COMMUNITY PARTICIPATION IN FOREST MANAGEMENT ACROSS PROTECTED AREAS IN SOUTH EASTERN NIGERIA

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ABSTRACT

The overall aim of this paper was to assess the level of deforestation across three selected protected area clusters assigned as REDD (Reducing Emissions from Deforestation and Forest Degradation) pilot sites in Cross River State over two 14 year periods (1986 – 2000 and 2000 – 2014) using multi-temporal remote sensing techniques and ground verification data. The annual deforestation rate for Afi-Mbe cluster declined from 2.1% to 0.5% over both 14-year periods investigated. A similar trend was observed in Ekuri-Ukpon-Cross River South cluster where annual deforestation declined from 1.2% in the first 14-year period to 0.1% in the second 14-year period. However, the mangrove forest cluster experienced a rise in the annual rate of deforestation over both 14-year periods investigated from 0.8% to 4.5%. These results showed that Afi-Mbe and Ekuri-Ukpon-CR South clusters (both managed by local communities, government and conservation organisations) experienced decline in deforestation and subsequent rise in afforestation over the time period investigated. The rapid rise in deforestation across the mangrove forest cluster was attributed to a number of factors which included massive exploitation of forest resources and pressures from high human population, commercial agriculture and immense levels of industrialisation. Based on inputs from local community stakeholders a number of deforestation drivers were identified and ranked in order of magnitude of highest to least and included thus: subsistence agriculture, fuel wood harvesting, logging/timber extraction and commercial agriculture.
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Keywords: Local Community, Deforestation, Remote Sensing, UN-REDD

INTRODUCTION

Historically, forest monitoring has been performed by external professionals who use strict scientific approaches (Angelsen *et al.,* 2009). However, in recent times these responsibilities have been successfully implemented by local community members through participatory and locally appropriate techniques (Palmer Fry, 2011). With the right training on appropriate methods of data acquisition, local people can collect reliable, accurate and precise information on a range of indicators including carbon (Danielsen *et al*., 2013), deforestation (Danielsen *et al*., 2011) and biodiversity (Brashares and Sam, 2005, Topp-Jorgensen *et al*., 2005, Jones *et al*., 2008, Skutsch *et al*., 2009, Rist *et al*., 2010).

The scope of community forest management is characterised by local communities' actively involved in management strategies established by the government (Clark *et al*., 2008). An example of such is demonstrated in Ekuri community situated in Cross River State (CRS), where the Community Based Forest Management Scheme approach is adopted. In this scheme, locals are given full responsibility and ownership as to how their forests are managed. Such schemes usually empower local community to enforce and confront illegal forest activities with adequate support from the Government (Brunner *et al*., 1999, UNDP, 2012). As demonstrated in Ekuri community, impending threats from commercial and industrial activities such as illegal logging has been mitigated through declaring ancestral forests situated in Ekuri as community conserved areas and enforcing the conservation of forests and wildlife through local community participation (Pathak *et al*., 2005). Similar community forestry/conservation initiatives are demonstrated in the Afi Mountain Wildlife Sanctuary (AMWS) with participants from surrounding villages. The AMWS is managed by Cross River State Forestry Commission (CRSFC) in partnership with four key nongovernmental organisations (NGOs) in the state, namely Wildlife Conservation Society (WCS), Pandrillus, Nigerian Conservation Foundation and Fauna and Flora International. In addition to AMWS, WCS is actively involved in the Cross River National Park (Okwangwo division), Mbe Mountains, and the Afi River Forest Reserve. Conservation efforts in the Iko Esai community of CRS, has been supported by CERCOPAN for over 12 years running.

In other parts of the world, studies have demonstrated the effectiveness of community forest management as a means to combating the threat of deforestation and forest degradation (Bray *et al.*, 2003, Ellis and Porter-Bolland, 2008, Smith *et al.*, 2014). In the study conducted by Ellis and Porter-Bolland (2008), two distinct study sites one under community-based forest management and the other a protected area were compared to evaluate the efficiency of community forest management. The results showed that forest conservation influenced by inputs from local communities greatly assisted in the conservation of forest in comparison to forest with protected area status. The influence and contribution from local communities in forest conservation has shown to be an effective means of reducing deforestation, as the locals tend to depend less on activities that greatly degrade the forest landscape present in such communities. In Tanzania, local communities are involved in two main forms of forest management: the Joint Forest Management (JFM) and Community Based Forest Management (CBFM) (Zahabu, 2006). Under the JFM, government involves local communities by engaging them in a number of activities (such as patrolling, clearing of boundaries and fire fighting), while for the CBFM local communities are the sole owners of the forests and take full responsibility of all the activities. Results of studies conducted across Tanzania indicated that the involvement of local communities in forest management (be it under full or joint community forest management) has resulted to a significant reduction in deforestation and forest degradation thereby resulting in carbon sequestration rise (Murdiyarso and Skutsch, 2006).

The use of satellite remote sensing combined with ground truth data has shown to be an effective tool for determining the extent of deforestation particularly for protected areas in tropical forest regions across the world (DeFries *et al.*, 2005, Ellis and Porter-Bolland, 2008). DeFries *et al.* (2005) analysed multiple satellite data to examine the spatial extent of forest habitats and loss over a period of two decades throughout the world's moist and dry tropical forests. Results of the study were able to estimate the percentage of protected areas affected by deforestation and proffer solutions on how well the reserve needed to be managed.

At present there is limited research on community participation in forest management across Nigeria. Hence, the overall aim of this study was to investigate the roles of local community participation in forest monitoring as tool to mitigating the effects of deforestation across three selected cluster sites in CRS. The key objectives of the study included thus: to determine the level of effectiveness associated with local community participation in forest conservation through spatially explicit results obtained using forest cover change analysis; and to conduct focus group discussions for selected local communities in selected cluster sites within CRS to ascertain the drivers of deforestation and forest degradation based on local knowledge.

