# Spatial Analysis of Change Detection and Total Carbon Stock Present in CORINGA Wildlife Sanctuary of Andhra Pradesh Coast

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*Abstract*— Mangroves growing near coast area at a constant threat of destruction due to anthropogenic pressure. Loss of these ecosystem can lead to at the loss of critical functions of mangroves, one of which is carbon sequestration. According to National Oceanic and Atmospheric Administration (NOAA), Mangroves can annually sequester carbon at a rate two to five times greater than mature tropical forests. Below ground content of mangroves is 4 to 18 times higher than the carbon content of tropical rainforests (Baba et al. 2002). Thus, it is very significant to quantify the carbon stocks in different components of this ecosystem. Carbon sequestration, emission and storage can be estimated by quantifying the amount of above and below ground biomass from which the C stored in forest ecosystems can be estimated (Momba 2010). However, this exercise becomes extraordinarily challenging when applied to mangrove ecosystems, which are relatively inaccessible. Determination of Above Surface Biomass (ASB) is an important step in planning the protection and sustainable use of mangrove resources. In the present paper, Change Detection is done and the total Carbon Stock is determined by using the formulas of ASB, BSB, TAB and TCS.

***Keywords:*** ASB, BSB, TAB, TCS, Mangroves

## I. Introduction

Remote sensing is the science of acquiring information about objects or areas from a distance without any physical contact with the object, typically from aircraft or satellites. Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record environment energy that is reflected or emitted from the Earth’s surface.

In the present usage, the word "remote sensing" implicates the use of satellite- or aircraft-based sensor technologies to detect, identify and classify objects on the Earth’s surface, including on the surface and in the environment and oceans, depending on propagated signals (such as electromagnetic radiation). This may be split into an "active" remote sensing (such as when a signal is emitted by a satellite or aircraft and its reflection by an object is detected by the sensor) and "passive" remote sensing (such as when the reflection of sunlight is detected by sensor).

Mangrove herbage is one of the forest ecospheres that gives a power substantial greenhouse gases (GHG) emission weakening, due to its ability to sink off the sum of $CO_2$ in the environment through the photosynthesis process. Mangroves keep providing multiple benefits either as the source of food, the habitat of wildlife, the coastline bodyguards as well as the Carbon Dioxide absorber, gaint than other types of forest. To inspect the role of mangrove herbage in sequestering the carbon stock, the study on the use of remotely sensed data in evaluating carbon stock was applied. By examination of the use of remote sensing data particularly Landsat-data with the main objective to estimate carbon stock of mangrove vegetation in. The carbon stock was estimated by analyzing the role between NDVI, Above Surface Biomass (ASB), and Below Surface Biomass (BSB). The total carbon stock was picked up by multiplying the total biomass with the carbon organic rate.

## II. Objectives

- To collect the satellite image of Kakinada.
- To identify mangroves separately from the regular other vegetation such as fields and other forester. Draw a shape file for the mangrove AOI.
- To calculate the change percentage of Change in the Sanctuary in Percentage.
- To calculate Total Accumulated Biomass by using Above Surface Biomass to derive Below Surface Biomass.
- To calculate the Total Carbon Stock which is our expected result which is calculated by correlating Above Surface Biomass and Below Surface Biomass.

## III. Study area

Coringa Wildlife Sanctuary is located in Godavari river estuarine forest area of coastal region of the Bay of Bengal in the East Godavari District of Andhra Pradesh. Coringa is second largest mangrove formation in India next to Sunderbans. The Coringa mangrove is bordered on the northern side by Kakinada Bay. The region covers an area of 24681.63 ha. It lies between *16°44'27.92"N,16°55'32.58"N* latitude and *82°13'29.94"E, 82°21'53.01"E* Longitude It was proclaim a sanctuary in the year 1978. The northern part of the sanctuary is covered by the back waters of the Kakinada Bay. The eastern side is bounded by the Bay of Bengal. It is located at 12 Km. south of Kakinada. The government announced this region a sanctuary to conserve the natural mangrove vegetation the region.

Fig. 1: Location map of study area

 

## IV. METHODOLOGY

Total carbon Stock can be analyzed in the study area can be following the steps of figure shown below.

