Students Research Colloquium

Topic:
Land cover change and landscape fragmentation around a protected forest area in Southwest Ghana

By Isaac Kyere (FIT 2012)
(28th April 2014)
Changes in forest cover are particularly severe in the tropics and have severe significant impacts on such controversial issues as biodiversity and climate change. Malhi et al. (2010) points out, “tropical forests have a major influence on global patterns of biodiversity, ecosystem ecology, productivity and biogeochemical cycles, but they remain understudied”.
Understanding the complexity of landscapes require mapping the landscape through time, incorporating spatial relationships and quantifying its structure (Narumalani et al., 2004).

The process of forest fragmentation has had three components: an overall loss of forest, a progressive fragmentation of surviving forest stands into smaller blocks, and an increasing spatial isolation of fragments through time (Bennett, 1998, 2003).
Landscape fragmentation analyses can be used to interpret the impact of land cover changes on a particular habitat, by calculating for each land use/cover class a range of landscape metrics to describe fragmentation and spatial distribution, from satellite-based classifications (Southworth et al., 2004).
Thus, the application of remote sensing and landscape metrics can be combined to provide more spatially consistent and detailed information on landscape structure, which will facilitate the identification of the social and biophysical processes driving these changes (Brown et al., 2000; Harold et al., 2005).
Though several researches relating to land cover change in Ghana has been carried out but not much has been done to analyse land cover change and landscape fragmentation of forest reserves.

In addition, land use/cover studies that aimed at identifying environmental problems such as deforestation focused on land use/cover conversions without considering the actual landscape structural changes.
Therefore, a study and analysis of land cover change and landscape structure is important to understand the extent and implications of fragmentation within the landscapes.

The objective of this project is to analyse land cover change and landscape fragmentation in one of Ghana’s ecologically important forest reserves with the Landsat images.
Research Questions

- How much has the land cover of the Bia Tano forest reserve change within a period of 1989 to 2002?

- To what extent has the landscape become fragmented over the period of 1989 to 2002?
Study Area
Methodology

Image download

Landsat images of 1989 (Landsat 4 TM, path 195 and row 055) and 2002 (Landsat 7 ETM, path 195 and row 055) were downloaded from USGS database using longitude and latitude of -2.616667 and 7 respectively.

Image processing

To obtain the needed information from the raw images, they were processed with Erdas Imagine 2013, ArcGIS 10.0, and Patch Analyst 5;
Image processing workflow

1. Individual bands of Landsat 4 TM 1989
   - Atmospheric correction (ATCOR 2)
   - Supervised classification
   - Neighborhood (7x7 majority function)
   - Clipping
   - Reclassification
   - Conversion of Raster to polygon
   - Computation/Calculation
   - Results
   - Pan sharpening
4. Individual bands of Landsat 7 2002

Additional processing in ArcMap
Normalised Difference Vegetation Index (NDVI)

Stacked Image (1989)

NDVI

Clipping of AOI to NDVI image

Resulting image (NDVI of AOI)

Statistics

Stacked Image (2002)

NDVI

Clipping of AOI to NDVI image

Resulting image (NDVI of AOI)

Image Difference

Statistics
R codes for statistical Analysis

> install.packages("foreign") and > library(foreign). The following codes were then used for the statistical test;

# set working directory > setwd("I:\Data_Research_project\ATCOR")
# Read the dbf files of both NDVI values of 1989 and 2002 (i.e. attribute table from ArcGIS) and stores them in data frame of R
> dfrm89<-read.dbf("extracted.dbf",as.is=FALSE)
> dfrm02<-read.dbf("extracted3.dbf")
# checking for outliers (extreme minimum values)
> min(dfrm89$RASTERVALU)
> min(dfrm02$RASTERVALU)
# Exclude missing values (coded as -9999)
> dfrm89<-subset(dfrm89,dfrm89$RASTERVALU > -2)
> dfrm02<-subset(dfrm02,dfrm02$RASTERVALU > -2)

Furthermore, in checking for normality, histograms with curve for the NDVI values (dfrm89$RASTERVALU-1989 NDVI, dfrm02$RASTERVALU-NDVI 2002) of both years were plotted using the found below set of codes;

# > hist(dfrm89$RASTERVALU,breaks=30,xlab="NDVI",main="Histogram of 1989 NDVI values",prob=TRUE)
#> curve(dnorm(x, mean(dfrm89$RASTERVALU), sd(dfrm89$RASTERVALU)), add=TRUE
#> hist(dfrm02$RASTERVALU,breaks=30,xlab="NDVI",main="Histogram of 2002 NDVI values",prob=TRUE
#> curve(dnorm(x, mean(dfrm02$RASTERVALU), sd(dfrm02$RASTERVALU)), add=TRUE)

To be sure of the normality, Kolmogorov test was done for both years NDVI values using the codes;

> ks.test(dfrm89$RASTERVALU, "pnorm")
> ks.test(dfrm02$RASTERVALU, "pnorm")
Landscape metrics analysis (Fragmentation)

- Using patch analyst 5 extensions for ArcGIS, certain landscape metrics or spatial statistics were computed to access the fragmentation of the study area.
Results