Study Area

Geographically, CRS is situated in the South Eastern part of Nigeria, and bound by Latitudes 4° 27' to 5° 32'N and Longitudes 7° 50' to 9° 28'E with an approximate landmass area of 20,156 square kilometres (Figure 1). For this study, three key sites (later known as cluster sites) were selected. The cluster sites used in the study form part of the proposed pilot sites for the on-going United Nation REDD+ programme (Reducing Emissions from Deforestation and Forest Degradation) currently on-going in CRS, Nigeria. The sites of interest include: Afi-Mbe cluster, Ekuri-Ukpon-Cross River (CR) South cluster and Mangrove forest cluster (Figure 1). The sites Afi-Mbe and Ekuri-Ukpon-CR South clusters are made up of community forests and forest reserves, jointly managed by local communities, government (in the form of the Cross River Forestry Commission - CRFC) and conservation organisations (such as Wildlife Conservation

Society – WCS). In the Afi-Mbe cluster, the existing protected areas include the Afi Mountain Wildlife Sanctuary, Afi River Forest Reserve (FR), Mbe Mountains and a community forest south of the Cross River National Park (Okwangwo Division). The Ekuri-Ukpon-Cross River (CR) cluster is made of the Ukpon River FR, Ekuri Community Forest, parts of the Oban Block FR and the CR South FR. Unlike the afore-mentioned cluster sites, the Mangrove forest cluster lacks government supervision, participation of local community members in the management of its forests and limited involvement of conservation organisations.

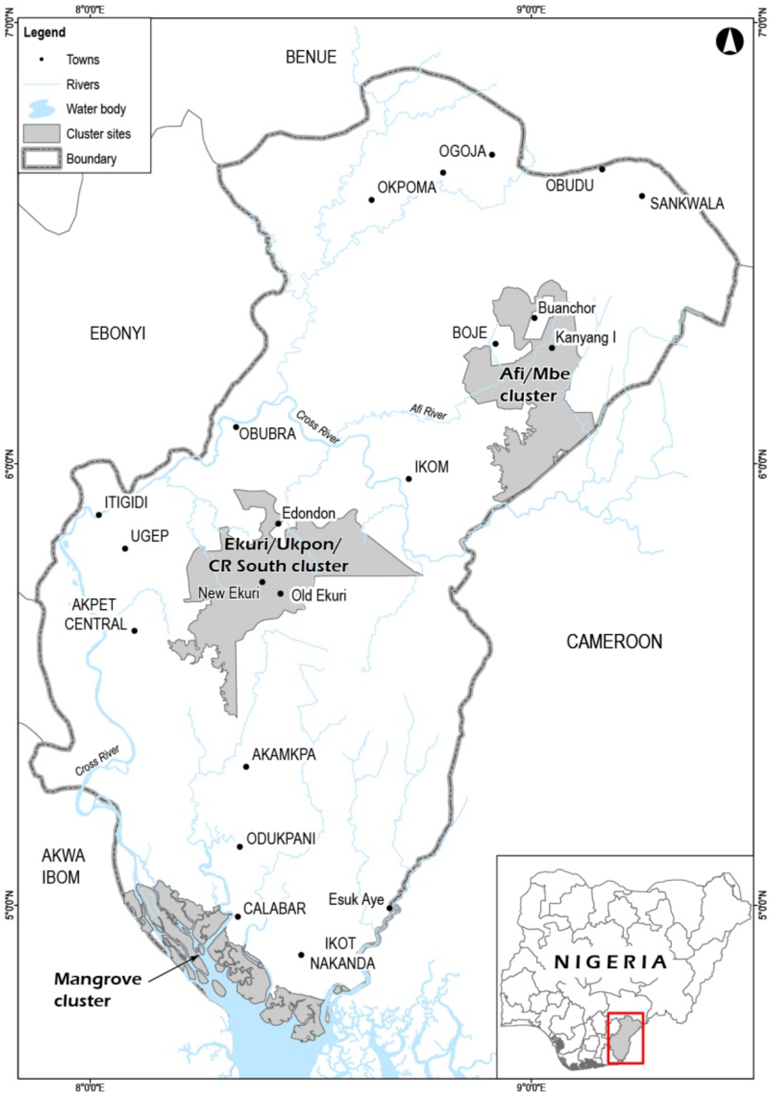

Figure 1: Map of Cross River State showing the Three Cluster Sites and an Insert Map of Nigeria

MATERIALS AND METHODS

Remote Sensing Analysis

Figure 2 presents the stages of image processing performed in the study. The satellite imagery used for this study was for three epochs, namely 1986, 2000 and 2014 respectively. The imageries included Landsat imageries (Thematic Mapper dated December 1986 and Enhanced Thematic Mapper – ETM+ dated December 2000) and UK-DMC-2 imagery dated January 2014). The Landsat imageries (TM and ETM+) were downloaded from the United States Geological Survey (USGS) Earth Explorer website (http://earthexplorer.usgs.gov/) while the UK-DMC-2 was supplied by the Nigeria Space Agency, NASRDA (National Space Research and Development Agency). Since the UK-DMC-2 sensors are cross calibrated with Landsat sensors, the near infrared, red and green bands of the afore-mentioned (i.e. bands 1, 2 and 3) are equivalent to Landsat bands 4, 3 and 2 (http://www.dmcii.com/). Description of the satellite imageries used in the study is presented in table 1 below. In order to avoid issues of seasonality variation the satellite imageries used in the study were acquired during the same season (i.e. dry season between November to February) (Malingreau *et al.*, 1995) (Table 1).

Table 1. Characteristics of Space Borne Satellite Imageries used in Sstudy

Platform / Sensor	Spectral resolution	Acquisition date	Path	Row	Spatial resolution (metres)
Landsat 5 TM (bands 3,4 & 5)	B3: 0.52-0.60µm (Green) B4: 0.63-0.69µm (Red) B5: 0.76-0.90µm (NIR)	12 Dec. 1986	187	55	28.5
		12 Dec. 1986	187	56	28.5
		12 Dec. 1986	187	57	28.5
		19 Dec. 1986	188	55	28.5
		19 Dec. 1986	188	56	28.5
		19 Dec. 1986	188	57	28.5
		12 Dec. 1986	187	55	28.5
Landsat 7 ETM+ (bands 3,4 & 5)	B3: 0.52-0.60µm (Green) B4: 0.63-0.69µm (Red) B5: 0.76-0.90µm (NIR)	27 Jan. 2001	187	55	28.5
		10 Dec. 2000	187	56	28.5
		10 Dec. 2000	187	57	28.5
		17 Dec. 2000	188	55	28.5
		17 Dec. 2000	188	56	28.5
		17 Dec. 2000	188	57	28.5
UK-DMC-2 (bands 1,2 & 3)	B1: 0.52-0.62µm (Green) B2: 0.63-0.69µm (Red) B3: 0.76-0.90µm (NIR)	7 Jan. 2014	N/A	N/A	22
					22
					22

The Landsat (TM and ETM+) and UK-DMC-2 imageries were geometrically corrected using the polynomial geometric model in ERDAS Imagine (ERDAS, 2014). As a means of utilising all spectral information contained in the satellite imageries, the process of eliminating atmospheric effects due to absorption and scattering of earth surface radiation during data acquisition was performed (Malingreau *et al.*, 1995).

