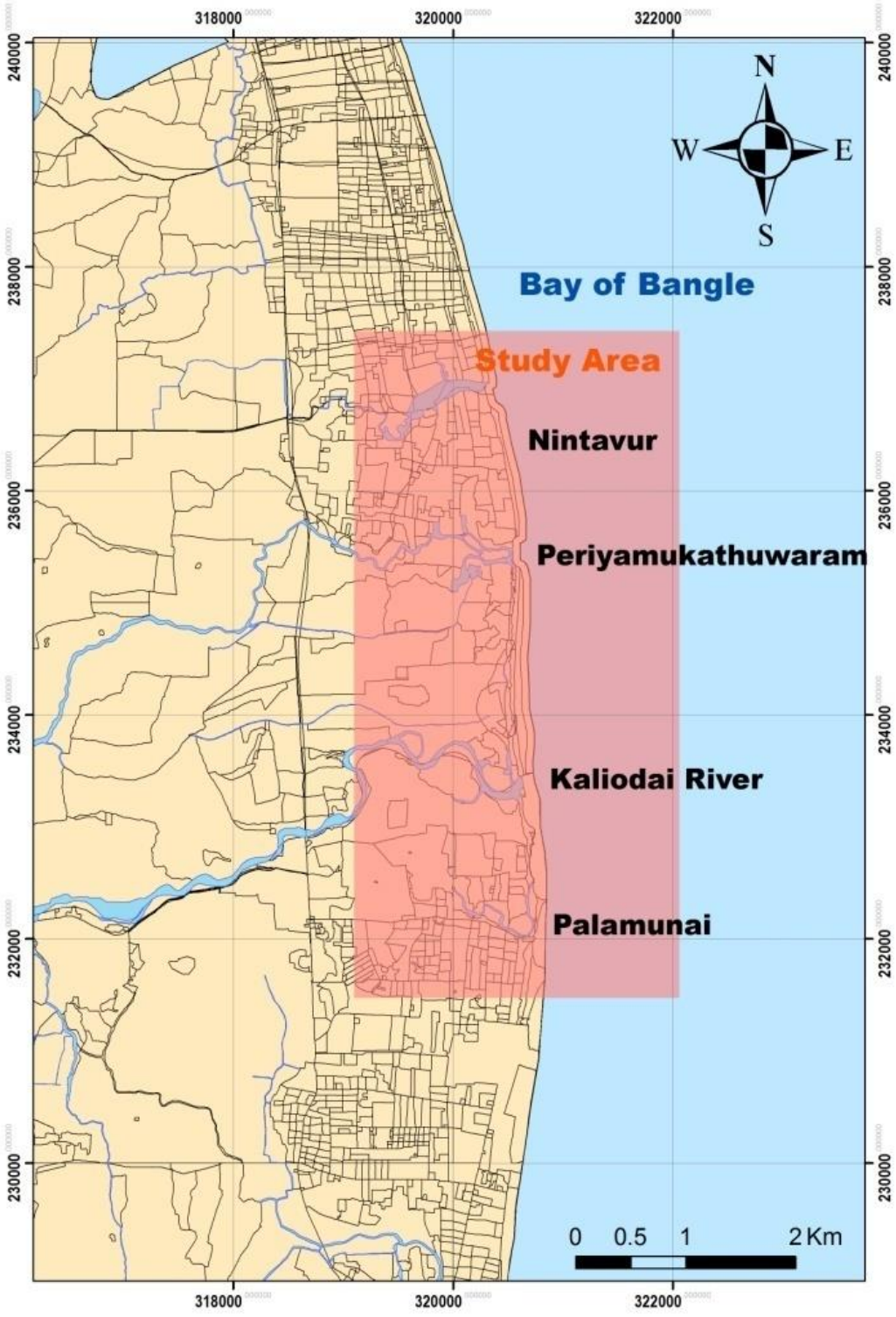

Figure 1. Study area.

