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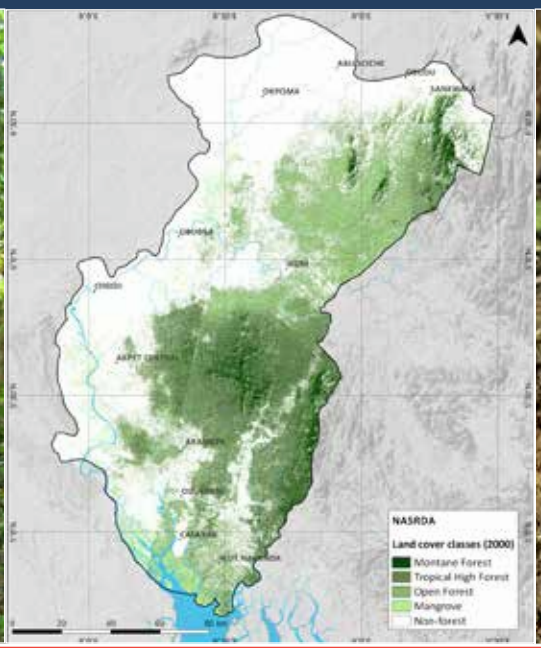
Using spatial analysis to explore multiple benefits from REDD+ actions in Cross River State, Nigeria



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Using spatial analysis to explore multiple benefits from REDD+ actions in Cross River State, Nigeria

Paulus Maukonen, Bridget Nkor, Moses Ama, Miriam Guth, Alana Williamson, Francis Okeke, Charlotte Hicks, Edu Effiom, Rasak Adekola and Alice Ekwu

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Acronyms and abbreviations

AfDB	African Development bank
AFOLU	Agriculture, Forestry and Other Land Use
AP	Action Plan
AU	African Union
CO_2	Carbon dioxide
CRS	Cross River State
DFID	U.K. Department for International Development
EIA	Environmental Impact Assessment
FAO	Forest and Agriculture Organization of the United Nations
FCPF	Forest Carbon Partnership Facility
FLR	Forest Landscape Restoration
FME	Federal Ministry of Environment of Nigeria
FORMECU	Forestry Monitoring, Evaluation Coordination Unit
FREL	Forest Reference Emission Levels
FRL	Forest Reference Levels
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographic Information System
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MRV	Measurement, Reporting and Verification
NASRDA	National Space Research and Development Agency of Nigeria
NS	National Strategy
NFMS	National Forestry Monitoring System
NNPC	Nigerian National Petroleum Corporation
NTFPs	Non-timber forest products
NSWG	Nigeria's National Safeguards Working Group
PGA	Participatory Governance Assessment
PIDA	Program for Infrastructure Development in Africa
REDD+	Reducing Emissions from Deforestation and Forest Degradation; 'plus' conservation of forest carbon stocks, sustainable management of forests; and enhancement of forest carbon stocks
UNDP	United Nations Development Programme
UN	United Nations
UNEP-WCMC	UN Environment's World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
UNICEM	United Cement Company of Nigeria
UN-REDD Programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries
WCS	Wildlife Conservation Society
WWF	World Wide Fund for Nature

1 Introduction

1.1 REDD+

The world's forests provide people with a number of goods and services, including playing a critical role in carbon sequestration and storage. The pivotal functions of forests within the carbon cycle mean that any changes to the extent and structure of these ecosystems will have a significant knock-on effect on greenhouse gas (GHG) emissions and sequestration, and subsequently on climate change.

Deforestation and forest degradation, alongside other land-use changes, are estimated to have contributed around 12% of global GHG emissions between 2000 and 2009 (Smith et al. 2014), once absorption of carbon dioxide (CO_2) by forest is taken into account. Since 2007, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have adopted significant decisions and provided guidance on Reducing Emissions from Deforestation and Forest Degradation and the role of conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+). This is an effort to provide positive incentives to developing countries to contribute to climate change mitigation through activities in the forestry and land-use sectors (Figure 1).

REDD+ is centred on the key principle that through more sustainable forest management practices, it is possible to both reduce GHG emissions produced by deforestation and by the forestry sector, and enhance the capacity of the forestry sector to act as a carbon sink. A decision[1] taken at the UNFCCC Conference of the Parties in Cancun in 2010 requests countries to have the following elements in place for REDD+ implementation. These are required in order to access results-based payments for GHG reductions and removals:

- National Strategy (NS) or Action Plan (AP);
- National Forestry Monitoring System (NFMS), including Measurement, Reporting and Verification (MRV);
- Forest Reference Emission Levels (FREL) and/or Forest Reference Levels (FRL); and
- Safeguard Information System providing information on how the safeguards for REDD+ are addressed and respected.

In addition to contributing to global GHG emissions mitigation, the integration of REDD+ activities at the national level can provide several advantages to countries, such as results-based payments for each ton of carbon emissions reduced or removed, international recognition for mitigation results, and other, non-carbon benefits to the environment, economy and society. The full range of benefits that may be achieved through REDD+ are known as 'multiple benefits'.