Before image classification was performed, the spectral radiance of each band contained in the imagery were converted to at-satellite reflectance values using methods outlined in the Landsat 7 Science Handbook (Irish, 2000). In order to remove all forms of noise caused by instrumental errors, changes in views and illumination during acquisition and atmospheric effects all raw digital numbers (DN) of both Landsat (TM and ETM+) and UK-DMC-2 imageries were converted to at-reflectance values (Huang *et al* 2002; Iqual, 2012). These were calculated using equations 1 – 3 below.

$$L_{\lambda} = \left(DN_{\lambda} * Gain_{\lambda}\right) + Bias_{\lambda} \qquad (1)$$

$$L_{\mu} = \left(\frac{DN_{\mu}}{Gain_{\mu}}\right) + Bias_{\mu} \qquad (2)$$

$$\rho_{\lambda\mu} = \frac{\pi * L_{\lambda\mu} * d^2}{ESUN_{\lambda\mu} * \mathrm{Sin}\,\theta_{se}} \qquad (3)$$

where $L_{1/\mu}$ = Spectral radiance at aperture of Landsat & UK-DMC-2 sensor [W/(m^{2}sr µm)]; $DN_{1/\mu}$= Digital number values of Landsat and UK-DMC-2 imageries; $Gain_{1/\mu}$= gain values of specific bands in the image header files Landsat &

UK-DMC-2/NigeriaSat images; Bias $_{1/\mu}$ = gain values for specific bands in the image header files; π = 3.14159; d = Earth-Sun distance [astronomical distance]; $ESUN_{1/\mu}$ = Mean exoatmospheric solar irradiance [W/(m2 μm)]; θ_{se} = Solar / Sun elevation angle (degrees)(Huang *et al.,* 2002; Iqual, 2012). It's important to state here that the cosine of solar zenith is the same as the sine of solar elevation. The value of solar elevation is provided in the metadata file that comes with the downloaded Landsat image and accompanied with the UK-DMC-2 satellite imageries. In order to normalise the spatial scale differences between bands of imagery used in the study, all bands used were resampled to a pixel size of 30 metres. These imageries were subsequently used in ISODATA classification and change detection analysis (Figure 2).

Image Classification and Accuracy Assessment

In this study the satellite imageries were classified using the unsupervised Iterative Self Organising Data Analysis (ISODATA) technique (Ball and Hall, 1965). This was performed using the ISODATA classification algorithm in ERDAS Imagine(ERDAS, 2014). A total of six broad classes were used in the study, based on the Intergovernmental Panel on Climate Change (IPCC) land use classification (LUC) scheme (Smith *et al*., 2014). The six broad classes comprised of forestland, cropland, grassland, wetlands, settlements and other land classes were further re-categorised into two distinct classes for the purpose of this study: Forest (comprising of forestland and wetlands) and Non-forest (comprising of cropland, grassland, settlements and other land classes) respectively. Table 2 summarises the vegetation scheme adopted for land use / cover classification in this study. The outputs of the classification process were forest cover maps for 1986, 2000 and 2014 covering the entire CRS.

Table 2 Classification Schemes Adopted for Land use/cover Classification in the Study

IPPC LUC Scheme	CRS Vegetation and LUC Scheme
Forestland	Tropical high forest, open forest, montane forest, mangrove forest
Cropland	Farmland, oil palm plantation, gmelina plantation
Grassland	Shrubs, grasslands
Wetlands	Swamp forest
Settlement	Built-up, major and minor urban
Other land	Water bodies (oceans and rivers), bare surfaces, mining area

To produce the land use / cover maps, ground truth data were used to train and classify the Landsat (TM and ETM+) and UK-DMC-2 satellite imageries. The land use / cover maps were further verified using an independent set of ground truth data totally different from that used for image classification. The ground truth data used for image classification and accuracy assessment were obtained using a variety of sources namely Google Earth, GPS (global positioning system) data over the study area, historic / recent aerial photographs and visual interpretation of the satellite imageries. The process of accuracy assessment was performed using the ERDAS Imagine Accuracy Assessment tool.After performing image classification and accuracy assessment, the boundary shapefiles of the three cluster sites were used as masks to extract forest cover maps (1986, 2000 and 2014) specifically over the study sites (Figures 1 and 2).

Forest Cover Change Analysis

For this study, the forest cover change detection was performed using the Land Change Modeler – Change Analysis extension in the IDRISI Selva 17.0 software (IDRISI, 2014). The forest cover maps (1986, 2000 and 2014) for each cluster site were used as inputs in the change detection analysis procedure. In order to perform the analysis using IDRISI, all ERDAS Imagine files format were exported and converted to compatible IDRISI file format. The forest transition maps for both time intervals (i.e. 1986 – 2000 and 2000 – 2014) showed the extent of deforested, unchanged and afforested landscape.The annual rate of deforestation was calculated using equation (4).

$$\text{Annual deforestation rate} = \frac{\log F_b - \log(F_a - B)}{(t_a - t_b)} * 100 \quad (4)$$

where F_a and F_b is the forested area in hectares, at times t_a (earlier) and t_b (later); and B is the deforested area between earlier.