Coastal erosion is evidenced by collapsed trees, buildings, and other structures, including breakwater. Sand pile-ups from the area have been washed away by monsoon tides at a depth ranging from 30 to 90 cm, resulting in a shoreline retreat of 80m landward from the end of constructed break water in places like Oluvil beach. A widening of Kaliodai river mouth from 1981 to 2015 and erosion of the sandy beach at the base of village road side have also been recorded. The present studies indicate that the coastal area of Oluvil is a dynamic one [1]. Shoreline change is an issue of concern in coastal management. In Sri Lanka, coastal communities about 5 million depend on coastal ecosystems for their livelihood. Remote Sensing data is widely used to analyze the coastal morphodynamics. Among the studies that have attempted to quantify the extent of shoreline change in Oluvil area. Using aerial photographs, it was found that there had been a drastic change of vegetation cover, and a shoreline recession of more than 80 meters in front of Oluvil and Nochchiyadi beach during the last 10 years. The objectives of the study reported here that to determine from aerial photographs taken in 1981, satellite images 2001 and Google earth image 2015, the quantitative extent of shoreline change in the Oluvil area [3].

The shoreline change study is very limited to the southeast coast of the study area. Furthermore, various developing projects have been recently started in this area. Therefore, the present study utilizes remote sensing and GIS will be very useful to assess the impact of hydrological and morphologic factors modifying the shorelines along this area [2, 6-13]

2. STUDY AREA

The study area is located on the East Coast of Sri Lanka facing the Bay of Bengal. It is located between latitude 81° 51' 09" and 81° 51' 52" East, and longitude 7° 14' 31" and 7° 21' 50" North (Figure 1). The shoreline is about 16 km long from Nintavur in the North to Addalaichenai in the South. The beach of this area is interrupted by the rivers of Kaliodai and Periyappalam. The climate of Oluvil area is characterized by the Northeast monsoon which prevails between November and January. The annual temperature is between 25 °C to 28 °C.

3. OBJECTIVES

i. To identify the coastal morphodynamics associated hazard caused by the wave in the study area

ii. To detect coastal morphodynamics using time series data from 1981 to 2015 and show the intensity of shoreline changes with the aid of Geo Spatial Technology

4. MATERIALS AND METHODS

Quantification of the extent of coastal morphodynamic in Oluvil area was accomplished using aerial photographs from 1981, and satellite images from 2001 and 2015. All the data were subjected to the mapping analysis with GIS 10.5 software.

4. 1. Dataset

Data used in this study was acquired from different sources as shown in Table 1, Aerial photographs scaled 1:20,000 were acquired from Survey Department. Remote Sensing data covering the Oluvil coastline from Nochchiyadi (Nintavur) to Sinnapalamunai (Oluvil) was acquired from satellite image and Google earth in 2001 and 2015.

Table 1. Acquisition Date.

Type of Data	Date	Scale	Resolution (m)
Aerial Photographs	1981	1:20,000	1 after scanning
Satellite Image	2001	-	10
Google Earth Images	2015	-	1

4. 2. Aerial photographs and geo-referencing

The base map was prepared by using the Survey Department toposheet map Scaled 1:10,000. To assess the shoreline changes for the past four decades from 1981 to 2015 using Survey Department topographical maps and Remote Sensing data details were shown in Table 1. As the digital data did not correct, using ground control points were taken from the Survey Department toposheet using an ERDAS image processing package. False color composite (FCC) of the study area was generated with the band combinations of 3, 2, and 1 in Red, Green and Blue band respectively. The displayed image with the above was spectrally enhanced by the histogram has real earth coordinates; data were geometrically intersection, canal-road equalization method. To eliminate the effect of tidal influence in shoreline change, low tide satellite data were used. Though, there is a different resolution, edge detection technique gives exact demarcation of land and water boundary (Figure 2).

The enhancement techniques improved feature exhibition and increased visual distinctions between features contained in a scene. This technique gives a clear demarcation of the land and water boundary. Then, the shorelines were carefully digitized and exported to shape file format for further analysis in ArcGIS.

5. RESULTS AND DISCUSSION

Shoreline is one of the important dynamic coastal features where the land and sea meet. Chauhan and Nayak (1995) have studied the shoreline changes using the satellite data covering low tide period. During this condition, maximum land is exposed and even low water line/ land water boundary and high water line are distinctly visible. This enables better mapping of the shoreline. The demarcation and the areal extent of the sites of erosion and accretion are queried and estimated through Arc GIS. The results show that there is spatially

significant change of all shorelines either erosion or accretion trends. The results were divided into 2 segments: segment 1; from Oluvil Harbor Northwards to Nochchiyadi river mouth and segment 2; from Oluvil Harbor to Sinnapalamunai shown in Figure 3.