Land cover map of the study area

1989

2002

Legend
- Forest
- Non-forest
- Water bodies

0 31,500 63,000 126,000 Meters

By: Isaac Kyere (FIT 2012)
## Share of Land cover classes

<table>
<thead>
<tr>
<th>Year</th>
<th>Land cover</th>
<th>Area (ha)</th>
<th>%Area</th>
<th>Total Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
<td></td>
<td></td>
<td>3278217.01</td>
</tr>
<tr>
<td>1989</td>
<td>Forest</td>
<td>2814379.0</td>
<td>85.85%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-forest</td>
<td>415042.29</td>
<td>12.66%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3229421.31</td>
<td>98.51%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water bodies</td>
<td>48795.70</td>
<td>1.49%</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>land</td>
<td></td>
<td></td>
<td>3278216.47</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>1987662.91</td>
<td>60.63%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-forest</td>
<td>1282568.94</td>
<td>39.12%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3270231.85</td>
<td>99.76%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water bodies</td>
<td>7984.62</td>
<td>0.24%</td>
<td></td>
</tr>
</tbody>
</table>
## Changes in Land cover classes

<table>
<thead>
<tr>
<th>Changes (ΔArea)</th>
<th>Land cover</th>
<th>Area (ha)</th>
<th>%Area</th>
<th>Relative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Forest</td>
<td>-826716.11</td>
<td>-25.22%</td>
<td>-29.37%</td>
</tr>
<tr>
<td></td>
<td>Non-forest</td>
<td>+867526.65</td>
<td>+26.46%</td>
<td>+30.53%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>+40810.54</td>
<td>+1.24%</td>
<td>+1.26%</td>
</tr>
<tr>
<td><strong>Water bodies</strong></td>
<td></td>
<td>-40811.08</td>
<td>-1.25%</td>
<td>-83.63%</td>
</tr>
</tbody>
</table>
Normality Test for NDVI values

Histogram of 1989 NDVI values

Histogram of 2002 NDVI values

> ks.test(dfrm89$RASTERVALU, "pnorm")

One-sample Kolmogorov-Smirnov test

data: dfrm89$RASTERVALU
D = 0.4974, p-value < 2.2e-16
alternative hypothesis: two-sided

ks.test(dfrm02$RASTERVALU, "pnorm")

One-sample Kolmogorov-Smirnov test

data: dfrm02$RASTERVALU
D = 0.4224, p-value < 2.2e-16
alternative hypothesis: two-sided
Hypothesis Test

```r
> wilcox.test(dfrm89$RASTERVALU, dfrm02$RASTERVALU, paired=TRUE)
```

Wilcoxon signed rank test with continuity correction

Data: dfrm89$RASTERVALU and dfrm02$RASTERVALU

V = 8132987742, p-value < 2.2e-16

Alternative hypothesis: true location shift is not equal to 0
Highlight of change from Image Difference
<table>
<thead>
<tr>
<th>Parameter</th>
<th>1989</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>0.73</td>
<td>0.36</td>
</tr>
<tr>
<td>Mean</td>
<td>0.12</td>
<td>-0.05</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>deviation</td>
<td>0.35</td>
<td>0.24</td>
</tr>
</tbody>
</table>

**Date of image**

- 1989
- 2002
# Landscape Metrics for the classes

<table>
<thead>
<tr>
<th>Indices</th>
<th>1989 Land cover classes</th>
<th>2002 Land cover classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSI</td>
<td>Forest 1.31</td>
<td>Non-forest 1.33</td>
</tr>
<tr>
<td>MPFD</td>
<td>1.32</td>
<td>1.32</td>
</tr>
<tr>
<td>NumP</td>
<td>3639</td>
<td>9509</td>
</tr>
<tr>
<td>CA</td>
<td>2814379.02</td>
<td>415042.29</td>
</tr>
<tr>
<td>AWMSI</td>
<td>24.78</td>
<td>17.66</td>
</tr>
<tr>
<td>Indicies</td>
<td>1989</td>
<td>2002</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>SDI*</td>
<td>0.46</td>
<td>0.69</td>
</tr>
<tr>
<td>SEI*</td>
<td>0.41</td>
<td>0.62</td>
</tr>
<tr>
<td>MSI</td>
<td>1.33</td>
<td>1.28</td>
</tr>
<tr>
<td>MPFD</td>
<td>1.33</td>
<td>1.35</td>
</tr>
<tr>
<td>NumP</td>
<td>18267</td>
<td>83834</td>
</tr>
<tr>
<td>MPS</td>
<td>179.46</td>
<td>39.10</td>
</tr>
<tr>
<td>AWMSI</td>
<td>23.54</td>
<td>56.44</td>
</tr>
</tbody>
</table>
Forests in Africa are believed to have been cleared 29 times faster than they were being planted in the early 1980s compared to 10.5 in Tropical America and 4.5 in Tropical Asia (Holmberg, Bass and Timberlake, 1991).

In relation to above, the study has revealed the extent of land cover change and landscape fragmentation in the Bia Tano Forest Tano (which is one of Ghana’s protected areas) within a 13 year period.
The area saw an intensive forest cover loss and a reduction in the water bodies within the reserve with an increase in non-forest areas.

Logging is one of the main reasons for forest fragmentation, and although it may change the landscape structure at a small spatial scale and not alter the structure of the entire forest mosaic (Leimgruber et al., 2002), it can be associated with
dramatic changes in the structure and composition of the forests (Echeverría et al., 2007), and the Bia forest reserve is not an exception to this assertion.

**Limitation of the Research**

No accuracy assessment using ground control points was done to ensure the reliability of the classified map obtained from the satellite images and neither were the results compared with any empirical data.
References


Thank You