NRS 533: LANDSCAPE PATTERN AND CHANGE

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FINAL PROJECT

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LANDSCAPE PATTERNS IN MANGROVE ECOSYSTEM

BACKGROUND/INTRODUCTION

Mangroves are an assemblage of tropical and sub-tropical halophytes (i.e., salt tolerant) woody plants which grow in loose wet soils of brackish-to-saline estuaries an shorelines in the tropics and sub-tropics (Joshi and Ghose, (2003);Aheto, Owusu Aduomih, & Obodai, (2011);Heumann, 2011). This unique forest type was reported to have covered up to 75% of the world's tropical coastlines (Spalding et al., (1997);Vaiphasa, Skidmore, & de Boer, (2006). The total global mangrove coverage is estimated to be about 180,000 km^2 (Tam and Wong, 2000), distributed in 112 countries and territories in the tropics.

The ecological and economic benefits of mangroves are well established. Mangroves actively contribute over US$25,000 billion annually to the global economy through their provisioning, cultural and regulatory ecosystem services (Nellemann, et al., 2009). Globally, they are known to be the most productive and unique coastal ecosystems that support a wide range of goods and services (Field, (1999);Aheto et al, 2011). The ecosystem goods and services that mangroves provide include (i) protecting the coastline from tidal waves and storm surges; (ii) acting as biological filters in polluted coastal areas; (iii) supporting aquatic food-chains; and (iv) shielding a large number of juvenile aquatic organisms; (iv) reduction of greenhouse gas emissions.

Unfortunately, the health and persistence of mangroves are seriously threatened. Major threats to mangroves include logging for fuel and timber, land conversion to aquaculture, primarily shrimp ponds, coastal development for shipping, and the direct and indirect effects of urban development including fresh water diversions. According to Achim Steiner (UNEP Executive Director)"The most crucial, climate combating coastal ecosystems are disappearing faster than anything on land and much may be lost in a couple of decades…… If the world is to decisively deal with climate change, every source of emissions and every option for reducing these should be scientifically evaluated and brought to the international community's attention."

OBJECTIVE

The main objective of this project was to map and characterize two mangrove forests in Southwest Ghana. Specifically, the project sought to;

- Map the current spatial dimension or coverage of mangrove forests in two sites.
- Description of the landscape pattern of the two mangrove forests.
- Explore the relationship between grain size and landscape metrics.

METHODS

Study area

Two mangrove forests in the southwestern part of Ghana were used for the study. These were Bakanta and Bonyere sites. The Bakanta site, which is along the Amanzule and Ebi rivers, forms part of the Greater Amanzule Wetland, which is one of the important wetland ecosystems in the country. The Bonyere forest, on the other hand surrounds the Domini lagoon.