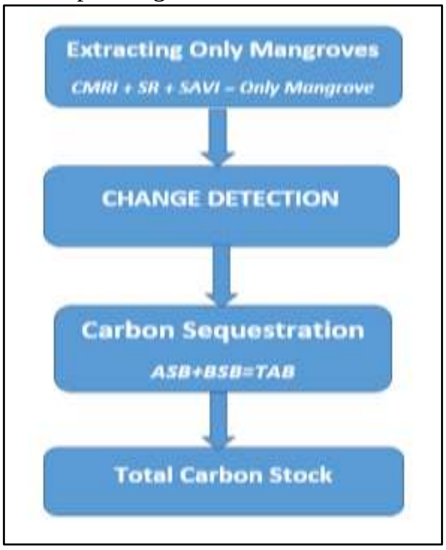


Fig. 2: Flowchart Of Methodology

### *A. Extracting only Mangroves:*

The data of Landsat 8 is available at the Earth Explorer website free of charge. The focus of this study was to employ spectral signatures and morphological characteristics of mangroves to generate an improved index for separating mangrove vegetation from non-mangrove vegetation classes and to compare the performance of the index with other established vegetation discriminating indices [(e.g. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Soil Adjusted Vegetation Index (SAVI), Simple Ratio (SR)] using Land Sat 8 OLI imagery. The latest index developed in this study namely 'Combined Mangrove Recognition Index (CMRI)' incorporates outputs from NDVI and NDWI indices in order to assess exclusively the mangrove vegetation using information like greenness and water content (succulence).

| FORMULA \ SATELLITE | LANDSAT 8 | LANDSAT | LANDSAT 4 | LANDSAT 1 | SENTINEL 2 |
|---|---|---|---|---|---|
| $NDVI = \frac{NIR-R}{NIR+R}$ | $\frac{5-4}{5+4}$ | $\frac{4-3}{4+3}$ | $\frac{4-3}{4+3}$ | $\frac{3-4}{3+4}$ | $\frac{8-4}{8+4}$ |
| $NDWI = \frac{G-NIR}{G+NIR}$ | $\frac{3-4}{3+4}$ | $\frac{2-4}{2+4}$ | $\frac{2-4}{2+4}$ | $\frac{4-7}{4+7}$ | $\frac{3-8}{3+8}$ |
| CMRI | NDVI-NDWI | NDVI-NDWI | NDVI-NDWI | NDVI-NDWI | NDVI-NDWI |
| $SR = \frac{NIR}{R}$ | $\frac{5}{4}$ | $\frac{4}{3}$ | $\frac{4}{3}$ | $\frac{7}{5}$ | $\frac{8}{4}$ |
| $SAVI = (\frac{NIR-R}{NIR+R+L})*(1+L)$ | $(\frac{5-4}{5+4+0.5})*1.5$ | $(\frac{4-3}{4+3+0.5})*1.5$ | $(\frac{4-3}{4+3+0.5})*1.5$ | $(\frac{7-5}{7+5+0.5})*1.5$ | $(\frac{8-4}{8+4+0.5})*1.5$ |

Fig. 3: Formula according to the satellite band numbers.

### *B. CMRI (Combined Mangrove Recognition Index):*

CMRI subtract from NDWI (Normalized Difference Water Index) from NDVI (Normalized Difference Vegetation Index) in order to assess exclusively mangrove vegetation using information like greenness and water content

CMRI=NDVI-NDWI

Where: $NDVI=\frac{(NIR-RED)}{(NIR+RED)}$ ; $NDWI=\frac{(GREEN-NIR)}{(GREEN+NIR)}$

### *C. Simple Ratio (SR):*

Simple Ratio is quite simple step

$$SR=\frac{NIR}{RED}$$

Where, SR=Simple Ratio, NIR= Near Infrared.

