



## Geospatial assessment of mangrove distribution across the Niger Delta

Ebong Mbuotidem Sampson, Rogers I Wilcox, Joseph C Udoh, Ubong Douglas

Department of Geography and Natural Resources Management, University of Uyo, Nigeria

### Abstract

Mangrove ecosystem is a most valuable ecosystem that renders various types of services. The Nigerian mangrove ecosystem is one of the largest in the world and most exploited yet it is still one of the most understudied mangrove ecosystems. Relative to other mangrove ecosystems, the Nigerian mangrove ecosystem has a low data quotient.

**Aim:** The aim of this study is to assess the distribution of mangrove ecosystem across the Niger Delta region of Nigeria in order to determine the nature of the distribution.

**Methodology:** Geographical Information Systems, field surveys and statistical techniques were used to show the nature of the distribution of mangrove forest in the area.

**Results:** The results show that there is similarity and no significant variation in the distribution of mangroves across the Niger Delta implying that most of the mangrove species are common to all areas in the Niger Delta. Also, the originality of the mangrove sustenance is threatened by the invasive Palm specie- *Nypa fruticans*.

**Conclusion:** This study has shown mangrove distribution across the Niger Delta and has analysed the variation in the distribution to show that the distribution is similar. It has shown that the original red mangrove the *Rhizophora* family is threatened by its invasive neighbour the palm specie- *Nypa fruticans* which acts to alter the mangrove ecosystem by modifying the ecosystem as it increases thereby compromising the original ecosystem services of the mangrove ecosystem and compromising original mangrove integrity as an internal enemy. NDVI analysis has shown a <1 indicating low vegetation index which is readily attributed to anthropogenic vegetation depletion thus putting the mangrove sustainability at threat externally.

**Keywords:** geospatial assessment, mangrove distribution, Niger Delta

### Introduction

Mangrove swamps in Nigeria stretch along the entire coastline, which is characterised by high rainfall and humid conditions.

The largest expanse of mangroves is found in the Niger Delta between the region of the Benin River in the west and the Calabar, Rio del Rey estuary in the east. A maximum width of 30 to 40 km of mangroves is attained on the flanks of the Niger Delta, which is itself a highly dynamic system.<sup>[5]</sup> Mangroves have numerous benefits wherever present. Most importantly mangroves act as a buffer that protects coastal communities from natural hazards<sup>[2]</sup> such as tropical storms, strong winds, beach erosion, and even tsunamis<sup>[11]</sup>. Mangroves are also known as blue carbon sinks because they can transfer and store carbon in their sediments more than those of terrestrial forests<sup>[9]</sup>.

### Materials and Methods

#### Location of Study Area

The Niger Delta lies in the southernmost part of Nigeria most of its states forming the shore line of Nigeria. It is located in Latitudes 4° 30' & 7° 40' N and Longitude 4° 20' & 9° 20' E (Fig 1). It has a total land area of 112,110 km<sup>2</sup> which is 12% of the total Nigerian landscape, It is bordered to the south by the Atlantic Ocean and East by Cameroon<sup>[8]</sup>.

It is in the tropical rainforest vegetation belt of Nigeria which is of great importance globally as a carbon sink which is critical to world climatic stabilization. It also bears high economic importance as it is the source of major revenue to the Nigerian Government due to the oil and gas exploration.