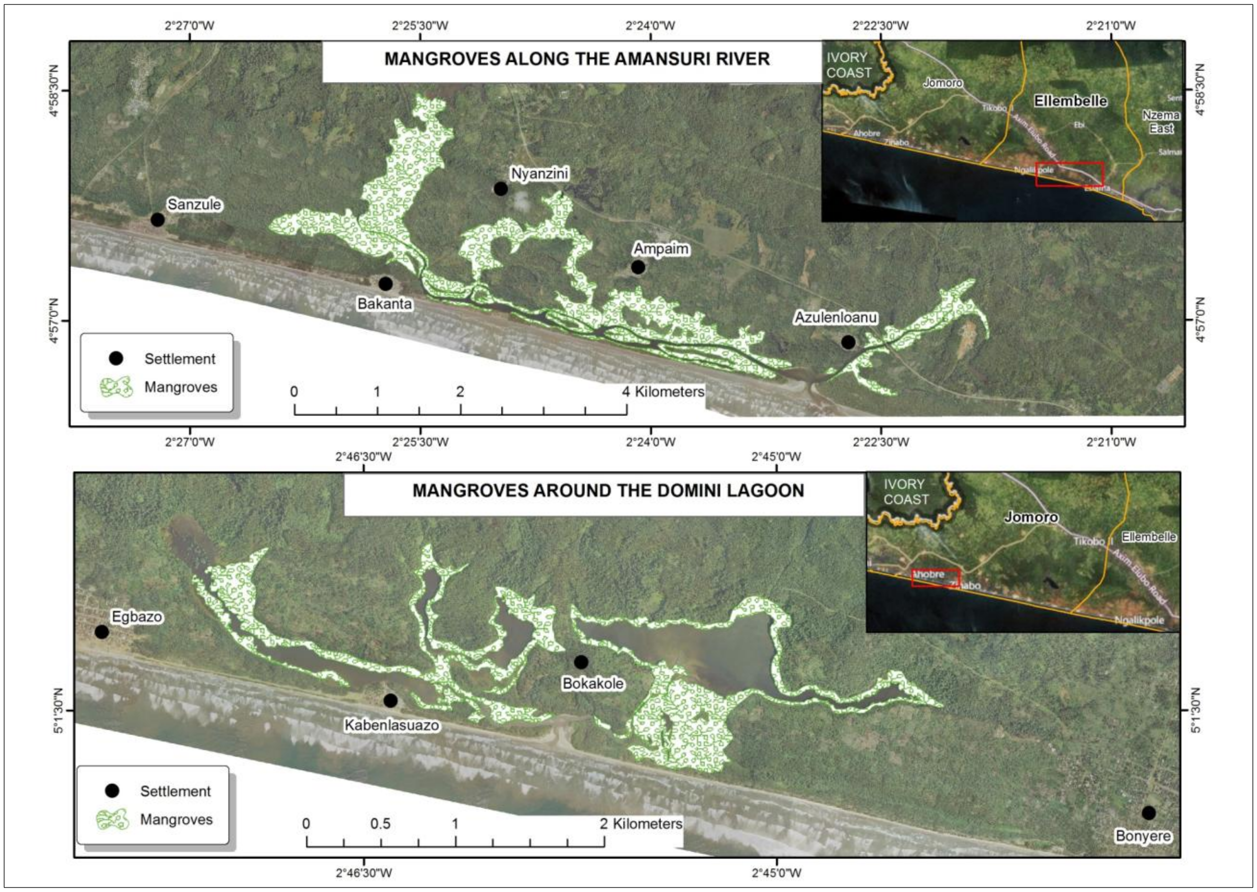


Figure 1: Map of the Study area showing the two sites

Despite their immense benefits to the surrounding communities, these forests are seriously threatened, by both the locals and investors. OFf the shore of these sites is the main oil field in Ghana, hence the west coast in general has become the hub of industrial activities, resulting in increased population and infrastructural development.

Data

Three main sources of data were employed in this study. These were remote sensing data, GPS data and GIS mapping with the local community members. An aerial ortho-rectified image which was acquired in 2005 served as the main imagery available for the study. The imagery had 3 spectral bands (RGB) and had a spatial resolution of 0.5 meters. A GPS survey of the two mangrove sites was conducted during summer to understand the landscape and also collect enough data for later classification and accuracy assessment. During the same period, a participatory mapping exercise was undertaken with the community members to delineate the mangrove coverage on printed maps. Additional data for this project was a Land cover/Land use (LCLU) map of the area that was developed by the Laboratory for Terrestrial Remote Sensing-URI.

Data preparation

The imagery which came in different tiles were mosaiked together and then a subset of the area of interest was taken for the two sites. This process was done with the ERDAS Imagine software (v 9.2) Polygons of potential mangrove areas were made from the LCLU data to inform the GPS mapping. The two sites were then visited for the mapping process-both the GPS mapping and the participatory GIS mapping.

Data from these sources served as the basis for the manual delineation of the major features through visual interpretation of the high resolution image data using ArcGIS 10.0. Additional visits to the sites helped to update the map. In all, five major land cover/land use classes were mapped, though the interest was on mangroves. The classes were Mangroves; other vegetation; water bodies; settlement and sandy beach.