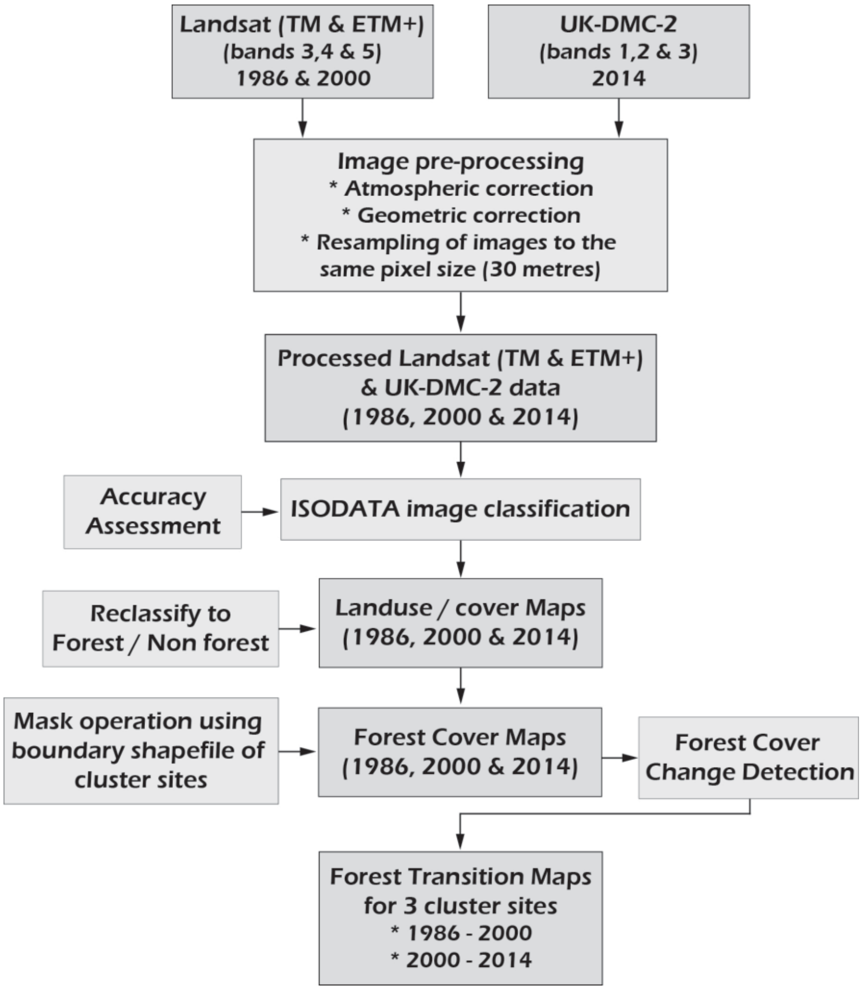

Figure 2: Workflow of Methodology Used for Image Processing

Data Collection for Focus Group Discussion

Following the forest change detection analysis, local communities that were within deforestation hotspots in the REDD cluster sites were visited for focus group discussions and interviews. Table 3 lists the local communities engaged in the focus group discussion which aimed to identify and rank the drivers of deforestation based on local knowledge. Focus group discussions and interviews were also conducted with key stakeholders in two major timber markets namely Ikom and Obubra timber markets, to solicit inputs regarding contributions from logging and timber extraction. The results of the questionnaires and focus group discussions with locals ranked the drivers of deforestation and forest degradation in order of impact to the environment. The ranking of deforestation drivers were ranked between 1 and 6, 1 representing the least contributing factor and 6 the highest contributing factor.The interviews and focus group discussions were performed in June 2014.In addition to the local community focus group discussions, investigations were made to obtain the views of timber merchants in two key timber markets within the Ekuri-Ukpon-Cross River South cluster.

Table 3 Communities of REDD cluster site for focus group discussions

REDD Cluster site	Community	Local Government Area
Afi - Mbe	Kanyang	Boki
	Buanchor	Boki
Ekuri-Ukpon-Cross River South	Edondon	Akampka
	Old Ekuri	Akampka
	New Ekuri	Akampka
Mangrove forest	EsukIdebe	Apkabuyo

RESULTS AND DISCUSSION

Accuracy Assessment of Classified Images

The overall land cover classification accuracy results were approximately 91 percent (1986), 89 percent (2000) and 91 percent (2014) respectively. Table 4 presents the classification accuracy reports for the classifications performed.

Table 4 Accuracy Assessment Results Showing User Accuracy (UA), Producer Accuracy (PA) and Overall Accuracy (OA) Generated for Classified Images

Land use	1986 (TM)		2000 (ETM+)		2014 (UK-DMC)	
	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)
Forestland	89.8	97.0	87.1	95.7	91.8	88.2
Farmland	89.4	94.7	88.6	87.8	90.9	86.2
Grassland	94.4	85.0	93.6	96.7	91.7	94.3
Wetland	87.5	75.0	86.4	88.4	90	87.8
Settlement	100	57.1	100	54.6	93.3	96.6
Other land	100	88.2	100	100	86.7	100
OA (%)	**90.7**		**89.4**		**90.8**	

Forest Cover Change Analysis and Rates of Change

The total forest in Afi-Mbe cluster for 1986, 2000 and 2014 were 85,323.4 ha, 64,955.5 ha and 79,563.2 ha respectively. For Ekuru-Ukpon-CR south cluster, the total forest cover across the cluster for the same years were 102,304 ha, 88,479 ha and 95,185 ha. The Mangrove forest cluster had a total forest cover area of 102,304 ha, 88,479 ha and 95,185 ha for 1986, 2000 and 2014 respectively. Table 5 presents the results of forest transition and annual deforestation rates for all three clusters investigated. Figure 3 presents the forest cover maps of the three cluster sites investigated in CRS. The results show that for Afi-Mbe cluster, the percentage of deforested landscape declined from 19.3% in the first 14-year period (1986 – 2000) to 3.8% in the second 14-year period (2000 – 2014). The percentages of afforestation for the same 14-year periods were increased from 0.6% to 17.2% respectively. For Ekuru-Ukpon-CR south cluster, the percentages of deforested landscape during the first and second 14-year periods were 21.1% and 10.2% respectively. The percentage of afforested landscape for Ekuru-Ukpon-CR south cluster in the first and second 14-year periods were 5.2% and 18% respectively. Finally, the percentage of deforested landscape in the Mangrove forest cluster increased from 15.9% in the first 14-year period to 35% in the second 14-year period. The percentage of afforested landscape declined from approximately 12% to 9% over both 14-year periods. Figure 4 shows the forest transition maps of all clusters analysed in the study.