### *D. SAVI (Soil Adjusted Vegetation Index)*

Soil Adjusted Vegetation Index (SAVI) acquires Normalized Difference Vegetation Index (NVDI) outcomes have been shown to be unbalanced, differ with soil color, soil dampness and saturation effects from high density greenery. In an attempt to improve NDVI, vegetation index that accounted for the differential RED and NIR extinction through the vegetation canopy. The guide is a tempering method that minimizes soil iuminosity influences from spectral vegetation indices both RED and NIR wavelength, where L is a Canopy background adjustment factor. L the constant value of 0.5 is reflectance space was found to reduce soil brightness variation and eliminate the need for additional calibration for different soil.

$$SAVI= \frac{(NIR-RED)}{(NIR+RED+L)} * (1 + L)$$

SAVI is to correct Normalized Difference Vegetation Index (NDVI) for the influence of soil brightness in zone where vegetative cover is low. Landsat Surface Reflectance derived SAVI is calculated as a ratio in middle of the R and NIR values with a soil brightness correction factor (L) constant as 0.5 to accommodate most land cover types.

In Landsat 4-7, SAVI = ((Band 4 – Band 3) / (Band 4 + Band 3 + 0.5)) * (1.5).

In Landsat 8, Soil Adjusted Vegetation Index (SAVI) = ((Band 5 – Band 4) / (Band 5 + Band 4 + 0.5)) * (1.5).

### *E. Layer Stacking*

Layer stacking is a process of were merged and stacked together in one image resulting in the final image containing three spectral variables and one topographic variable. Combine CMRI, SR and SAVI. This final image was used to classify and map the real extent of mangrove forests in each image.

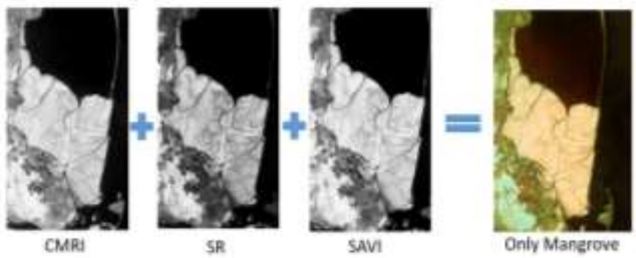


Fig. 4: Only mangroves

Now that the only Mangroves are extracted, the Area of Interest can be shape fie can be generated.

 

### *F. Change Detection:*

Changes in vegetation patterns were detected using LANDSAT TM and ETM+ imagery, owing to their good spectral and temporal resolution and moderate spatial resolution and accessibility in terms of price. Various authors have used multispectral LANDSAT satellite image imagery to detect change in vegetation and land cover patterns.

Apply NDVI formula on using the clipped band of both years' images. To calculate the Percentage of change took place in by calculating the pixels with the resolution. As the attribute table is not available for the image, reclassify the images so that we get the pixel details.

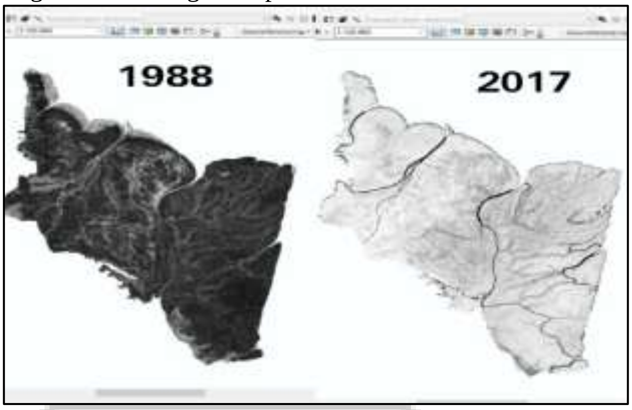


Fig. 5: NDVI images of both years

### *G. Area Calculation in Excel:*

Copy the Pixel values of both images into the Excel Sheet. Pixel Value is multiplied with the resolution of the satellite data. In formula it is given as Area=Pixel value*30*30..As the result is expected to be in area of percentage, each feather is divided with the total area and multiplied with 100. In formula it is given as (Area/Total area)*100.Sum of forest and dense forest gives the total percentage of the forest. The Percentage of forest in year 1988is 66.9325 % whereas the forest percentage of year 2017 is 85.2449%. Which means there is an increment of 18.3124 % in the span of 29 years.

### *H. Carbon Sequestration:*

Forests play an important role in the global carbon balance; as both carbon sources and sinks, they have the potential to form an important component in efforts to combat global climate change. In the past few years there has been an increasing tendency to consider forest ecosystems as possible sinks of carbon dioxide. In this way, it is attempted to mitigate the dramatic increase of global emissions of CO2 gas in the industrialized areas. Carbon dioxide is the major commonly produced greenhouse gas. Carbon sink is the process of capturing and storing atmospheric carbon dioxide. It is one of the method that reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. Compared to the tropical forests, Mangroves absorbs 10 times more carbon from the environment. The Total Carbon stock present in the AOI is acquired by the sum of Above Surface Biomass and Below Surface Biomass.