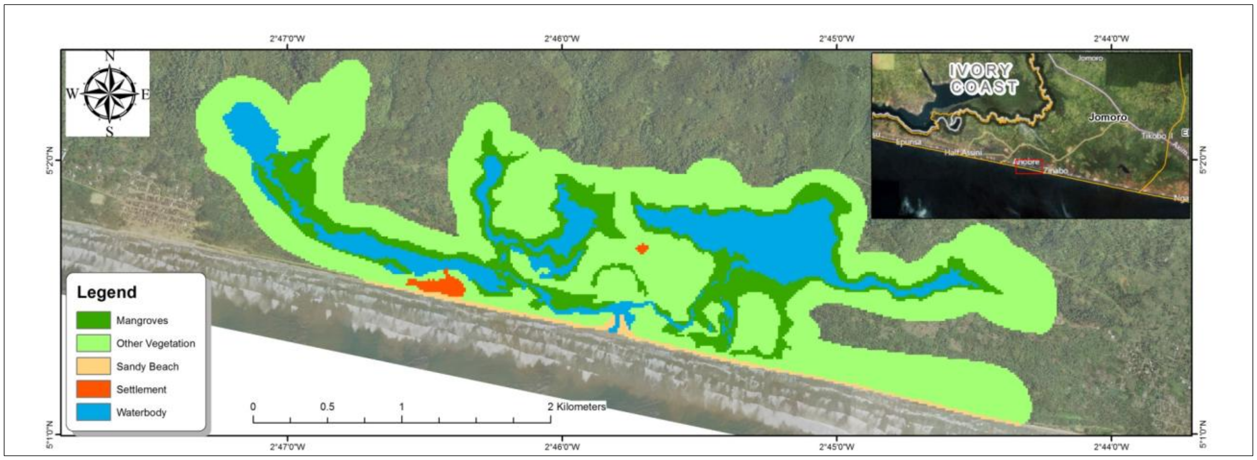


Figure 2: A Thematic map of the Bonyere Site showing the five LCLU classes

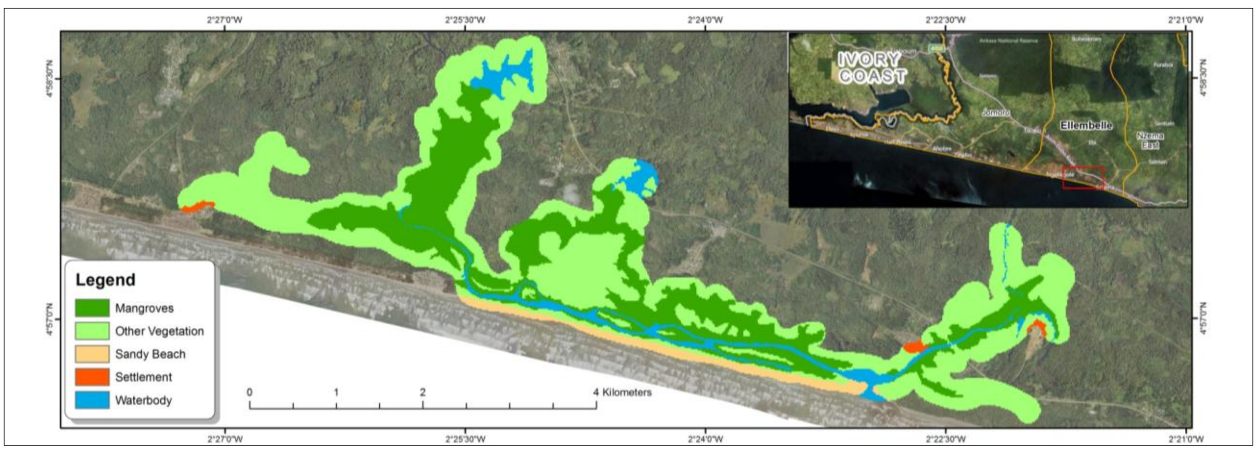


Figure 3:A Thematic map of the Bakanta Site showing the five LCLU classes

Analysis

In ArcMap, the polygons were converted into raster and saved in a .img format. The scale of the raster was specified as 15meters based on the size of the minimum mapping unit. The raster image was then imported into the Fragstats 4.1 software for further analysis. A class descriptor file was made to include the classes that should be used for the pattern analysis. Metrics in Fragstats which involve the patch edges in their computation requires an edge depth file which specifies the depth-of-edge between patches. For this study, an edge depth file was developed with a consistent depth of 20 meters.

In all nine (9) class- level metrics were computed in the Fragstats software for each site. These were the Total (Class) Area (CA), Percentage of Landscape (PLAND), Largest Patch Index (LPI), Total Edge (TE), Edge Density (ED), Total Core Area (TCA), Core Area Percentage of Landscape (CPLAND), Number of Disjunct Core Areas (NDCA), and Disjunct Core Area Density (DCAD).

