Analysis of Land Cover Change in the Oban Division of Cross River National Park and Adjacent Forest Areas

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Summary

The forests of Cross River State represent the most extensive area of relatively undisturbed tropical moist forest remaining in Nigeria. Most of this remaining forest is found within the Cross River National Park and adjoining forest reserves and community forests. Established in 1991 from existing forest reserves, Cross River National Park consists of two separate divisions: Okwangwo and Oban. This study focuses on the Oban Division (Oban) of Cross River National Park and adjacent areas including six forest reserves (Ukpon River, Cross River South, Cross River North, Agoi, Uwet Odot and Ekinta) and two community forests (Ekuri and Iko Esai). These forests are recognized as a biodiversity hotspot (Myers et al 2000; Oates, Bergl and Linder, 2004). However, significant parts of these forests are being lost due to illegal logging and agricultural conversion including commercial monoculture plantations. In this study, we analyzed remote sensing data to assess patterns of deforestation in Oban and adjacent forest reserves and community forests over the period from 2000 to 2018. We used satellite land cover data for 2000 (Landsat 7 Enhanced Thematic Mapper) and 2018 (Landsat 8 Operational Land Imager). For both years, we downloaded three scenes (World Reference System path 187 row 56, path 187 row 57, and path 188 row 56) from the United States Geological Survey's Global Visualization Viewer (GloVis) website (http://glovis.usgs.gov/). We used the Supervised Maximum Likelihood Classifier (MLC) method in ERDAS Imagine software (ver.2014) for image classification. Forest cover in the study area declined from 473,204 ha (67.8%) in 2000 to 397,513 ha (57.2%) in 2018, equivalent to an annual deforestation rate of 0.96%. Most of the deforestation in the study area occurred in community land outside the Ekuri and Eko Esai community forests and within forest reserves including Ukpon and Cross River South forest reserves. Within the Oban Division of Cross River National Park deforestation occurred mostly in the area between the legal boundary and the proposed boundary, outside the area managed by the park authority as its operational boundary.

Introduction

Tropical forests, the world's most biologically diverse ecosystems, are being lost at an alarming rate with grave consequences for biodiversity (Achard et al., 2002; FAO 2015). Nigeria has one of the highest annual deforestation rates in the word (FAO 2015). As of 2010, Nigeria had 8.86Mha of tree cover, equivalent to 9.7% of its land area (GFW 2010). The forests of Cross River State represent the largest block of relatively undisturbed tropical moist forest remaining in Nigeria today. Most of this remaining forest is found within the Cross River National Park and adjacent community forests and forest reserves. The forests of Cross River once formed part of one of the lowland rainforest refugia of equatorial Africa during the Pleistocene era, and this has resulted in high levels of biological diversity and endemism. However, these forests are threatened by increasing human activity such as illegal logging and agriculture. This study assesses patterns of deforestation in the Oban Division of Cross River National Park (Oban) and adjacent forest reserves and community forests over the period from 2000 to 2018. The area covers approximately 694,225 hectares, located between latitudes 4°56'50" to 6°1'17" and longitudes 8°1'57" to 8°55'.35" (Figure 1). Forest Reserves within the study area include Ukpon River, Cross River South, Cross River North, Agoi, Uwet Odot and Ekinta. Community forests include Ekuri and Iko Esai.

Oban.