Table 5: Results of Forest Cover Spatial Extent and Forest Transition from 1986 to 2014

REDD Cluster sites:	**Afi-Mbe**	**Ekuri-Ukpon-CR South**	**Mangrove forest**
Forest cover (86) – ha	85,323.40	102,304.00	42,645.30
Forest cover (00) – ha	64,955.50	88,479.00	40,873.20
Forest cover (14) – ha	79,563.20	95,185.20	27,507.90
Deforested (86-00) – ha	21,023.60	18,229.40	8,110.17
Deforested (00-14) – ha	4,117.95	8,759.30	17,816.90
Unchanged forest (86-00) - ha	64,296.90	84,074.70	34,533.40
Unchanged forest (00-14) - ha	60,828.80	79,719.70	23,042.60
Afforested (86-00) – ha	646.74	4,468.95	6,215.22
Afforested (00-14) – ha	18,762.10	15,436.20	4,392.32
Annual deforestation rate (%) - 00 - 86	2.1	1.2	0.8
Annual deforestation rate (%) - 00 - 14	-0.5	0.1	4.5
Total land mass area - ha	*109,060.19*	*86,257.60*	*50,955.97*

The annual deforestation rate for Afi-Mbe cluster declined from 2.1% to -0.5% over both 14-year periods investigated. A similar trend was observed in Ekuri-Ukpon-Cross River South cluster where annual deforestation declined from 1.2% in the first 14-year period to 0.1% in the second 14-year period. However, the mangrove forest cluster experience a rise in the annual rate of deforestation over both 14-year periods investigated, 0.8% to 4.5%.

The results showed that Afi-Mbe and Ekuri-Ukpon-CR South clusters (both managed by local communities, government and conservation organisations) experienced declines in deforestation and subsequent increase in afforestation over the time period investigated; an indication of forest conservation practices across both clusters. However, the unmanaged mangrove forest cluster experienced a rise in deforestation and decline in afforestation. The rapid decline in mangrove forest across the state could be attributed to a number of factors some of which include: massive exploitation of forest resources for fuel wood, stake pole production, fish traps and boat carving; fishing and the impact of tidal waters from the oceans upon the mangroves that serve as natural shoreline protection (Mmom and Arokoyu, 2010). Also other factors such as high human population, commercial agriculture and immense levels of industrialisation in the region have negatively impacted on the spatial coverage of mangrove forest in the state (Bisong, 2001).

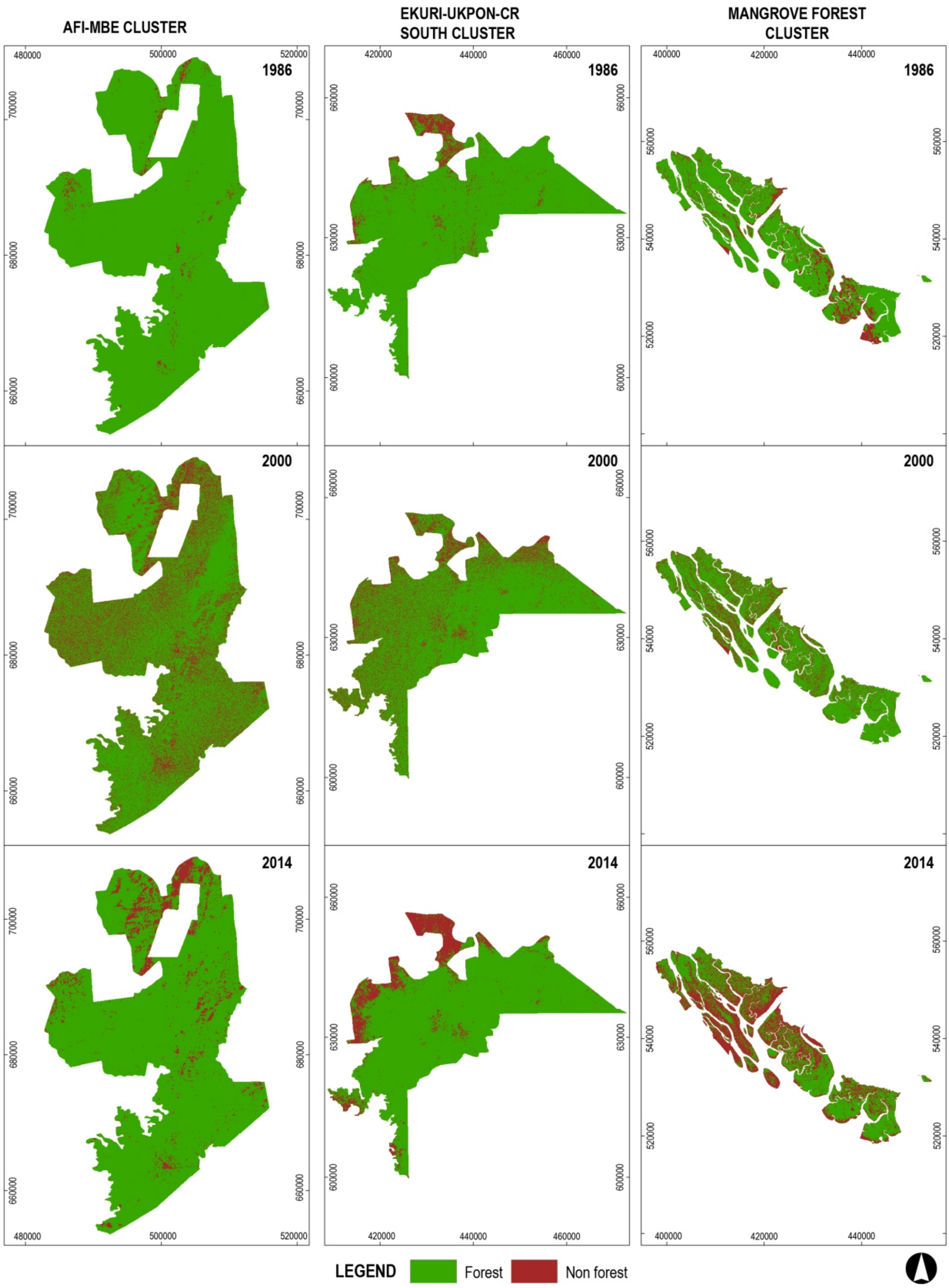

Figure 3: Forest Cover Maps of Cluster Sites in CRS for 1986, 2000 and 2014.