### *I. Converting Digital Values into Reflectance:*

*1) Step 1: Converting digital values into reflectance*

The Landsat sensor is converted into reflectance value by using the variable factors that provided in the metadata. Landsat suggests to converting the digital value into Radian using the following formula:

ρλ' =MρQcal + Aρ

Where,

ρλ' = a reflectance value without correction to the sun's elevation,

*Mρ* = Band specific multiplicative rescaling factor (where *x* is *Band* (*REFLECTANCE_MULT_ BAND_x*),

*Aρ* =Band-specific additive rescaling factor from metadata (where x is Band (REFECTANCE_ADD_BAND_x))

*Qcal* = Quantized and Calibrated Standard product the pixel values (DN).

The Landsat data ID being used is LC08_L1TP_141048_20190326_20170505_01_T1_Bn.TIF. For the present process only Band 4 and Band 5 are enough as only NDVI is done. *Mρ* value is taken from Metadata of the image.

ID=LC08_L1TP_141048_20190326_20170505_01_T1_Bn.TIF.

Qcal=LC08_L1TP_141048_20190326_20170505_01_T1_B4.TIF.

LC08_L1TP_141048_20190326_20170505_01_T1_B5.TIF.

Mρ= *REFLECTANCE_MULT_ BAND_2=2.0000E-05*

Aρ= REFECTANCE_ADD_BAND_2=-0.0100000

ρλ'=(0.00002*Float("LC08_L1TP_141048_20190326_202_Band4_clip"))+(-0.1)

ρλ'=(0.00002*Float("LC08_L1TP_141048_20190326_203_Band5_clip"))+(-0.1)

*2) Step 2: Conversion of reflectance value to the sun elevation follows equation*

$$P\lambda' = \frac{\rho\lambda'}{\cos(\theta SZ)} = \frac{\rho\lambda'}{\sin(\theta SE)}$$

Where,

*Pλ'* = Relfection value to Sun Elevation,

ϴ*SE* = a local sun elevation. The scene center sun elevation in degrees (SUN_ELEVATION);

Here ϴ*SE* = 46.57994480 taken from Metadata

ϴ*SZ* = local solar zenith angle =*90°*- ϴ*SE*.

ϴ*SZ* =90̊- 46.57994480 = 43.4200552

ϴSZ Radian $= \frac{\theta SZ * \pi}{180} = \frac{43.4200552 * 3.14}{180}$ =0.7574387407

Cos ϴ*SZ* = Cos (0.7574387407) = 0.9999126197

In Raster Calculate it's given as ("rastercalc169_REF_B4") / (0.9999126197), "rastercalc171_REF_B5"/0.9999126197

*3) Step 3:NDVI of Conversion of Reflection Value of Sun's Elevation.*

In Raster Calculate it is given as: (Float("rastercalc181_B5_Ref Sun Elevation")-Float("rastercalc178_B4_Ref Sun Elevation"))/(Float("rastercalc181_B5_Ref Sun Elevation")+Float("rastercalc178_B4_Ref Sun Elevation"))

*4) Above Surface Biomass: Step 4:*

Above Surface Biomass is estimated in this step. Estimation of above surface biomass value was done using the approach of NDVI result of equation correlation with Above Surface Biomass (ASB) of mangrove that is equal to 0.787 by Jha *et al.* (2015) as follows:

$$ASB = 305.9 * NDVI^{4.864}$$

First calculate the power of NDVI, which is given as "rastercalc182_NDVI" ** 4.864 in Raster calculator. Multiple NDVI Power with 305.9 which is given in Raster Calculator as 305.9*"rastercalc183_ Power"

The value of after the raster calculation is obtained in ton ha-1. So, The Above surface Biomass is 61.87 ton ha-1

☑ rastercalc185_305_ASB
<VALUE>
0 - 17.22792206
17.22792207 - 32.02937622
32.02937623 - 61.87493134

*5) Below Surface Biomass: Step 5:*

The estimated value of Below Surface Biomass (BSB) is obtained from the estimation of ASB which is formulated using the equation compiled by Cairns, *et al* (1997) as follows:

BSB=*exp*(-1.0587+0.8836*Ln(ASG))

Where,
*ASB* = the value of Above Surface Biomass (ton ha-1),
*BSB* = the Below Surface Biomass value (ton ha-1).