Established in 1991 from existing forest reserves, Cross River National Park consists of two separate divisions: Okwangwo (640 km^2) and Oban (3,000 km^2). Oban represents one of the most important sites for biodiversity conservation in Nigeria. Oban is listed as an 'Exceptional Priority Site' in the Regional Action Plan for the Conservation of the Nigeria-Cameroon Chimpanzee produced by the IUCN/SSC Primate Specialist Group in 2011 (Morgan et al, 2011). It is a renowned hotspot for the conservation of primate diversity with 14 primate species present (Oates, Bergl & Linder, 2004). It is the only site in Nigeria where the critically endangered Preuss's red colobus monkey *Procolobus preussi* is known to occur. Other rare and endangered species found in Oban include the slender-snouted crocodile *Mecistops cataphractus* (CR), drill *Mandrillus leucophaeus* (EN), Nigeria-Cameroon chimpanzee *Pan troglodytes ellioti* (EN), forest elephant *Loxodonta cyclotis* (VU) and grey-headed rockfowl *Picathartes oreas* (VU) as well as 75 plant species endemic to Nigeria (Oates, Bergl & Linder., 2004). The area is a center of species richness and endemism, particularly for primates, birds, amphibians, butterflies, fish and small mammals (Bergl, Oates and Fotso, 2007; Oates, Bergl & Linder, 2004). With peaks reaching between 500 m and 1,000 m, the Oban Hills are also an extremely important watershed, giving rise to numerous rivers that guarantee a perennial

supply of freshwater to hundreds of downstream communities in Cross River State (Caldecott, Bennett and Ruitenbeek, 1989).

Despite its recognition, locally and internationally, as an important site for biodiversity conservation, Oban has received little conservation attention since a European Union funded project aimed at developing the Park ended abruptly in 1996. As a result, hunting is widespread and deforestation from illegal logging and agricultural conversion – both subsistence and commercial – is increasing. Commercial agriculture is a particularly serious threat to Oban. The Oban Division of Cross River National Park adopted the boundaries of existing Oban Group Forest Reserves established by the Cross River State Government via Forest Order No. 20 of 1932. However, the boundaries of the Oban Group of forests included areas that were already significantly degraded, including large communities, markets, and petrol stations. Consequently, a proposal was made to revise the boundaries of Oban to reflect the realities on the ground. Although started, the process to officially gazette the proposed Park boundary was never completed and the legal boundary of the Oban Division of Cross River National Park remains as gazetted in 1991. Unresolved park boundaries and confusion regarding their legal status created a situation whereby the Cross River State Government was able to award agricultural concessions inside Oban to a number of companies including Wilmar International Limited, Real Oil, and Dansa Agro Allied Company (Figure 1) despite its status as a National Park.

Forest Reserves and Community Forests.

Managed by the Cross River State Forestry Commission, six forest reserves are located within the study: Ukpon River, Cross River South, Cross River North, Agoi, Uwet Odot and Ekinta. Forest cover within some of these reserves has been significantly reduced, with some such as Ekinta and Agoi having already been completely lost to commercial agriculture, logging, and mining operations and presently existing only on paper. Cross River South Forest Reserve and Ukpon River Forest Reserve are the largest and relatively most intact of the forest reserves in the study area. The Ekuri Community Forest covering approximately 336 square kilometres, and managed by Old Ekuri and New Ekuri communities through the Ekuri Initiative, remains largely intact. The Iko Esai forest covers 400 square kilometres and is managed by the community of Iko Esai and neighbouring communities.