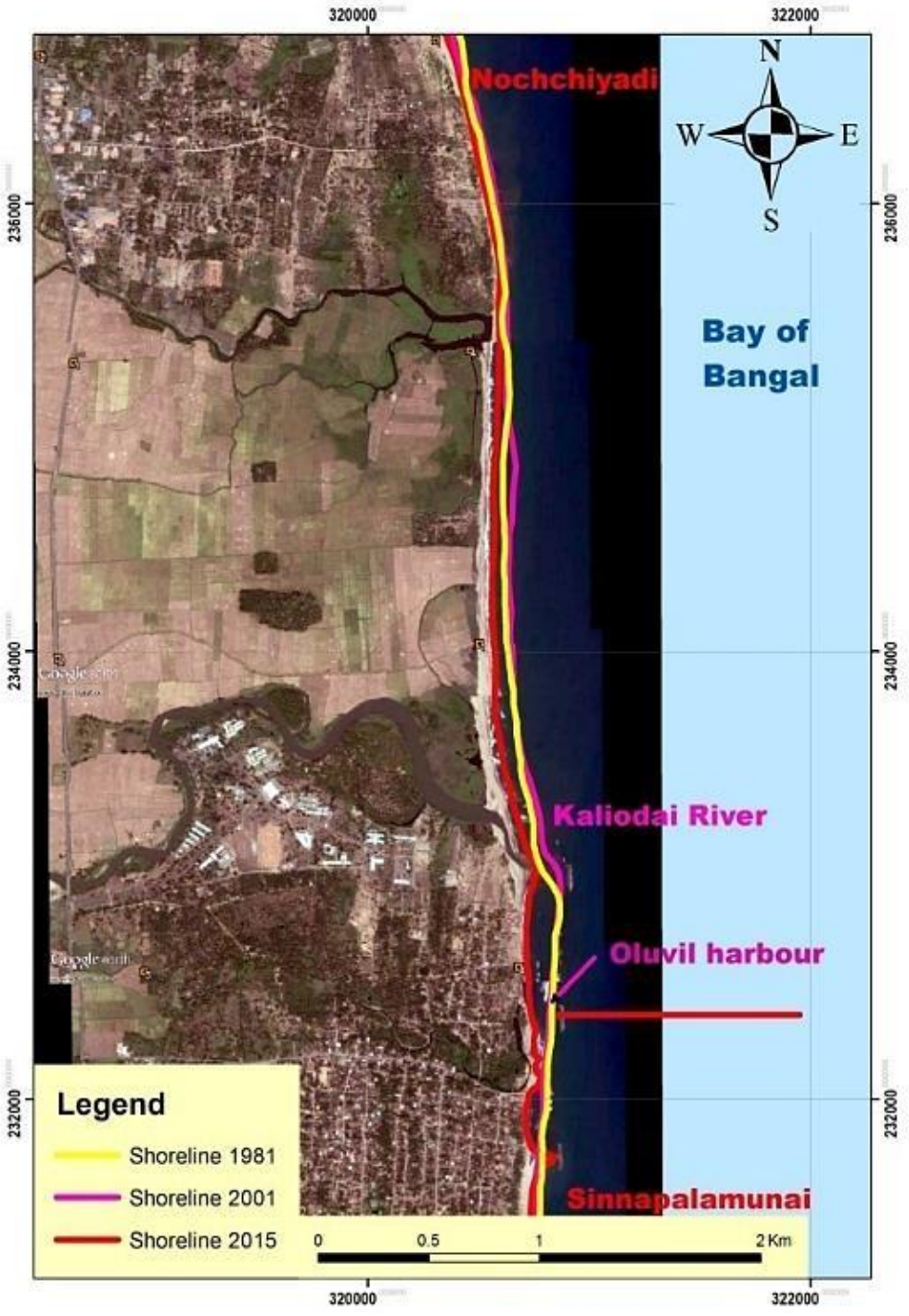

Figure 2. Shoreline in Various Years

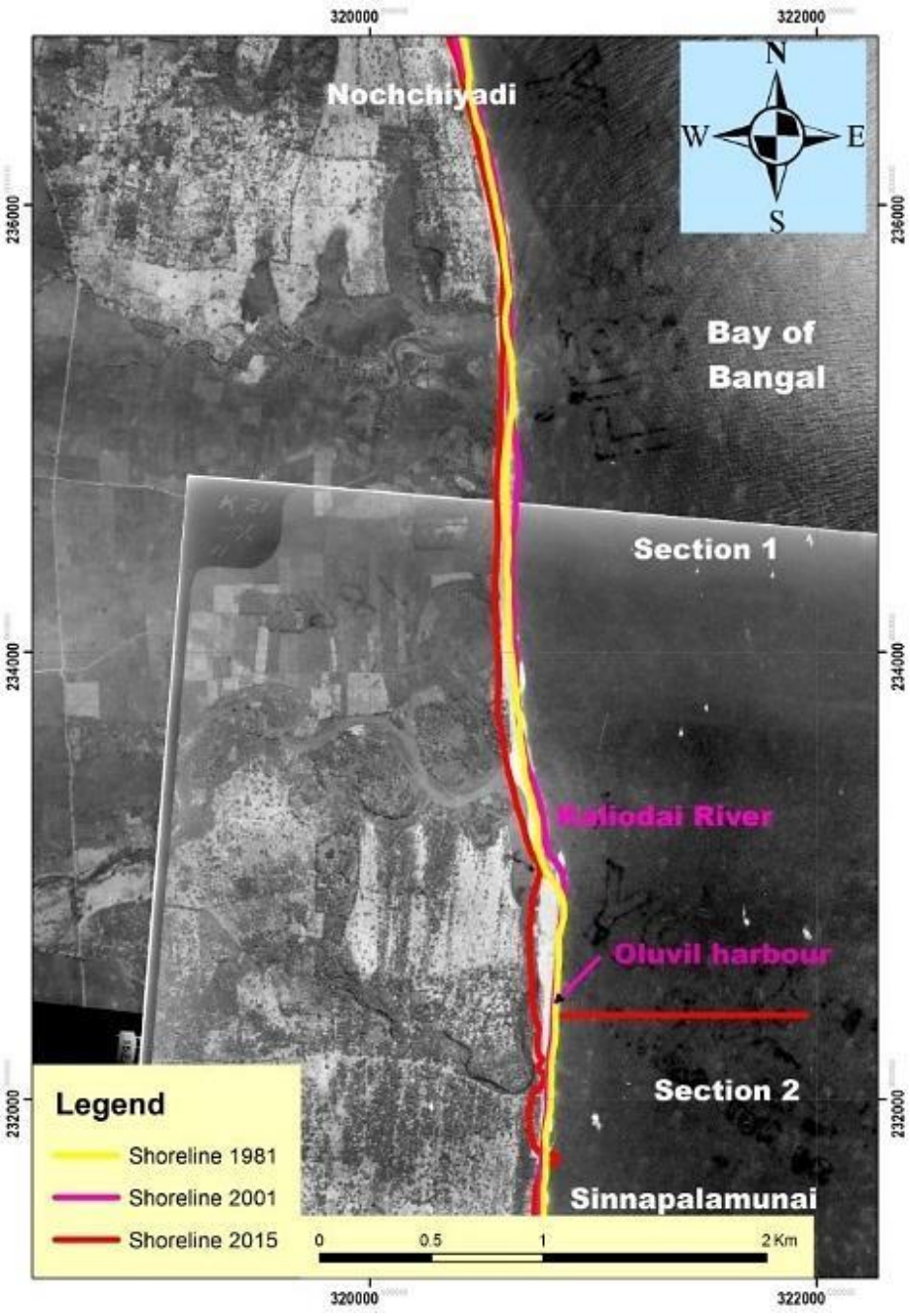

Figure 3. Sections of Study Area

5. 1. Oluvil Harbor Northwards to Nochchiyadi River Mouth

5. 1. 1. 1981–2001

The analysis on the shoreline change between 1981 and 2001 is shown in table 2. About 4.07 ha of land were eroded from the shore in the northern part of the harbor. The blue line in

the photomap represents the shoreline in 1981 whereas the yellow line represents the position of the shoreline in 2001 (Figure 4). However, between 1981 and 2001 accretion is about 1.25 ha. Total growth is -2.82 (ha) even growth rate annually is -0.14 (ha).