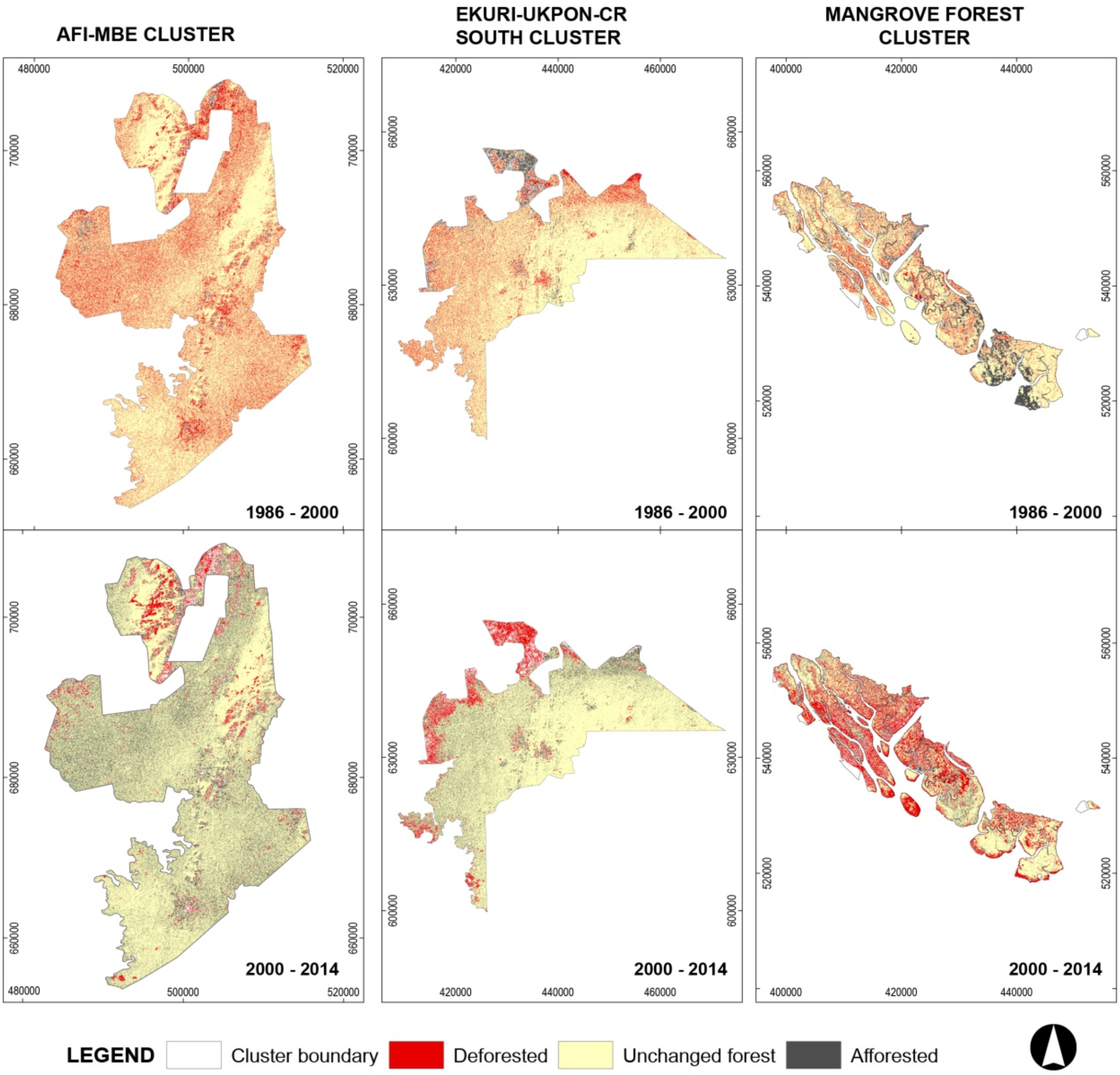

Figure 4: Forest Transition Maps of Cluster Sites in CRS for 1986 - 2000 and 2000 - 2014.

Results of Local Community Focus Group Discussions

Table 6 summarises the key outcomes of focus group discussions with local community members conducted across the REDD cluster sites in CRS. It presents the number and background of local community members interviewed, the predominant occupation, identified drivers of deforestation, land tenure practices, conservation efforts and local community suggestions as to how deforestation and forest degradation threats can be mitigated.

The focus group of timber merchants in the Obubra timber market comprised of 15 marketers (all males). The profession is predominantly made of males as indicated in the number of registered members (49 males and 1 female). A major issue of concern amongst the timber merchants interviewed was the moratorium of logging issued by the CRS government, which places a total ban on logging across the state since 2008 till date (Kehinde *et al.*, 2009, Schoneveld, 2014). The timber traders were of the view that this enforcement of banning timber extraction was counter-productive as it will only increase the occurrence of illegal logging activities across the state.

With respect to the questionnaires and focus group discussions held at the local community level, the direct/proximate drivers of deforestation and forest degradation were ranked in order of priority based on levels of impact using inputs from localstakeholders interviewed. Figure 5 shows ranking of deforestation and forest degradation drivers across CRS. The key drivers of deforestation based on inputs from local stakeholders involved in order of ranking from the highest to the least were as follows: subsistence agriculture, fuel wood harvesting, logging/timber extraction and commercial agriculture respectively. The most dominant of all the deforestation drivers, subsistence agriculture, was justifiable given that most people across the state particularly in the local communities engage in small-scale farming activities. These results have demonstrated the importance of obtaining inputs from local communities in understanding the trends of forest transition across cluster sites. The results further shows that local communities involved in the focus group discussions, have in place, local laws for enforcing forest conservation and protection of endangered wildlife.