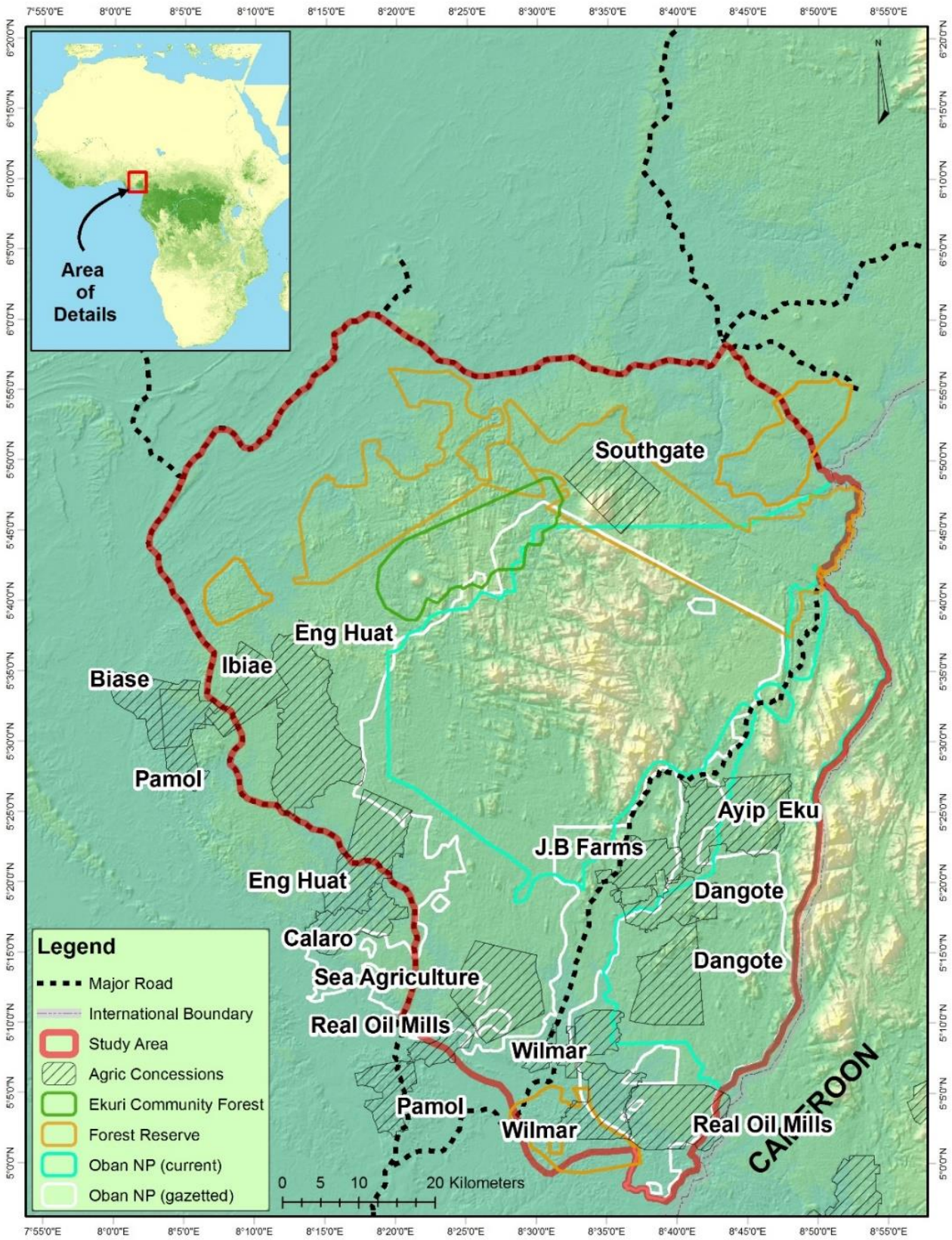

Figure 1: Map of the study area showing protected areas and agricultural concessions

Methodology

Forest Cover Mapping

We analyzed remote sensing land cover data for 2000 and 2018 to assess forest cover change in the study area. Three scenes (World Reference System path 187 row 56, path 187row 57 and path 188 row 56) of Landsat 7 ETM+ and Landsat 8 OLI for 2000 and 2018 respectively were downloaded from the United States Geological Survey GLOVIS web page (http://glovis.usgs.gov/). The images were processed to Level 1 Terrain-corrected, implying that they were already ortho-rectified, a property that makes them suitable for direct image-to-image comparison in change detection analysis. To further enhance the spatial and spectral quality both images were radiometrically and geometrically corrected and the digital numbers converted to Top of Atmosphere Reflectance. This conversion process was done to remove all forms of noise present in the satellite images such as instrument error, errors from view changes during data acquisition and effects of illumination geometry (Wharton, 1989). Before image classification, Landsat 7 bands with same spectral ranges as well as the Landsat 8 image were selected for input during image classification (Figure 2).

The supervised maximum likelihood classifier (MLC) was used in ERDAS Imagine software (ver.2014) to classify the images according to three main land cover types – "forest", "disturbed forest/farmland/low vegetation", and "bare earth/human settlement". Image classification and accuracy assessment was performed using independent training and testing data obtained from the field, as well as data extracted from Google Earth, historic and recent aerial photographs and visual interpretation of the satellite images.