5. 1. 2. 2001–2015

Figure 3 also shows the shoreline change between 2001 and 2015. About 5.16 ha of land were eroded from the shore in the northern part of the harbor. A yellow line in the photomap represents the shoreline in 2001 whereas the red line represents the position of the shoreline in 2015. An area in between the two lines represents the eroded area. However, this is not an accretion from natural processes, but is a human-induced stone structure constructed in order to control shoreline erosion at the Oluvil light house area. This stone structure was built after break water failed to control shoreline erosion. The break water can be clearly seen in the photomap that shows changes between 2001 and 2015. Due to the increased erosion, natural vegetation of the coastal area have been destructed and also the landform of the study area has gradually been changed due to the natural hazard.

5. 1. 3. 1981–2015

About 9.28 ha of land were eroded from the northern part of the harbor between 1981 and 2015 (Figure 4). The blue line on the photomap represents the shoreline in 1981 whereas the red line represents the position of the shoreline in 2015. The area between the two lines on the photomap represents the eroded area. From this photomap the current shoreline (2015) is very close to the Oluvil light house. From 2001 to 2015, the accretion decreased to 0.22 ha and increasing of erosion to 5.16 ha. If we compare between 1981 and 2015, the erosion is more dominant 9.28 ha than accretion 1.47 ha. The area between 1981 and 2015 was affected by erosion 7.81 ha and growth rate annually is -0.23 ha as shown Table 2.

Table 2. Erosion and Accretion in Oluvil Harbor Northwards to Nochchiyadi river mouth

Year	Accretion (ha)	Erosion (ha)	Total Growth-erosion (ha)	Growth Rate (ha/yr)
1981-2001	1.25	4.07	2.82	0.14
2001-2015	0.22	5.16	4.94	0.35
1981-2015	1.47	9.28	7.81	0.23

5. 2. Oluvil Harbor Southwards to Sinnapalamunai

5. 2. 1. 1981–2001

Between 1981 and 2001 about 1.14 ha of land were eroded from the shore in the southern part of the harbor. The blue line in the photomap (Figure 5) represents the shoreline in the 1981 whereas the yellow line represents the position of the shoreline in 2001. There was an accretion about 2.12 ha, in the southern part of the harbor over the same period.