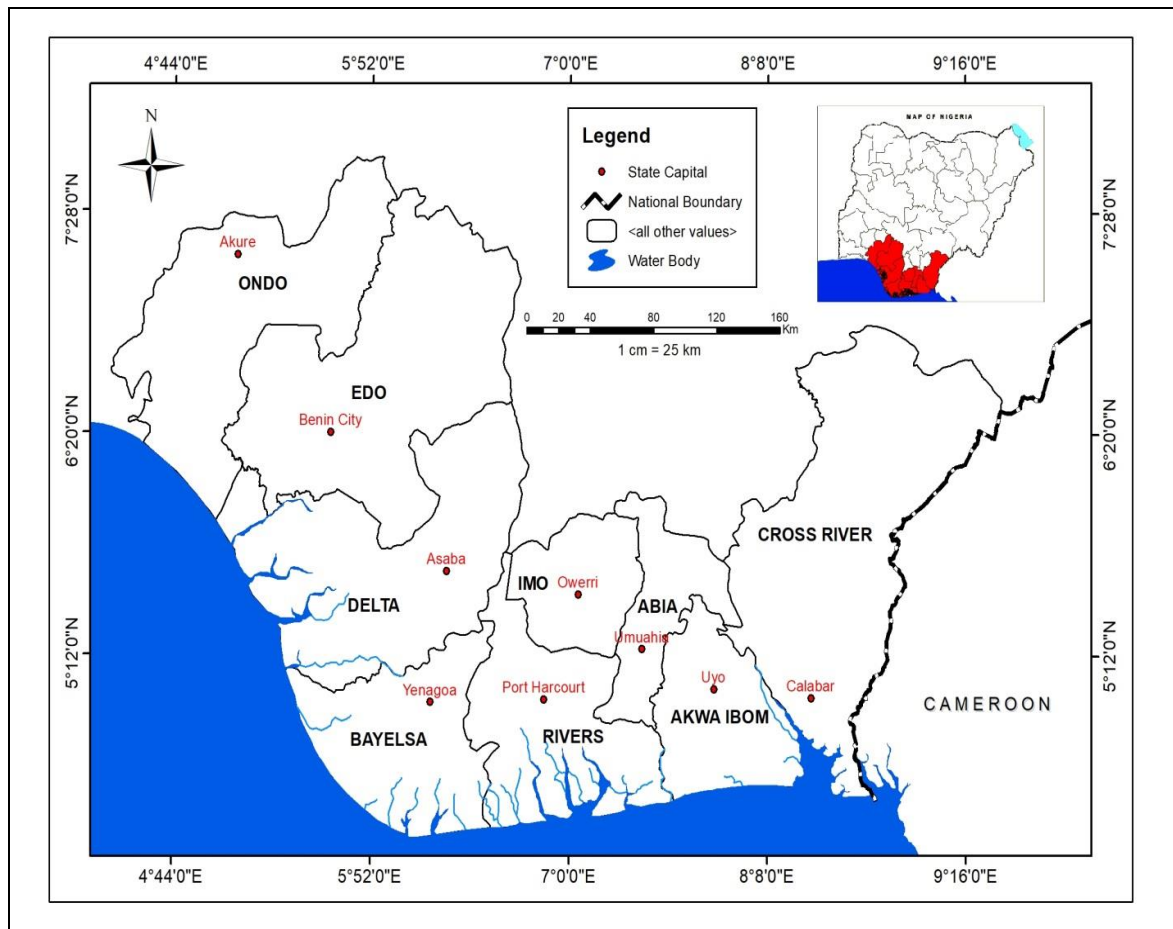
#### Field Data

The field studies were carried out throughout various ecological communities in the Niger delta. Ranging from forests to river estuaries and was carried out by<sup>[8]</sup> for Buguma and Okrika Forest,<sup>[10]</sup> for Cross River Estuary, Kwa Iboe river estuary, and Imo River Estuary,<sup>[4]</sup> Buguma And Okrika Forest. In order to represent species heterogeneity, Barbour's method was used<sup>[1]</sup>. This include:

- a. Locating quadrats in a completely random fashion
- b. Locating quadrats in a restricted or stratified random manner (stratified random sampling).

### Buguma and Okrika

A study on species distribution was conducted between seaward and landward sites in Buguma. Along a 20 m transect running across the middle of the plot, eight equally spaced points were identified and soil samples collected and species composition and diversity indices estimated from seaward to landward locations. Floristic diversity, which is the percentage occurrence of mangrove species present around the forests, was determined within a 5 × 5 m<sup>2</sup> sub-plots within a 20 × 20 m plot in Buguma and Okrika.