Forest Cover Change Analysis

Analysis of changes in land cover is important for understanding relationships and interactions between human and natural phenomena to support decision-making (Singh 1989). We used the neural network built-in module in the Selva version of IDRISI to analyze and compare forest cover change in the study area over the period from 2000 to 2018. Deforestation rates were estimated for the entire study area over the period from 2000 to 2018 using the following model (Dirzo, 1990):

$$r = 1-\{1-[(A1-A2)/A1]\}1/t \times 100$$

Where r is the deforestation rate, A1 is the area of forest at the beginning of the period, A2 is the area of forest at the end of the period, and t is the number of years for a given period. In this model, the rate of deforestation is expressed as the percentage of remaining forest that is cleared per year.

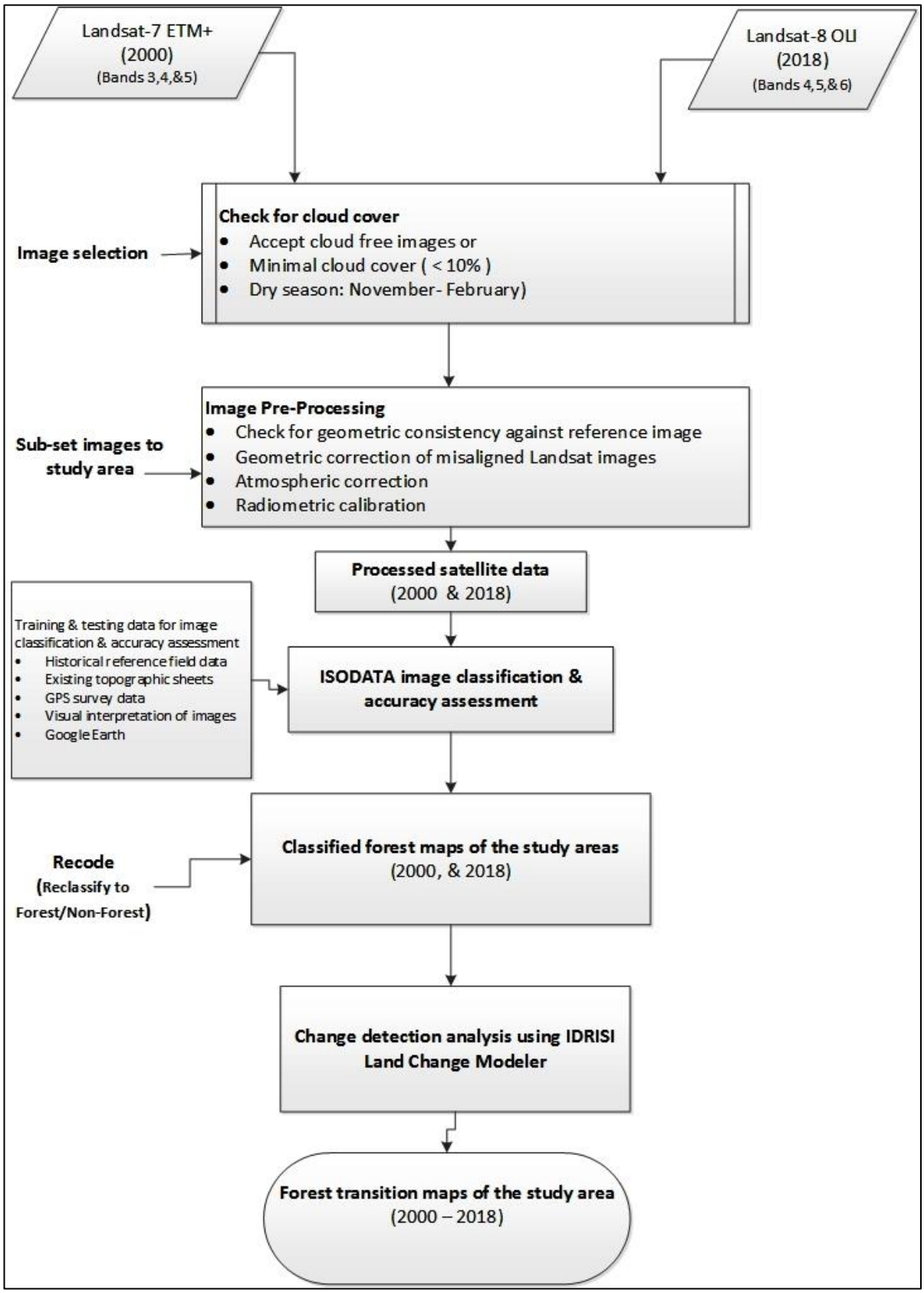

Figure 2. Workflow for image processing and GIS analysis

Results

Forest cover in the study area declined from 473,204 ha (67.8%) in 2000 to 397,513 ha (57.2%) in 2018 (Table 1), representing a loss of 75,691 ha of forest over eighteen years at an annual deforestation rate of 0.96% (Table 2). Most of the deforestation occurred in community land (outside the Ekuri and Eko Esai community forests) and within forest reserves including Ukpon and Cross River South forest reserves. Within the Oban Division of Cross River National Park deforestation occurred mostly in the area between the legal boundary and the proposed boundary, which the park authority manages as its