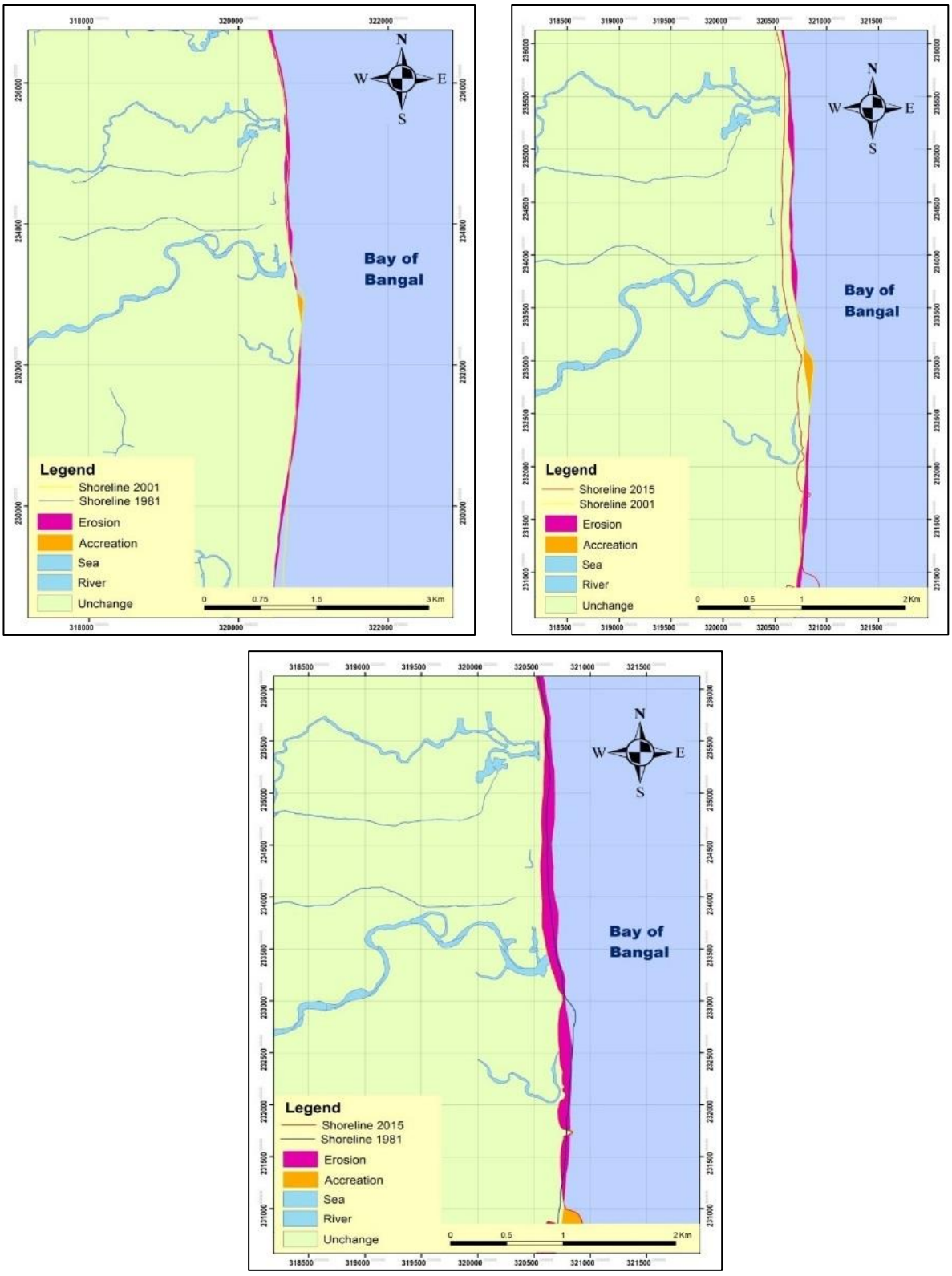

Figure 4. Coastal morphodynamics from 1981 to 2015 between Oluvil Harbor Northwards to Nochchiyadi