**Fig 1:** Niger Delta.

### Cross River Estuary

A 20 m by 20m quadrant was established along a transect line. The total number of quadrants placed were 28. From these, species abundance was determined only the dominant species type in each segment was established. The study considered both mangrove species and the domineering brackish water palm *Nypa fruticans*. The quadrant spanned across Okobo Island, Oron-Esuk Ewang and Effiat Mbo.

### Kwa Ibo River Estuary

A 20 m by 20m quadrant was established along a transect line. The total number of quadrants placed were 10 following this pattern. From these, species abundance was determined only the dominant species type in each segment was established. The study considered both mangrove species and the domineering brackish water palm *Nypa fruticans*.

### Imo River Estuary

A 20 m by 20m quadrant was established along a transect line. The total number of quadrants placed were 35. From these, species abundance was determined only the dominant species type in each segment was established. The quadrant spanned across the eastern obolo segment. The study considered both mangrove species and the domineering brackish water palm *Nypa fruticans*.

### Escravos Community

The study site covers 7 transects across the Ogidigben, Okegbe, Olegin and Madagho, Ugbagboro, Remure and Kpokpo communities in Warri North Local government Area of Delta state. Floristic data were collected in each of the area using the plot less method of Curtice and Cottom (1956) at preselected points, approximately 5 km apart. At each point along the direction of the transect-Point Centre Quadrat (PCQ), the area was divided into 4 quarters.

### Normalised Differentiated Vegetation Index [NDVI]

NDVI was computed to identify the general vegetation richness index for the area. The NDVI value pixel by pixel ranges between -1 and +1. The implication being that higher values of NDVI indicate the richer and healthier vegetation.

The NDVI image was computed from the band 3 and band 4 reflectance data for 2016 while the NDVI was calculated in ArcGIS using the map algebra function with the formula below:

$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$

Where,

NIR = the near infrared

RED = the red reflectance

### Analysis of Variance

ANOVA was used to check the variation of mangrove species distribution across the Niger Delta. This was necessary to determine if there is similarity and uniformity in the mangrove occurrence of there exist spatio-temporal differences.

### Analysis of Results

#### Buguma and Okrika

For Buguma and Okrika forest community, five mangrove species were discovered to dominate the landscape and two major palm species. Shannon wiener's diversity index was calculated for the study area.

**Table 1:** Shannon wiener diversity index (H) for major mangrove species.

Scientific Name	Colour	Abundance	Poportion (Pi)	Ln(Pi)	PLn(Pi)
Rhizophora mangle	Red	5	0.21	-1.561	-0.328
Rhizophora racemosa	Red	8	0.33	-1.109	-0.366
Rhizophora harrisoni	Red	2	0.08	-2.526	-0.202
Avicennia germinans	White	6	0.25	-1.386	-0.347
Laguncularia	Black	3	0.13	-2.040	-0.264
Total		24		H	1.508

**Table 2:** Shannon wiener diversity index for major non-mangrove palm species.

Scientific Name	Common Name	Abundance	Poportion (Pi)	Ln (Pi)	PLn (Pi)
Nypa fruticans	Nypa palm	5	0.83	-0.186	-0.154
Elaeis guineensis	Date palm	1	0.17	-1.772	0.366
Total		6			0.52

**Table 3:** Percentage species abundance for Buguma and Okrika

Scientific name	Abundance	Percentage abundance
Rhizophora mangle	5	16.67
Rhizophora racemose	8	26.67
Rhizophora harrisoni	2	6.67
Avicennia germinans	6	20
Laguncularia	3	10
Nypa fruticans	5	16.67
Elaeis guineensis	1	3.33
Total	30	100

### Cross River Estuary

For Cross River Estuary, three major mangrove species were discovered by the field studies that dominates the mangrove landscape. The abundance level of each species was computed.