Consequently, the grain size of the LCLU image for Bakanta study site was aggregated systematically into larger grain size using the majority rule. In ERDAS Imagine, the grain size was progressively changed from 1x1, 3x3,5x5 and 7x7. Eight(8) landscape level metrics were then computed for each of the resulting data with varying grain sizes. These metrics were the Number of Patches (NP), Patch Density (PD), Largest Patch Index (LPI), Edge Density (ED), Landscape Shape Index (LSI), Contagion (CONTAG), Mean Fractal Dimension Index (FRAC_MEAN), and Shannon's Diversity Index(SHDI)

Results

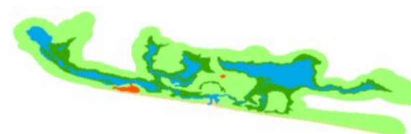
The first part of the results seeks to describe the landscape patterns of the two study sites with emphasis on mangroves. The second part, on the other hand will seek to validate the relationship between changing grain size and the results of the landscape level metric.

- Description of the landscape pattern of the two mangrove forests

The results of the class level metrics were useful for characterizing the landscape. It also allowed for the quantitative comparison of the patterns in the two sites.

TYPE	CA	PLAND	LPI	TE	ED	TCA	CPLAND	NDCA	DCAD
Other Vegetation	638.3025	56.5435	23.4035	75780	67.1291	559.3275	49.5476	55	4.8721
Waterbody	79.8975	7.0777	4.3132	40695	36.0493	40.5675	3.5936	50	4.4292
Mangroves	359.865	31.8783	25.4405	81915	72.5637	275.265	24.3841	44	3.8977
Settlement	7.1775	0.6358	0.2531	2055	1.8204	5.1525	0.4564	3	0.2658
Sandy Beach	43.6275	3.8647	3.793	7365	6.5242	35.5275	3.1472	2	0.1772

Figure 4:Results of the Class level metrics for Bakanta study site



TYPE	CA	PLAND	LPI	TE	ED	TCA	CPLAND	NDCA	DCAD
Other Vegetation	366.39	63.3915	61.8538	38475	66.568	324.945	56.2208	13	2.2492
Waterbody	97.74	16.9106	8.2023	31575	54.6299	67.2975	11.6436	31	5.3635
Mangroves	99	17.1286	8.9147	52500	90.8336	46.53	8.0505	76	13.1492
Settlement	3.87	0.6696	0.5995	1650	2.8548	2.2275	0.3854	2	0.346
Sandy Beach	10.98	1.8997	1.0628	5820	10.0696	3.8925	0.6735	47	8.1318

Figure 4:Results of the Class level metrics for Bonyere study site

From the two tables above, it is clear that the mangrove coverage in the Bakanta site (359.865 hectares) is thrice as big as the mangrove coverage in Bonyere (99 hectares). The total mangrove area of Bakanta and Bonyere of the total landscape were 32% and 17% respectively. Also, Bakanta site has bigger patches than Bonyere. This could be explained in relation to the adjacent water bodies. The Bakanta site is along a much longer river with two estuaries and smaller tributaries which provide regular source of saline water for mangroves. The Bonyere site on the other hand is a fringing mangrove forest which propagates only within a restricted area between the lagoon and coconut trees (the most important cash crop in the area). This situation is evident in the wide difference in the Largest patch index for Bakanta (25%) and Bonyere (9%). This means that the dominant patch in the Bakanta site is mangroves.

Interestingly, the Edge Density of Bonyere site was higher than that of the Bakanta site though the same edge depth was specified. The difference could be attributed to the dissimilarities in the total landscape area. Total Core area is the aggregation of all the areas in the patches that are greater than the specified edge depth. This is affected by the edge depth and the individual patch sizes. Another interesting observation is the Disjunct core area which is basically a spatially contiguous and functionally distinct core area. This therefore implies that the Bonyere site has more functionally distinct mangrove patches (76) than the Bakanta site (44)

- Exploring the relationship between grain size and landscape metrics

This part of the result presentation looks at the relationship between changes in grain size and the landscape metrics. It was done to validate the data based on the result of the study by Wu (2004). According to him, the effect of the changing grain size will lead to 1)simple scaling functions; 2) unpredictable, and 3) staircase-like behavior in the landscape level metrics.