operational boundary (see Fig 3). Ranger patrols are limited to areas within the proposed boundary. Areas within the legal boundary that are outside the proposed boundary are not patrolled and illegal human activities are widespread including plantation agriculture and commercial logging. Unclear boundaries remain an unresolved problem affecting the management of the park. Deforestation within the proposed park boundary was limited to small areas around the northern axis of the Ikpan Block and west of the Oban-Ekang road. It is important to complete the ongoing boundary adjustment exercise in Oban to resolve the problem of unclear park boundaries. Although much of the Eko Esai and Ekuri community forests remain intact, deforestation is a growing threat. For example, deforestation is threatening to split the Ekuri community forest in two halves. The two Ekuri communities seem to be growing rapidly with farming activities expanding deeper into the forest.

Table 1. Forest cover in the study area in 2000 and 2018

	2000		2018	
Land cover type	**Area (ha)**	**% of total**	**Area (ha)**	**% of total**
Forest	473,204	68.1%	397,513	57.2%
Disturbed forest/farmland/low vegetation	161,971	23.3%	201,615	29.0%
Bare earth/human settlement	51,817	7.5%	90,646	13.0%
River	1,838	0.3%	1,845	0.3%
Cloud	5,871	0.8%	3,081	0.4%
Total	694,700	100.0%	694,700	100.0%

Table 2. Forest loss and annual deforestation rate in the study area from 2000-2018

Forest cover 2000 (ha)	Forest cover 2018 (ha)	Forest loss 2000-2018 (ha)	Annual deforestation rate 2000-2018
473,204	397,513	75,691	0.96