**Table 4:** Mangrove and palm species abundance in Cross River Estuary.

Scientific Name	Abundance	Percentage Abundance
Rhizophora racemosa	6	21.43
Nypa fruticans	16	57.14
Avicennian Africana	6	21.43
Total	28	100

### KWA IBO RIVER ESTUARY

In Kwa Ibom River estuary, four domineering mangrove species were discovered. Three of them being pure mangrove species and one being a palm species.

**Table 5:** Mangrove and palm species abundance in Kwa Ibo River Estuary

Scientific Name	Abundance	Percentage Abundance
Rhizophora racemosa	3	27.27
Nypa fruticans	6	54.54
Avicennian Africana	1	9.09
Laguncularia racemosa	1	9.09
Total	11	100

### IMO RIVER ESTUARY

Imo River Estuary presents two dominant original mangrove species and one palm species.

**Table 6:** Mangrove and palm species abundance in Imo River Estuary

Scientific name	Abundance	Percentage Abundance
Rhizophora racemose	14	40
Nypa fruticans	15	42.86
Avicennian Africana	6	17.14
Total	35	100

### ESCRAVO AND ENVIRONS MANGROVE FORESTS

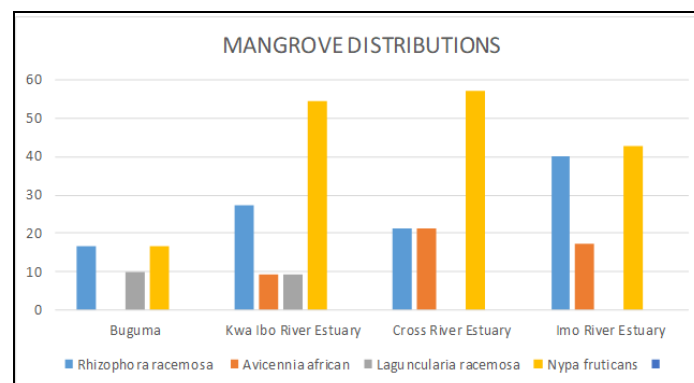
In escravos community seven mangrove forest sites was studied. It was discovered that three Mangrove and one palm species was dominant.

**Table 7:** Mangrove Species Distribution in Escravos and environs.

Species	Ogidigben	Okegbe	Olegbin	Madagho	Ugbagboro	Remure	Kpokpo	Total	Percentage Abundance %
Avicennia aficana	-	-	16	18	17	19	-	70	22.01
Rhizophora racemosa	10	-	2	18	23	19	-	72	22.64
Laguncularia racemosa	-	18	14	-	16	10	-	58	18.24
Nypa fruticans	-	-	43	43	32	-	-	118	37.11
Total	10	18	75	79	88	48	-	318	100
Percentage Proportion %	3.14	5.66	23.58	24.84	27.67	15.09	0	100	

**Table 8:** Mangrove Species distribution across study sites

Species	Buguma	Kwa Ibo River Estuary	Cross River Estuary	Imo River Estuary	Escravos Community Forest
Rhizophora racemosa	16.67	27.27	21.43	40	22.64
Avicennia Africana	0	9.09	21.43	17.14	22.01
Laguncularia racemosa	10	9.09	0	0	18.24
Nypa fruticans	16.67	54.54	57.14	42.86	37.11



Source: Fieldwork

**Fig 2:** Mangrove distribution in the Niger Delta

**Table 9:** ANOVA data calculation table.

Location	Rhizophora racemosa (X1)	X1 <sup>2</sup>	Avicennia africana (X2)	X2 <sup>2</sup>	Laguncularia racemosa(X3)	X3 <sup>2</sup>	Nypa fruticans (X4)	X4 <sup>2</sup>
Buguma	16.67	277.89	0	0	10	100	16.67	277.67
Kwa Ibo River Estuary	27.27	743.65	9.09	82.63	9.09	82.63	54.54	2974.61
Cross River Estuary	21.43	459.24	21.43	459.24	0	0	57.14	3264.98
Imo River Estuary	40	1600	17.14	293.78	0	0	42.86	1836.98
Escravos Community forest	22.64	512.57	22.01	484.44	18.24	332.69	37.11	1377.15
Total	128.01	3593.35	69.67	1320.09	37.33	515.32	208.32	9731.39

