Long term coastal erosion and shoreline positions of Sri Lanka

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Abstract
Coastal zone of Sri Lanka is a key to sustainable development of the country. The erosion of country’s coastal zone has been identified as a long standing problem. Therefore, coastal sediment dynamics around the country has to be identified to develop an appropriate coastal zone management plan. Remote sensing and GIS techniques can be used for quantitative and qualitative analyses of coastal processes including the coastal erosional and accretional trends. In this study, past and very recent Google Earth satellite images have been processed and analysed in an Arc Gis environment to investigate erosional and accretional trends in the coastal zone all around Sri Lanka. Using the results of the study, near shore sediment transportation directions and patterns along the coastline around the country were also predicted. Most of the south-western coastline of Sri Lanka shows considerable erosion during stormy conditions under south-western monsoon period, but most of them get recovered during fair weather north-eastern monsoon conditions. Therefore, no any severe long term erosion conditions prevail in the western, south-western and north-western coasts. However, some isolated locations in the north-eastern and eastern coastline show considerable erosion. Predicted nearshore sediment transportation directions proved that it is mainly governed by wind and waves of southwest and northeast monsoons.

Keywords: Coastal Erosion, Coastal Sediment Dynamics, Coastline, Google Earth Images

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Introduction
Being an island Sri Lanka possesses 1620 km length coastline all around the country. This coastline is a treasure of flora and fauna, heavy minerals, sands, creatures and sites with special significance. All of them provide immense support to the economic development of the country. As a nation, preservation of this valuable coastal area is becoming current requirement because the erosion of this area is identified already as a longstanding problem in Sri Lanka by the coast conservation department. Under the research an image analysis was done to investigate coastal erosion trend and nearshore sediment transportation around the country qualitatively.

Material and Methods
Google earth images were collected and saved by considering there time taken. To determine longterm changes two images of one particular location were saved. In most cases the time gap between the two images was 5 years. For long term the images collected that were captures in same months of different years. As example January 2010 and January 2015.

As first step polygons were drawn in both selected images as Fig. 1. A common polygon was drawn as Fig. 2 and union it with other two polygons separately. Attribute tables of unioned polygons were edited. There new grid code was defined by assigning 0 for water and value 1 for land.

Converted those polygons into raster and then raster calculation was done by using raster calculator of Arc Tool box. Finaly result file was obtained as Fig. 4. For seasonal changes two images were selected that are captures within two seasons.
For example image of January and image of August in the same year. Then above same procedure were followed.

Results

Table 1: Long-term conditions of straight beaches

| Location       | Beach condition | Quantity (m/yr) |
|----------------|-----------------|-----------------|
| Wellawatta     | Erosion         | 0.60            |
| Dehiwala       | Accretion       | 0.75            |
| Rathmalana     | Erosion         | 0.69            |
| Mount Lavinia  | Erosion         | 0.59            |
| Angulana       | Accretion       | 2.35            |
| Wadduwa        | Accretion       | 2.76            |
| Ambalangoda    | Erosion         | 1.80            |
| Hikkaduwa      | Accretion       | 6.36            |
| Matara         | Erosion         | 1.26            |
| Tangalle       | Accretion       | 4.29            |
| Kirinda        | Accretion       | 5.13            |
| Verugal        | Erosion         | 2.80            |
| Jaffna         | Accretion       | 0.90            |
| Kuchchaweli    | Accretion       | 0.60            |
| Kalnumai       | Accretion       | 2.10            |
| Komari         | Erosion         | 1.10            |
| Arugambay      | Accretion       | 0.80            |
| Mullativu      | Accretion       | 0.70            |
| Puttalam       | Accretion       | 0.40            |