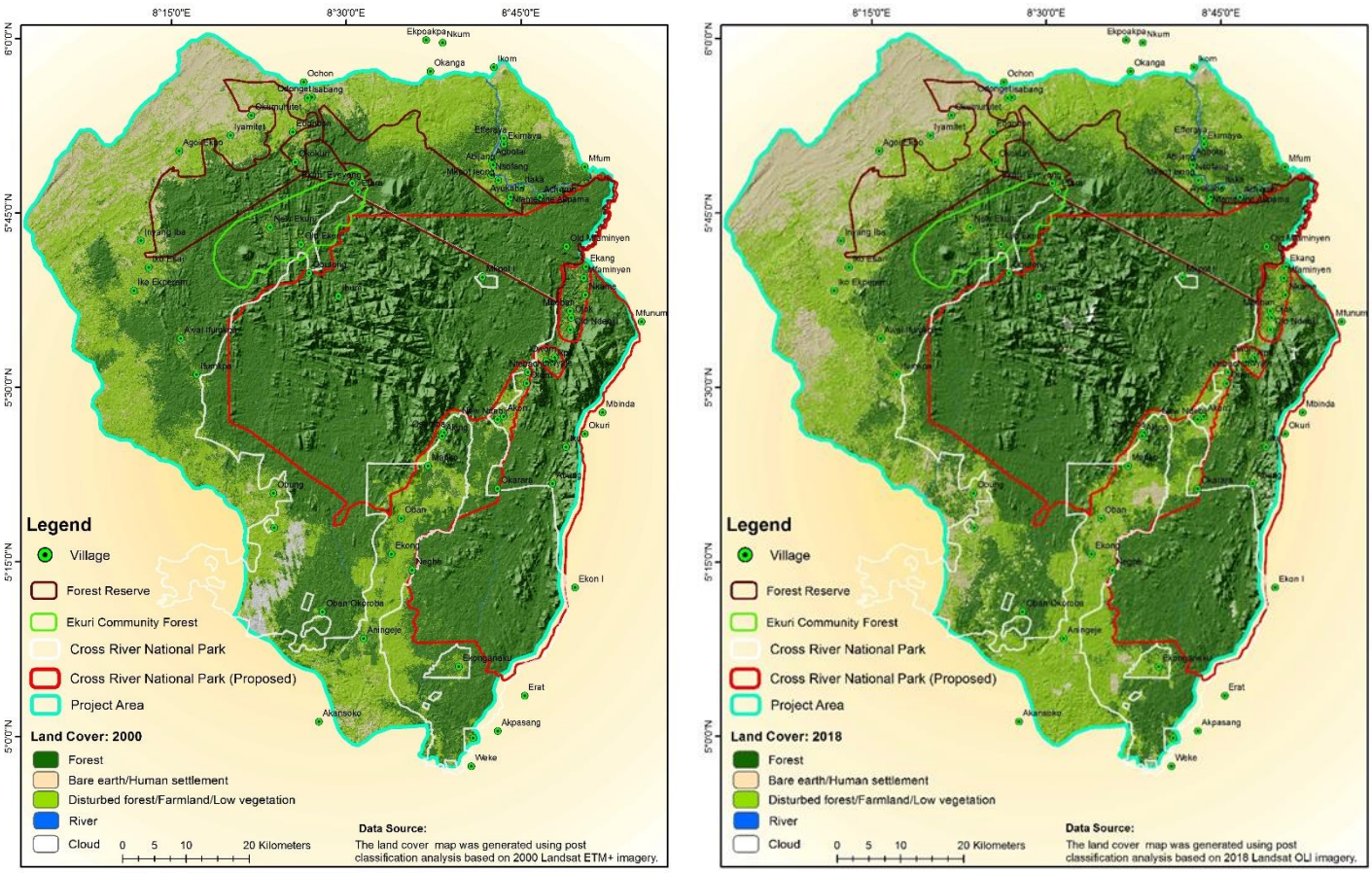

Figure 3. Land-cover maps of the project area, produced from 2000 Landsat ETM+ data and 2018 Landsat OLI data.

Forest transition map for the period (Fig 4) shows apparent gain in forest cover (non-forest to forest transition) around northern and southwestern axes of the study area. However, this is likely due to the presence of cloud in the base forest cover image (no cloud in the later image) and increased canopy cover within plantations rather than actual forest gain.