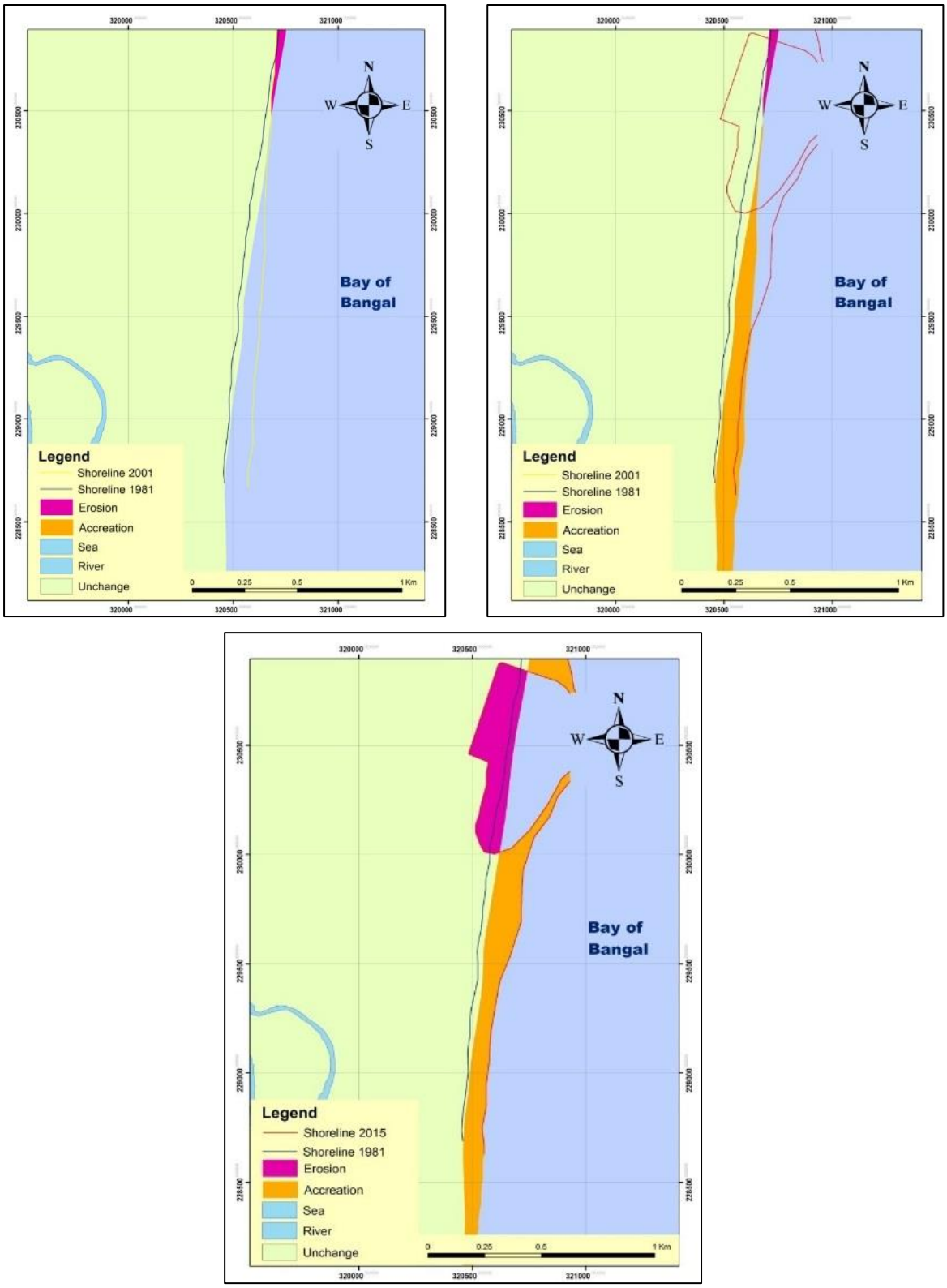

Figure 5. Coastal morphodynamics from 1981 to 2015 between Oluvil Harbor Southwards to Sinnapalamunai

5. 2. 2. 2001–2015

There were considerable shoreline changes in this area from 2001 to 2015. There was no shoreline erosion in areas denoted in yellow shown in Figure 5. However, there was more accretion during this period, which gradually formed a piece of land with an area of 14.47 ha protruding southwards.

Table 3. Erosion and Accretion in Oluvil Harbor Eastwards to Nochchiyadi river mouth

Year	Accretion (ha)	Erosion (ha)	Total Growth-accretion (ha)	Growth Rate (ha/yr)
1981-2001	2.12	1.14	0.98	0.05
2001-2015	14.47	0	14.47	1.03
1981-2015	16.68	1.14	15.54	0.46

5. 2. 3. 1981–2015

During 1981 to 2015 about 1.14 ha of land was eroded from the area labeled with a yellow in Figure 5. There was more accretion of about 16.68 ha. The annual growth rate is 0.46 ha per year.

The wave action in Oluvil area has caused socio-economic impact as well.

- Coconut 15 hectares of coconut occupied-land in Oluvil light house area have been lost. The income of the coconut owners have been affected by coastal erosion.
- Dwindling of Subsistence fishing; due to the intensified erosion the biodiversity of the shoreline of the study area have been severely affected. This caused the impact of the subsistence fishers who depended on the coastline fishing
- Dry fish cottage destruction

6. CONCLUSION

This study highlights the coastal morphodynamics of specific areas such as Oluvil Harbor Northwards to Nochchiyadi and Oluvil Harbor Southwards to Sinnapalamunai beach, beach ridge, brackish water creeks, coastal plain deep, swale, sand spit and mangrove forest in the study area. The coastal morpodynamics has caused the environmental and socio-economic effects of inhabitants of the study area. In Oluvil Harbor Northwards to Nochchiyadi, accretion was noticed at 1.25 ha, 0.22 during the period of 1981 to 2001, 2001 to 2015 respectively. Whereas the erosion also observed at Oluvil Harbor Northwards to Nochchiyadi during the period of 1981 to 2001 and 2001 to 2015 was 4.07 ha, and 5.16 ha. Overall, during the study periods, accretion activities are high compare to erosion in study area. However, erosion activities are not occurred in the southern part of harbor area. The study indicates that an area, both erosion and accretion activities during the 34 years.

Many suggestions have been proposed to control the shoreline erosion of the coastal area of Oluvil region. Extending the breakwater to the larger coverage area by small segments, using alternative breakwater system such as wave-eater system (floating breakwater), protecting mangroves, rift fences to control wind erosion and replanting and laying concrete interlocking pieces to control the shoreline changes.

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