Table 2: Long-term conditions within bays

| Location       | Beach condition | Quantity (m/yr) |
|----------------|-----------------|-----------------|
| Dehiwala       | Erosion         | 9.38            |
| Rathmalana     | Erosion         | 7.03            |
| Mount Lavinia  | Erosion         | 14.9            |
| Hikkaduwa      | Erosion         | 13.5            |
| Jaffna         | Accretion       | 8.70            |
| Kuchchaweli    | Erosion         | 4.40            |
| Kalnumai       | Accretion       | 14.3            |
| Komari         | Erosion         | 7.80            |
| Arugambay      | Accretion       | 5.50            |
| Mullativu      | Accretion       | 8.40            |
| Puttalam       | Accretion       | 4.50            |

Table 3: Long-term conditions near river mouths.

| Location       | Condition | Quantity (m/yr) |
|----------------|-----------|-----------------|
| Bolgoda Ganga  | Upstream  | Accretion       | 14.59          |
|                | Downstream| Accretion       | 11.19          |
| Mahaweli Ganga | Upstream  | Erosion         | 7.47           |
|                | Downstream| Erosion         | 3.04           |
| Kalani River   | Upstream  | Accretion       | 2.82           |
|                | Downstream| Accretion       | 7.21           |
| Deduru Oya     | Upstream  | Accretion       | 6.76           |
|                | Downstream| Accretion       | 3.11           |
| Kalu Ganga     | Upstream  | Erosion         | 4.88           |
|                | Downstream| Erosion         | 0.83           |

Table 4: Long-term conditions within bays.

| Location     | Condition | Quantity (m/yr) |
|--------------|-----------|-----------------|
| Koddiyar bay | Erosion   | 2.5             |
| Weligama bay | Erosion   | 2.7             |
| Marichchikaddi Bay | Accretion | 1.5             |

Table 5: Long-term conditions near artificial structures.

| Location     | Condition | Quantity (m/yr) |
|--------------|-----------|-----------------|
| Wattala      | Accretion | 25              |
| Nainamadama  | Accretion | 10              |

Apart from these result tables series of images were obtained during the research (Final Thesis, 2016).

Discussion

Along the south west coast several locations were covered namely Dehiwala, Mount Lavinia, Wellawatta,
Wadduwa, Rathmalana Hikkaduwa etc., In these images huge seasonal erosion can be observed, mainly during the south west monsoon period.

Figure 5: Mount lavinia - long term erosion

Figure 6: Mount lavinia - seasonal erosion

Severe erosion that observed along the most parts of the south west coast is not permanent. They are only seasonal changes and it gets recovered and accreted after the season. Therefore the south west coastline is in stable condition or in dynamic equilibrium now and there is no long-term erosions can be observed.

In the north east coastline severe long term erosions can be observed some places like verugal. After the starting of the pulmudei plant the sediment supply has been reduced to downstream. Therefore downstream erosion resulted.

Other than that, since there is submarine canyon near Trincomalee some of the sediment gets loss from the beach areas. This also causes erosion of this coastline.

Figure 7: Verugal - long term erosion

Earlier many locations in these coastlines were subjected to severe erosion such as Lansigama, Uswetakeiyawa etc. This was mainly due to alternation of sand budget supply to the beaches mainly through river sand mining. After the CZMP of 2004 several protective structures were constructed in order to prevent coastal erosion. Now it can be observed series of groins along this coast. So now these structures become well functioned and beach area has subjected to growth in some locations. Therefore now this coastline is gradually becoming into a stable condition.

Figure 8: Nainamadama breakwater
Along the south east coast we have covered limited number of locations due to lack of availability of mages. This part of the coastline remain steady condition. There is no severe erosion or accretion can be seen. Existence of tombola structures such as arugambay proved that there is bidirectional sediment transportation along this coast. In the down part of the south east coast several number of pocket beaches can be seen. These are act as natural protective structures of beaches.

Conclusions
As a conclusion of the above result it can be concluded that the sediment transportation direction around the country prevails as in Fig. 1. Near the Arugambay it shows bidirectional movement. In Nainamadama area also showed bidirectional movement of the long shore drift of sands. However it is predominantly during the north east monsoon period. The logshore drift and its direction mainly governed by waves and wind of southwest and north eastern monsoons of sri lanka.

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