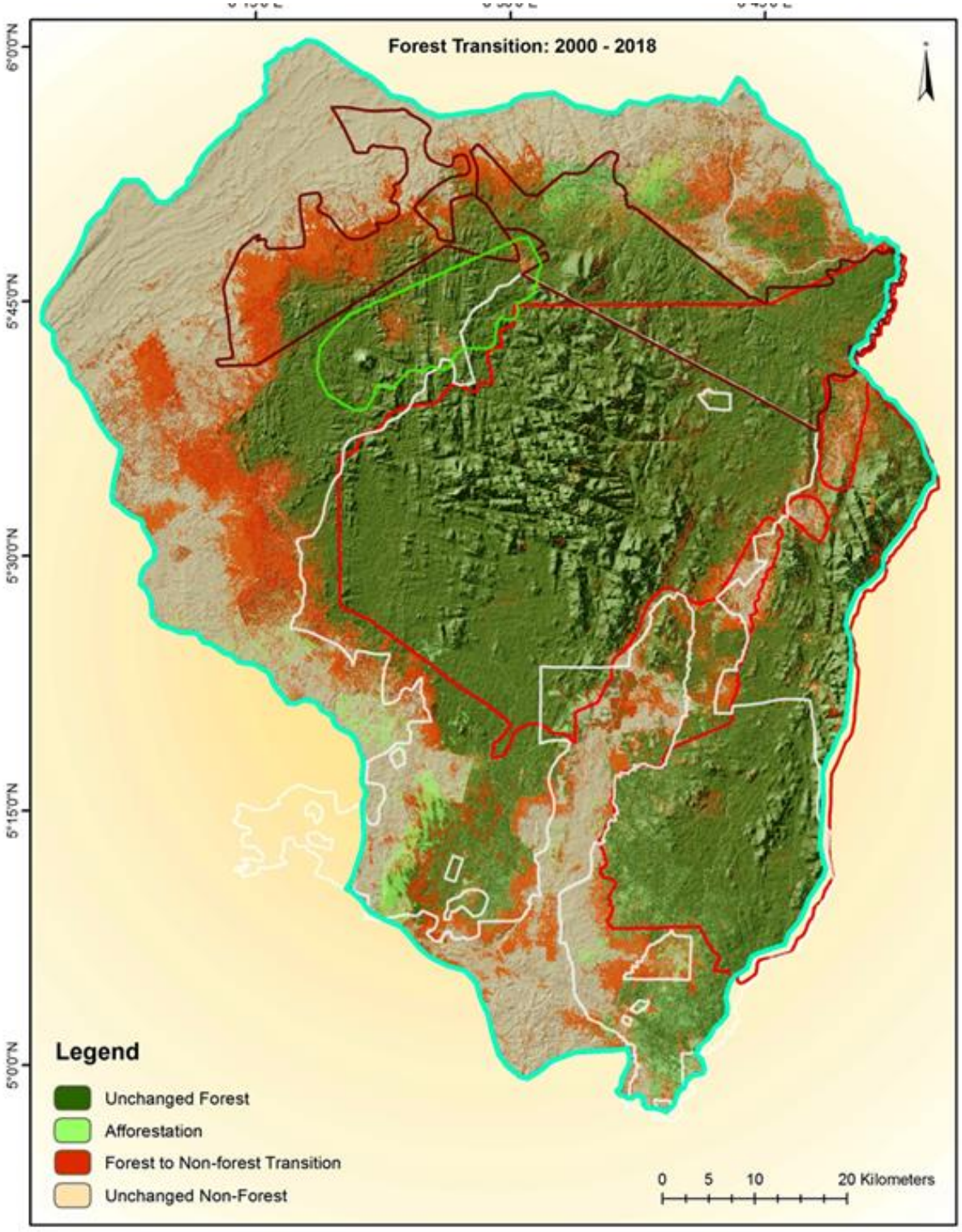

Figure 4. Forest transition map for the period 2000-2018

Conclusion

The Oban Division of Cross River National Park together with surrounding forests is an important area for biodiversity conservation in Nigeria. These forests are also important to the livelihoods of over a hundred communities who rely on them for food, water, medicine and other resources. Much of the remaining forest in the study area is found within the park, highlighting the importance of its effective management to mitigate the threat of deforestation in Cross River State. It is important to resolve the problem of unclear boundaries of the park to facilitate law enforcement. Results of this study also show relatively less deforestation within the Ekuri and Eko Esai community forests compared to forest reserves, highlighting the importance of community conservation. This highlights the need to support efforts by communities such as Eko Esai and Ekuri. Similar initiatives such as the Conservation Association of the Mbe Mountains, which is protecting an important area of community forest between the Afi Mountain Wildlife Sanctuary and the Okwangwo Division of Cross River National Park in the northern sector of Cross River State, should also be encouraged and supported to complement efforts by government.

Acknowledgements

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