In Raster Calculate it's given as Exp((-1.0587+0.8836)*Ln("rastercalc185_305_ASB")).

The value of after the raster calculation is obtained in ton ha-1. So, The Above surface Biomass is 82.10 ton ha-1

☐ rastercalc199_BSB
<VALUE>
0 - 22.85980156
22.85980157 - 42.49991276
42.49991277 - 82.10210419

*6) Total Accumulation Biomass: Step 6:*

Total Accumulation Biomass, (TAB) is formulated using the formula given below:

TAB=ASB+BSG

Where,
TAB= Total Accumulation Biomass (ton ha-1),
ASB= Above Surface Biomass (ton ha-1),
BSB= Below Surface Biomass (ton ha-1).

In Raster Calculator is given as "rastercalc185_305_ASB"+"rastercalc199_BSB"

The value of after the raster calculation is obtained in ton ha-1. So, The Above surface Biomass is 143.97 ton ha-1

By this it is estimated that the Above Surface Biomass is 61.87 ton ha-1, Below Surface Biomass is 82.10 ton ha-1 and Total Accumulation Biomass is 143.97 ton ha-1

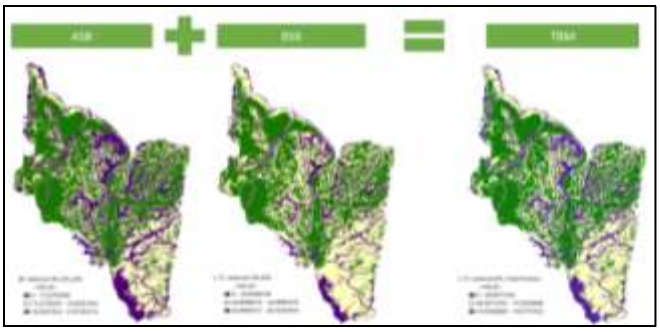

Fig. 6: ASB+BSB= TAB

*7) Total Carbon Stock: Step 7:*

Calculation of total carbon stock based on Westlake (1963) using the following formula:

TCS= TAB * %C Organic

Where,
*TCS* = the value of Total Carbon Stock (ton C ha-1),
*TAB* = the value of Total Accumulated Biomass (ton ha-1),
*%C organic* = the percentage value of carbon stock (0.47)

In Raster Calculate it is given as ("rastercalc201_Total Biomass")*0.47

The value of after the raster calculation is obtained in ton ha-1. So, Total Carbon Stock is the Mean and Standard Deviation of the Raster image which is 30.15 ± 12.916 ton C ha-1.

## V. CONCLUSION

The main concepts of this study is to detect the change and to estimate the Carbon stock present in the Coringa Wildlife Sanctuary.

Regarding the change detection percentage of forest in year 1988is 66.9325 % whereas the forest percentage of year 2017 is 85.2449%. Which means there is an increment of 18.3124 % in the span of 29 years.

Carbon Stock, The use of NDVI is still relevant for biomass and carbon stock estimation in a mangrove ecosystem. Estimated carbon stocks can be done using remote sensing data with the good enough result, which is Total Carbon Stock is 30.15 ± 12.916 tonC ha-1 with an estimate of the Above Surface Biomass is 61.87 ton ha-1, Below Surface Biomass is 82.10 ton ha-1 and Total Accumulation Biomass is 143.97 ton ha-1.

| | Statistics (t ha-1) | | |
|---|---|---|---|
| | Mean± SD | Max | Min |
| NDVI | 0.58± 0.108 | 0.719 | 0.243 |
| ASB | 27.56± 11.81 | 61.87 | 0 |
| BSB | 36.58 ± 15.67 | 82.102 | 0 |
| TAB | 64.15 ± 27.48 | 143.97 | 0 |
| TCS | 30.15 ± 12.91 | 67.66 | 0 |

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