TSS= 5333.08  
 D/F=N-1= 19  
 BSS= -4432.33  
 D/F= N-1=3  
 WSS= TSS-BSS  
 = 9765.41  
 D/F= 19-3 =16

**Table 10:** Anova Table

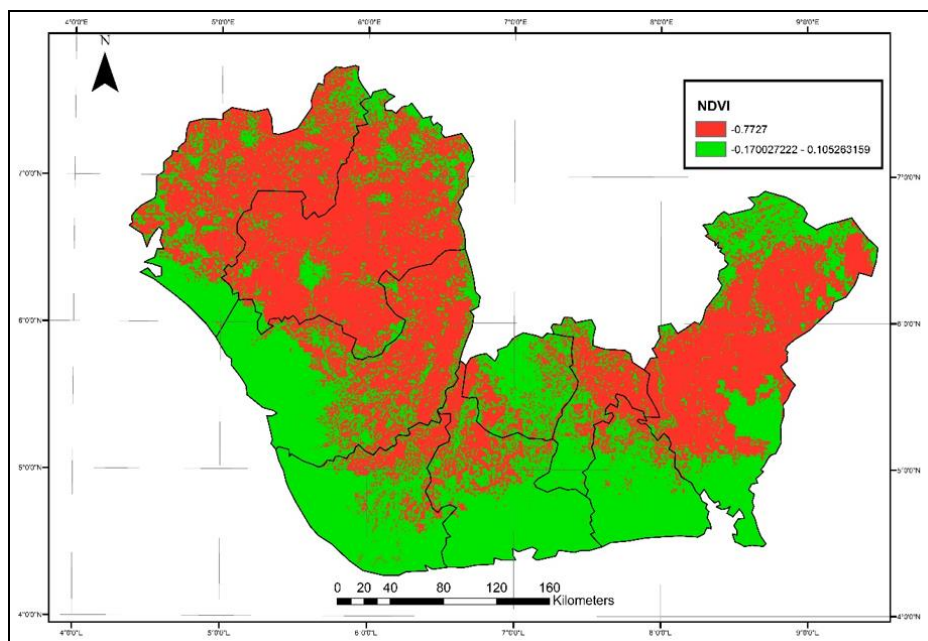
Source of variation	Sum of Square	D/F	Variance Estimate
BSS	-4432.33	3	-1477.44
WSS	9765.41	16	610.34
TSS	5333.08	19	280.69

Calculated F=  $\frac{\text{Greater variance estimate}}{\text{Lesser variance estimate}} = -2.42$

Calculated F= -2.42  
 D/F= 2 under 3 @ 0.05  
 =9.55

**Decision**

since the table value is greater than the calculated value we conclude that there is no significant variation in the distribution of Mangrove species in the Niger Delta.



**Fig 3:** NDVI for Niger Delta 2018

### Discussion of Findings

The study has discovered that across the Niger Delta, the originality of the Mangrove ecosystems still remains but is threatened. In Escravos community where seven mangrove sites were studied most ¾ were rich in at least 2 types of Mangroves species or one palm species. In Fig 2 it is shown that the mangrove flora common to all study areas across the Niger Delta is *Rhizophora racemosa* which is an original red mangrove species. This indicates that original mangrove still exists. *Laguncularia racemosa* is the least dominant mangrove flora specie. The NDVI was used to test the vegetation richness across the Niger delta. the result show that most of the area have a <1 value which indicates a general low vegetation index. The significance of this is to relate our study findings with the overview vegetation state. When Shannon wiener's index was computed for Buguma Okrika area, none of the species was up to 0.5 this indicates a poor vegetation-environment index, this was what the NDVI was meant to relate.