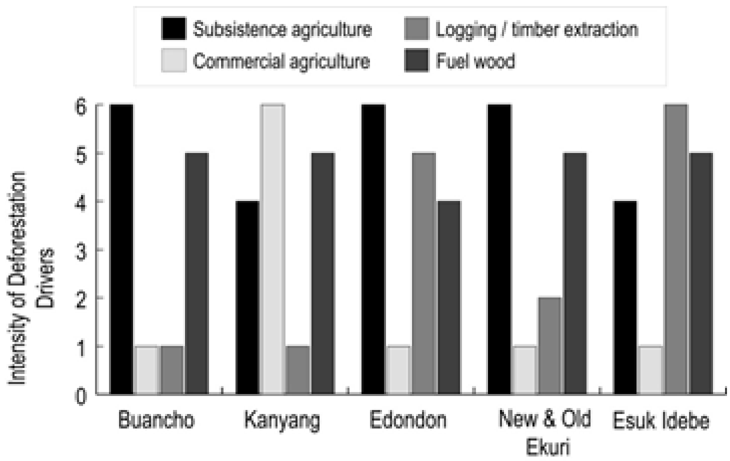

Figure 5: Ranking of Deforestation and Forest Degradation Drivers Ranking across CRS

Table 4 Summary of FocusedGroup Discussions held in Local Communities Across CRS REDD Cluster Sites

Focus Group Composition	**Predominant Occupation**	**Prominent Deforestation Drivers**	**Land Ownership**	**Conservation Practices**	**Local Community Suggestions**
Community / REDD Cluster: Kanyang community/ Afi-Mbecluster					
• 33 participants (25 males &8 females) • Age limit: 15-45 years • Education level: Most had secondary school education	• Subsistence agriculture • Extraction of NTFPs by women	• Commercial agriculture • Fuel wood extraction • Timber extraction • Subsistence agriculture • Mining operations	Landownership through inheritance and clearing of virgin forests	• The community is involved in forest conservation through establishing forest management committees mandated to enforce forest laws in the community. • There is a ban on animal poaching in conservation areas and persons found guilty are fined or arrested and handed to law enforcement agencies.	• There's need to embark on awareness creation on the importance of forest conservation • Educate the local community on laws of CRS relating to conservation and wildlife protection • Need to reduce the dependence on forest resources through provision of alternative sources of livelihood • Introduce an alternative source of energy for fuel wood used in cooking
Community / REDD Cluster: Buanchor community/ Afi-Mbecluster					
• 33 participants (27 males &6 females) • Age limit: 31-60 years • Education level: 30% secondary school educated, 50% primary educated &20% uneducated	• Subsistence agriculture • Extraction of NTFPs by women	• Subsistence agriculture • Wild fire • Fuel wood extraction	Land ownership through inheritance, nuclear family farmlands or individual ownership	• Local community is involved in forest conservation through local law enforcement and customs (e.g. fine payment for illegal poaching) • Ban of illegal logging • Seizure of chain saw machines used for illegal logging • Arresting of persons involved in hunting endangered wildlife such as chimpanzees, gorillas, drills etc.	• Local communities request provision of alternative source of livelihood to reduce dependence on forest resource extraction • Youths in local community require employment to reduce dependence on forest resources

Focus Group Composition	Predominant Occupation	Prominent Deforestation Drivers	Land Ownership	Conservation Practices	Local Community Suggestions
Community / REDD Cluster: Old & New Ekuri communities (Ekuri-Ukpon-Cross River South cluster)					
• 31 participants (21 males &10 females) • Age limit: 46-60 years • Education level: 30% secondary school educated, 50% primary educated &20% uneducated	• Subsistence agriculture • Fishing • Extraction of NTFPs by women (e.g. bush mangoes, herbs, bitter colas, raffia and bush mangoes)	• Subsistence agriculture • Fuel wood extraction by women for household use	Land ownership is mostly through inheritance, clearing of virgin forests and direct ownership.	• Prohibition of logging activities is enforced by local community • Indigenes and non- indigenes found guilty of illegal logging are arrested, fined or banished from the community • Youths are involved in patrolling forests for illegal logging and poaching of endangered wildlife • The local communities practice boundary tracing to prevent encroachment & uncontrolled fire during bush burning.	• Equip and empower youth patrol volunteers with adequate tools for effective monitoring • Local communities request support to enhance agricultural produce through supply of fertilisers • Equip local communities with preservation facilities to preserve agricultural produce • Empowerment of youth in community to reduce dependence on forest resources.
Community / REDD Cluster: EsukIdebe / Mangrove forest cluster					
Focus Group Composition	**Predominant Occupation**	**Prominent Deforestation Drivers**	**Land Ownership**	**Conservation Practices**	**Local Community Suggestions**
• 15 participants (12 males &3 females) • Age limit: 15-60 years • Education level: All have primary school education	• Subsistence farming • Fishing	• Timber extraction • Subsistence agriculture • Commercial agriculture • Fuel wood extraction • Over dependence on forest resources	Land acquisition is through inheritance and communal methods	• Forest conservation is implemented through traditional laws that forbid certain sections of the forest to local community members	• Provision of alternative source of livelihood as a means of reducing deforestation • Capacity building of local community members to enhance fishing activities • Empowerment of women with alternative skills (such as sewing, soap making, catering etc.) to enable over-dependence on forest resources for livelihood

CONCLUSION

The results of spatially explicit analysis showed that the cluster sites jointly managed by locals, government and conservation organisations experienced a reduction in deforestation. In Afi-Mbe cluster, annual deforestation rates declined from 2.1% to 0.5% over both 14-year periods investigated (i.e. 1986 – 2000 and 2000 – 2014). A similar trend was observed in Ekuri-Ukpon-Cross River South cluster where annual deforestation declined from 1.2% in the first 14-year period to 0.1% in the second 14-year period. However, the mangrove forest cluster experienced a rise in the annual rate of deforestation over both 14-year periods investigated, 0.8% to 4.5%. The rapid rise in deforestation across the mangrove forest cluster was attributed to a number of factors such as: massive exploitation of forest resources and pressures from high human population, commercial agriculture and immense levels of industrialisation.

The results of the focus group discussion revealed that most local communities had instituted local laws and practices aimed at enforcing forest conservation and protection of wildlife. Based on inputs from local community stakeholders a number of deforestation drivers were identified and ranked in order magnitude from highest to least and included thus: subsistence agriculture, fuel wood harvesting, logging / timber extraction and commercial agriculture. The support of existing Forest Management Committees (such as Ekuri Initiative), conservation organisations (such as CERCOPAN, WCS, Pandrillus, Nigerian Conservation Foundation and Fauna and Flora International) and government (such as CRSFC) has demonstrated to be an effective tool for community forest management in CRS.

Overall, the study has demonstrated the importance of utilising multi-temporal remote sensing to estimating the spatial extent and rates of land cover change. Using remote sensing techniques,the authors have generated valuable information on current extent and distribution of forest landscape across the study sites. With such baseline data, forest conservation programmes aimed at mitigating the effects of deforestation and promoting conservation would have access to vital localised baseline data.