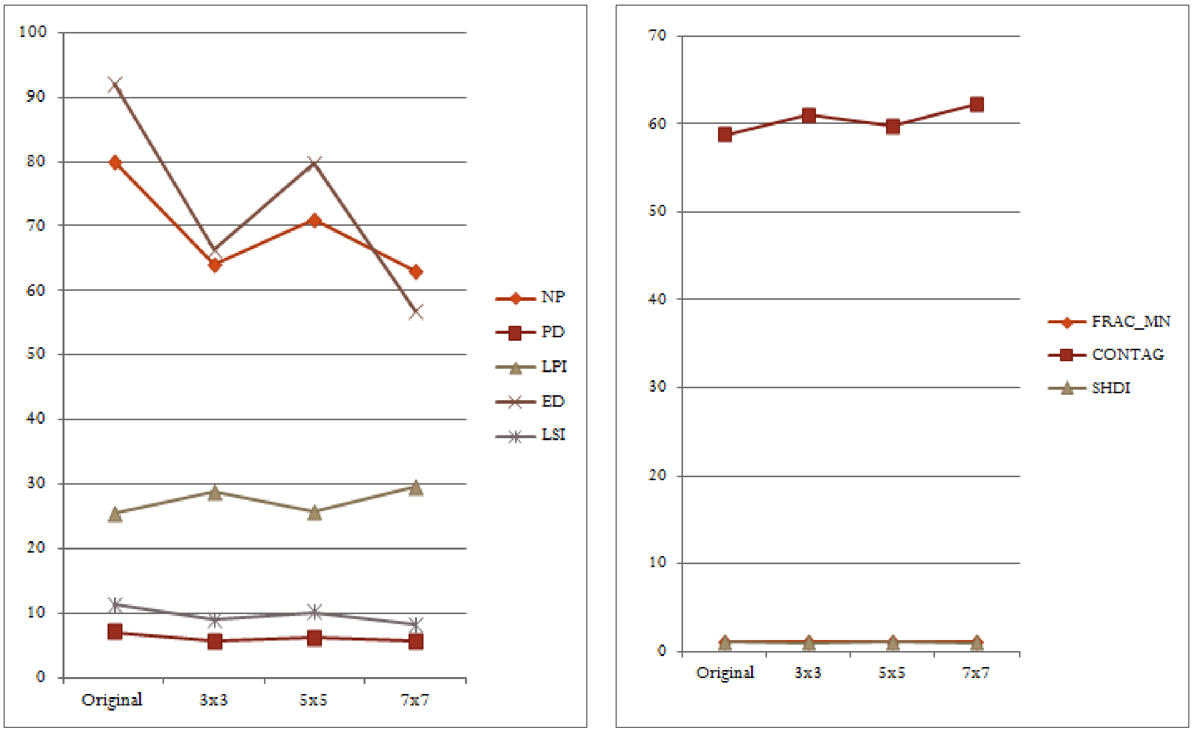


Figure 5:Graph of the scaling relation of some selected landscape level metrics

Contrary to the observation of Wu (2004), all the metrics tested had predictable scaling relation. Wu (2004) concluded that metrics like NP, PD, LP, ED and LSI produce simple scaling relations, which was true for this study also. However, the conclusion that Contagion and FRAC_MN produce unpredictable behavior could not be verified. The FRAC_MN showed a linear relationship. Another metric which could not agree with Wu (2004) was the SHDI which was linear instead of staircase.

DISCUSSION

The landscape pattern of the two sites have unique factors that affect both the composition and the configuration of the features in study. Mangroves depend on hydrology for survival, hence the configuration of the hydrology is very important. Surrounding the Domini lagoon and restricted by adjacent coconut trees, the mangroves in Bonyere have limited room for expansion. This situation, coupled with frequent cutting by members of the surrounding communities, the mangroves are really threatened. Though members of the Bakanta community also engage in mangrove cutting, the hydrology of the area provides avenue for replenishment.

The relationship between the grain size and the metrics as observed from the analysis could have two sides. It could mean that the scale of the data could be altered often to reduce the patchiness and still generate reliable metrics. It could also mean that the classification scheme should be revisited to avoid the effect of thematic resolution on my analysis (Buyantuyev and Wu (2006).

CONCLUSION

In order to evaluate and monitor this important ecosystem, there is the need for up to date data on the coverage of mangroves for subsequent monitoring. Remote sensing technology has been proven to be the most effective way of mapping mangroves. In this study, remotely sensed data were used alongside GPS survey and GIS participatory mapping to map the current coverage of mangroves in two sites in west coast of Ghana. The result was then analyzed using the Fragstats software to quantitatively characterize the landscape pattern.

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