The ANOVA computation indicates no significant spatial variation in the distribution of mangrove across the study area. However the study reveals that apart from the original mangrove flora composition, there is a threat to the mangrove integrity by the invasive associated Palm specie *Nypa fruticans*. Across all study areas, *Nypa fruticans* dominates the mangrove study site in abundance rate with as high as 57% in Cross River Estuary. This poses threat to mangrove system integrity as the *Nypa fruticans* is highly invasive.

### Conclusion

The study has conducted a comprehensive analysis of Mangrove Distribution across the Niger Delta using, statistical techniques, Geo-spatial techniques, direct field studies. It has shown the dominant mangrove species across the Niger Delta not being particular to pure mangroves but showing the dominant flora observed in the study sites. Considering eleven study sites across four communities in Niger Delta, the study has evaluated mangrove distribution. it has discovered that there is at least still presence of Original red mangrove *Rhizophora racemosa* across all the study sites studied. However, the study has shown that the mangrove integrity is threatened by the invasive *Nypa fruticans* whose presence greatly overrides the original mangrove flora with a ration of 3:1. NDVI conducted showed that the area is generally experience a low vegetation index due to mostly anthropogenic vegetation depletion thus apart from the internal threat posed to the Mangrove by the *Nypa fruticans*, External vegetation depletion poses threats to not just the mangrove integrity but to the mangrove sustainability.

### References

1. Barbour MG, Burk JH, Pitts WD. Terrestrial Plant Ecology. Menlo park, CA: Benjamin Colins Publishing, 1987.
2. Chen C Son N, Chang N, Chen N, Chang L, Valdez M. "Multi-Decadal Mangrove Forest Change Detection and Prediction in Honduras. Central America, with Landsat Imagery and a Markov Chain Model." Remote sensing,2013;5:6408-6426. <https://doi.org/10.3390/rs5126408>.
3. Curtice JT, Cottom G. Plant Ecology Work Book: Laboratory Field Reference Manual. Burgess Publication Co., Minnesota, Pages, 1956, 163.
4. Ebigwa JK, Akomaye F. Species Diversity and Regeneration Potential of Some Mixed Mangrove Forests in Escravos Communities Delta State Nigeria. Research Journal of Forestry, 8: 34-47.
5. FAO UNEP. Tropical forest resources assessment project. Forest resources of tropical Africa. Part II: Country Briefs. Rome, 2006, 586.
6. Lawrence A. "Blue Carbon: A new concept for reducing the impacts of climate change by conserving coastal ecosystems in the Coral Triangle."WWF report, Brisbane, Queensland, 2012.
7. WWF-Australia. [http://www.taccire.suanet.ac.tz/\(10 June 2017\)](http://www.taccire.suanet.ac.tz/(10 June 2017)).
8. Mchenga ISS, Ali AI. "A review of status of mangrove forest in Zanzibar Island, Tanzania." International Journal of Research and Review,2015;2(8):518-526. [www.gkpublication.com](http://www.gkpublication.com).
9. Numbere Aroloye. Mangrove Species Distribution and Composition, Adaptive Strategies and Ecosystem Services in the Niger River Delta, Nigeria. 10.5772/intechopen.79028.
10. Rhyma P, Norizah K, Ismail Adnan AM, Shamsudin I. "A review of uses of satellite imagery in monitoring mangrove forests." Earth and Environmental Science,2016;37:1-14. <https://doi.org/10.1088/1755-1315/37/1/012034>.
11. Robert EE, Imoh U, Sola O, Idongesit E, Mbuotidem E, Edidiong RE. Journal of Geography, Environment and Earth Science, 2018.
12. International,2018;18(3):1-22. Article no.JGEESI.45953ISSN: 2454-7352
13. Spalding M, McIvor A, Tonneijck FH, Tol S, Van Eijk P. Mangroves for coastal defence: Guidelines for coastal managers & policy makers. Wetlands International and the Nature Conservancy. <https://www.nature.org/media/oceansandcoasts/mangroves-forscoastal-defence.pdf> (12 October 2017).