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REFERENCES

Angelsen, A., Brown, S., Loisel, C., Peskett, L., Streck, C.and Zarin, D., 2009. REDD: An Options Assessment Report.

Ball, G. H. and Hall, D. J. 1965. ISODATA, a novel method of data analysis and pattern classification. DTIC Document.

Bisong, F.E., 2001. Natural Resource Use and Conservation Systems for Sustainable Rural Development. Calabar, (Ed). Baaj International.

Brashares, J. S. and Sam, M. K. 2005. How much is enough? Estimating the minimum sampling required for effective monitoring of African reserves. *Biodiversity and Conservation,* 14**,** 2709-2722.

Bray, D. B., Merino-Perez, L., Negreros-Castillo, P., Segura-Warnholtz, G., Torres-Rojo, J. M. and Vester, H. F. M. 2003. Mexico's Community-Managed Forests as a Global Model for Sustainable Landscapes. *Conservation Biology,* 17**,** 672-677.

Brunner, J., Seymour, F., Badenoch, N. and Ratner, B. 1999. *Forest problems and law enforcement in Southeast Asia: The role of local communities* World Resource Institute Resources Policy Brief.

Clark, S., Bolt, K. and Campbell, A. 2008. Protected areas: an effective tool to reduce emissions from deforestation and forest degradation in developing countries. *UNEP-WCMC, Cambridge, UK.*

Danielsen, F., Adrian, T., Brofeldt, S., Van Noordwijk, M., Poulsen, M. K., Rahayu, S., Rutishauser, E., Theilade, I., Widayati, A. and An, N. T. 2013. Community monitoring for REDD+: international promises and field realities. *Ecology and Society,* 18**,** 41.

Danielsen, F., Skutsch, M., Burgess, N. D., Jensen, P. M., Andrianandrasana, H., Karky, B., Lewis, R., Lovett, J. C., Massao, J. and Ngaga, Y. 2011. At the heart of REDD+: a role for local people in monitoring forests? *Conservation Letters,* 4**,** 158-167.

Defries, R., Hansen, A., Newton, A. C. and Hansen, M. C. 2005. Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecological Applications,* 15**,** 19-26.

Ellis, E. A. and Porter-Bolland, L. 2008. Is community-based forest management more effective than protected areas? A comparison of land use/land cover change in two neighboring study areas of the Central Yucatan Peninsula, Mexico. *Forest Ecology and Management,* 256**,** 1971-1983.

ERDAS 2014. ERDAS Imagine 2014. 2014 ed. Peachtree Corners Circle Norcross: Hexagon Geospatial.

Huang, C.; Wylie, B.; Yang, L.; Homer, C.and Zylstra, G. 2002. Derivation of a tasselled cap transformation based on Landsat 7 at-satellite reflectance. *International Journal of Remote Sensing*, 23, 1741-1748.

IDRISI 2014. IDRIS Selva version 17. Worcester, United States of America: Clark Labs, Clark University.

Irish, R. 2000. Landsat 7 science data users handbook. National Aeronautics and Space Administration, 430-415.

Iqbal, M. 2012. *An introduction to solar radiation*. Elsevier.

Jones, J. P. G., Andriamarovololona, M. M., Hockley, N., Gibbons, J. M. and Milner-Gulland, E. J. 2008. Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. *Journal of Applied Ecology,* 45**,** 1205-1212.

Kehinde, A., Akande, J. and Ntabe, E. 2009. Forest stakeholder's awareness of reduced impact logging (RIL) in Nigeria and Cameroon. *Journal of Horticulture and Forestry,* 1**,** 176-181.

Malingreau, J., Achard, F., D'souza, G., Stibig, H., D'souza, J., Estreguil, C. and Eva, H. 1995. AVHRR for global tropical forest monitoring: The lessons of the TREES project. *Remote Sensing Reviews,* 12**,** 29-40.

Mmom, P. C. and Arokoyu, S. B. 2010. Mangrove forest depletion, biodiversity loss and traditional resources management practices in the Niger Delta, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*, 2, 28-34.

Murdiyarso, D. and Skutsch, M. 2006. *Community forest management as a carbon mitigation option: case studies*, CIFOR.

Onojeghuo, A. O. and Fonweban, J. 2014. UN-REDD+ Forest Monitoring and MRV Training Workshop Report. Calabar: UN-REDD Programme Nigeria.

Palmer Fry, B. 2011. Community forest monitoring in REDD+: the 'M' in MRV? *Environmental Science & Policy,* 14**,** 181-187.

Pathak, N., Kothari, A. and Roe, D. 2005. Conservation with social justice? The role of community conserved areas in achieving the Millennium Development Goals. *International Institute for Environment and Development (IIED). http://www. iied. org/pubs/pdfs G,* 1283.

Rist, J., Milner-Gulland, E. J., Cowlishaw, G. and Rowcliffe, M. 2010. Hunter Reporting of Catch per Unit Effort as a Monitoring Tool in a Bushmeat-Harvesting System. Conservation Biology, 24, 489-499.

Schoneveld, G. C. 2014. The politics of the forest frontier: Negotiating between conservation, development, and indigenous rights in Cross River State, Nigeria. *Land Use Policy,* 38**,** 147-162.

Skutsch, M. M., Van Laake, P. E., Zahabu, E., Karky, B. S. and Phartiyal, P. 2009. Community monitoring in REDD+. *In:* ANGELSEN, A. (ed.) *Realising REDD+: National Strategy and Policy Options*. CIFOR.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N. H., Rice, C. W., Robledo Abad, C., Romanovskaya, A., Sperling, F. and Tubiello, F. 2014. Agriculture, Forestry and Other Land Use (AFOLU). *In:*Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. Von Stechow, Zwickel, T. & Minx, J. C. (eds.) *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth*

Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press.

Topp-Jorgensen, E., Poulsen, M. K., Lund, J. F. and Massao, J. F. 2005. Community-based monitoring of natural resource use and forest quality in montane forests and miombo woodlands of Tanzania. *Biodiversity & Conservation,* 14**,** 2653-2677.

UNDP 2012. *Ekuri Initiative, Nigeria,* New York, NY, Equator Initiative Case Study Series.

Zahabu, E. 2006. Handei Village Forest Reserve, Tanzania. *In:* MURDIYARSO, D. & SKUTSCH, M. (eds.) *Community forest management as a carbon mitigation option: case studies.* CIFOR.