Site selection for seaweed culture in southern coastal region of Sri Lanka

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Keywords: Mari-culture, coastal waters, remote sensing, livelihood development.

Introduction

Sea weeds are widely used as a raw material in cosmetics, fertilizers, agar algin and carrageenan production industry [4]. Therefore, Seaweed cultivation has become one of the popular Mari-culture. However, finding a suitable site for sea weed culture is a challenge. Several important factors are to be concerned during site selection. Less total suspended solids (TSS), optimum sea surface temperature (SST) and the calm water sheltered from waves, strong currents and predators are identified as best sites for culturing sea weeds [2]. As a coastal nation, the government of Sri Lanka has introduced seaweed cultivation to benefit the coastal community [1]. However, finding best sites is still challenging due to lack of information. Therefore, we focused on introducing a GIS and Remote sensing-based method to identify the suitable areas for sea weeds culture. For that, we selected the Southern coast of Sri Lanka where commercially valuable seaweed species are found along the coast [3].

Methodology

We carried out the study along the southern coastal belt of Sri Lanka from 6°25'7.45"N and 79°59'38.35"E to 6°30'38.46"N and 81°42'27.59"E, covering a distance of approximately 292 kilometers. Since the continental shelf off the southern coast of Sri Lanka is narrower than other coastal regions, a 10 km wide strip was selected for our study (Figure 1).

Sea Surface Temperature (SST), Total Suspended Matter (TSM) and Bathymetry were extracted from Landsat 8 (OLI) images taken from United States Geological Survey (USGS. Wind and current data for 2018 and 2019 were obtained from European Centre for Medium-Range Weather Forecasts with 0.1250*0.1250 resolutions as Network Common Data Form (NetCDF). The NetCDFs data were converted to raster data for extracting the wind direction and velocity & current direction and velocity Using Arc GIS 10.1 Software.

Band reflectance was calculated for Landsat 8 images followed by Atmospheric and radiometric corrections with ArcGIS software. Modified Normalized Difference Water Index (MNDWI) was used to extract the open water information from the land and cirrus clouds present in the Landsat 8 image. After extracting open water, a buffer zone was created from 5-10 km away from the shoreline to make a boundary to the coastal area for the suitability analysis. Normalized Suspended Material Index (NSMI) and Band ratio between green and blue bands were used for the extraction of TSM.

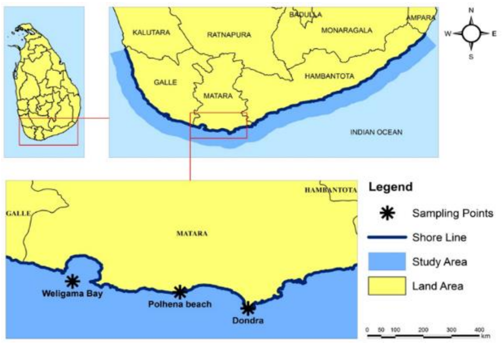

Figure 1. The study area.

SST was calculated based on brightness temperature [1], and the bathymetry was calculated based on log ratio model [3]. U and V 10 m wind components data were downloaded to extract wind velocity and direction. Eastward seawater velocity and northward seawater velocity data were used to extract current velocity and direction. Resampling technique was used to increase the resolution.

Temperature, depth and water samples were taken with respect to the relevant coordinates of 30 sampling points for ground truthing.

After extracting all the relevant data, area suitability analysis was performed using ArcGIS 10.1 software based on the criteria given in Table 1. Pearson correlation analysis was conducted to determine the accuracy between in-situ data and satellite derived data using IBM SPSS statistical software version 25.

Results and Discussion

Area suitability. The most suitable area for seaweed culture was identified based on conditions given in Table 1. The temperature, wind, and ocean current were considerable factors that changed significantly with monsoon seasons.

During the inter-monsoon and north-east monsoon period in 2018, 31000 hectares of the coastal area seems to be suitable for seaweed culture (Figure 2).

In 2019, about 19200 hectares area was identified as a suitable for seaweed culture during the inter-monsoon and north-east monsoon period (Figure 3). However, about 1500 hectares of the coastal area was available for seaweed cultivation during the south-west monsoon in 2018 (Figure 4) and in 2019 it was 570 hectares (Figure 5). Our results indicated that Tangalle and Ambalanthota are the most suitable areas for seaweed culture based on the observations in 2018 and 2019. Previous studies showed that the suitable area during 2008 and 2012 are 3728.87 hectares [8] and 1780.06 hectares [2] respectively. Nevertheless, the results of this study, suggests that only about 570 hectares area is suitable for the seaweed culture regardless the monsoons. However, in 2018 and 2019 the moderately suitable locations were mostly abundant due to significance variation occurred in wind and ocean current velocity in monsoon seasons.

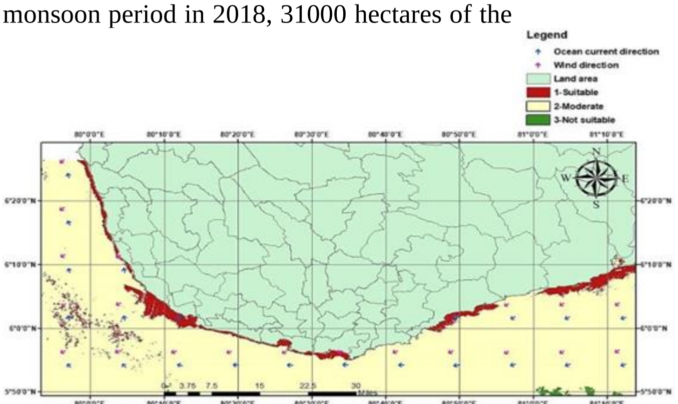

Figure 2. Area suitability in 2018 during inter-monsoon and north-east monsoon period.

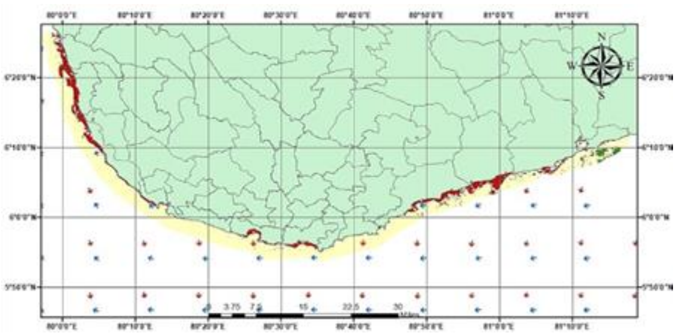

Figure 3. Area suitability in 2019 during inter-monsoon and north-east monsoon period.

Correlation Analysis. A significant Positive correlation of 0.91 ($p<0.05$) was observed between in-situ TSM data and satellite derived TSM data, elucidating that there is no notable difference between the in-situ TSM data and satellite derived TSM data. In addition, bathymetry data which were derived from the satellite images and in-situ depth data also did not show significant difference since they showed a positive correlation of 0.88 ($p<0.05$). Only the satellite derived SST and actual SST had a positive correlation of 0.35 ($p>0.05$) which was not significant. Thus, the respective results from the correlation analysis clearly show that there is no any notable difference between the in-situ and satellite derived data for the physical parameters which highly influence the habitat selection of sea weeds in a tropical environment.

Table 1. The criteria that used to select suitable sites for sea weed culture.

Bathymetry (m)	**Breakpoint**	**Reclassification**
Minimum value -2	2	3
2-6	6	1
6-11	11	2
11-maximum value	Maximum value	3
Temperature (^{0}C)	**Breakpoint**	**Reclassification**
Minimum value -24	24	3
24-26	26	2
26-28	28	1
28-30	30	2
30- maximum value	Maximum value	3
TSM: NSMI	**Breakpoint**	**Reclassification**
Minimum value-0.210	0.210	1
0.210-0.272	0.272	2
0.272-maximum value	Maximum value	3
TSM: Band ratio	**Breakpoint**	**Reclassification**
Minimum value-0.926	0.926	1
0.926-1.046	1.046	2
1.046-maximum value	Maximum value	3
Current velocity	**Breakpoint**	**Reclassification**
Minimum value-19	19	2
19-41	41	1
41-maximum value	Maximum value	3
Wind velocity	**Breakpoint**	**Reclassification**
Minimum value-5	5	1
5- maximum value	Maximum value	3

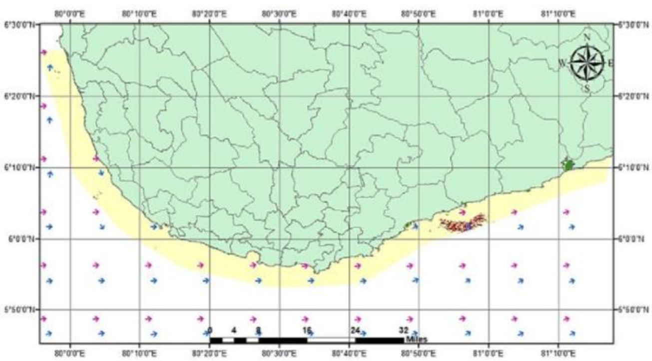

Figure 4. Area suitability in 2018 during south-west monsoon period.

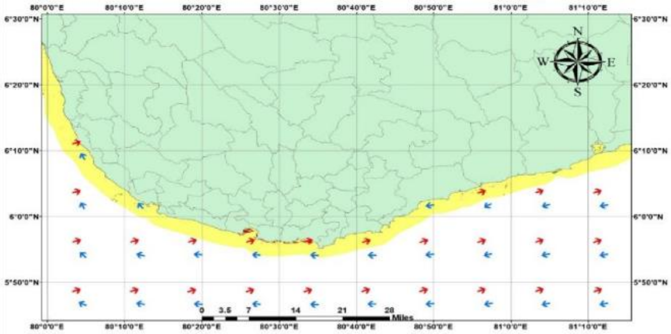

Figure 5. Area suitability in 2019 during south-west monsoon period.

Conclusion

The suitability analysis revealed that Ambalanthota and Tangalle have the highest potential for sea weed cultivation during both monsoons period. It was identified that the best time to implement seaweed cultivation techniques in these regions is from October to April. Galle, Weligama, Matara, Hikkaduwa, and Bentota were identified as moderately suitable areas for seaweed cultivation. A significant correlation was observed between observed data and remote sensed data supporting the accuracy of the data retrieved from satellite images in our study. The future field validations will require to assess the accuracy of the proposed method to identify the suitable areas for sea weed cultivation.

Acknowledgment

I would like to express my heartfelt gratitude to all the academic and non-academic staff of the Department of Fisheries and Aquaculture and the Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, for facilitating me to carry out this research.

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