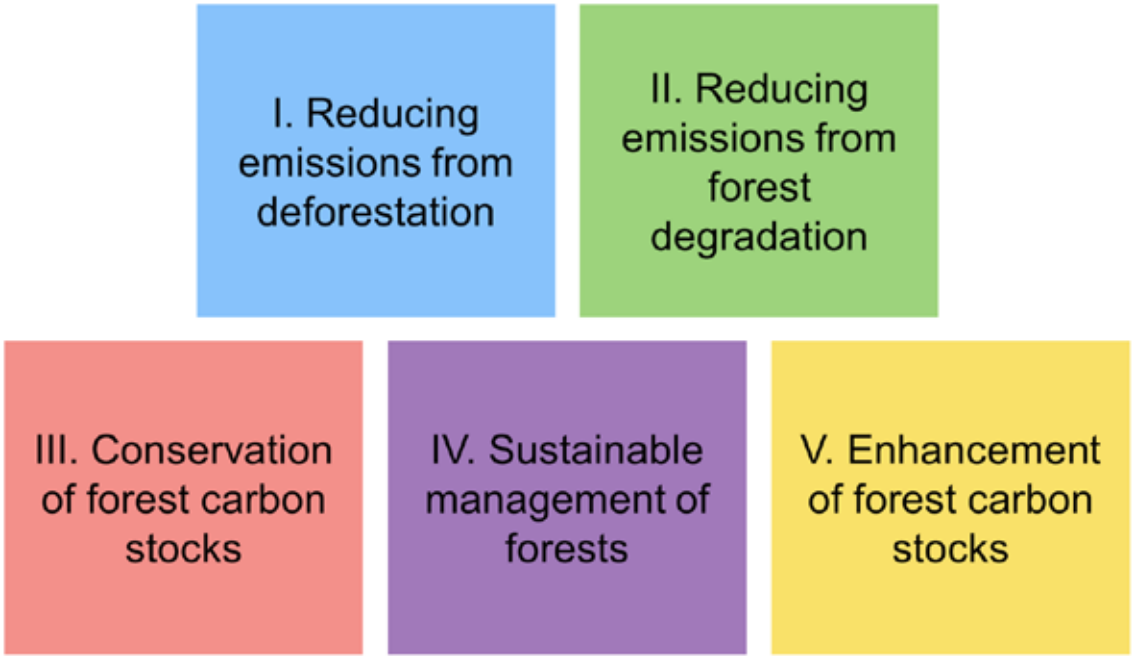

Figure 1: *The five REDD+ activities agreed under UNFCCC*

[1] Decision 1/CP.16

1.2 REDD+ multiple benefits and risks

REDD+ has the potential to deliver multiple benefits, including a wide range of social and environmental benefits in addition to climate change mitigation. These are sometimes referred to as 'non-carbon benefits' (e.g. in the 2015 Paris Agreement of the UNFCCC). A REDD+ programme that delivers multiple benefits and avoids social and environmental risks can contribute to a range of policy goals beyond climate change mitigation. Social benefits from REDD+ implementation can include improved governance of natural resources and increased participation in local decision-making on land use, and in some cases financial improvements to livelihoods. Environmental benefits from securing the many ecological functions of forests can include biodiversity conservation and the provision of ecosystem services on which people depend (Box 1).

Well-planned REDD+ implementation should secure or enhance forest ecosystem services, while reducing risks. By reducing deforestation and forest degradation, REDD+ can ensure that ecosystem services are retained which may otherwise have been lost. Through reforestation and forest restoration, REDD+ can restore ecosystem services that have previously been lost or degraded. As the importance of forest for providing different ecosystem services varies across the landscape, decisions about how and where REDD+ is implemented will influence the resulting benefits to people. Depending on how REDD+ is implemented, it also carries potential risks. These may include pressures on forests, such as illegal logging or conversion of forests to farmland, being moved or displaced from one area to another, or local communities' access rights to forests being reduced.

In order to reduce potential risks and enhance the benefits of REDD+, the UNFCCC requests countries to promote and support the Cancun Safeguards and to provide information on how they are being addressed and respected throughout implementation of REDD+ activities.

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1.3 REDD+ in Nigeria

The Federal Government of Nigeria's involvement in REDD+ began in 2009, through engagement in regional networks and interest in promoting REDD+ in Cross River State. Nigeria requested support from the Forest Carbon Partnership Facility (FCPF) in 2009, and became a partner country of the United Nations Collaborative Initiative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme[2]) in February 2010. A Nigerian National UN-REDD Programme was approved in 2012, and supports a two-track approach for developing REDD+ readiness: (i) the development of institutional and technical capacities at Federal level, and (ii) carrying out demonstration activities in Cross River State, as a pilot state for REDD+ (FME 2013) (Map 1).

Map 1: Location of Cross River State in Nigeria

Data sources:
Tree cover: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available online from: http://earthenginepartners.appspot.com/science-2013-global-forest.

[2] The UN-REDD Programme is the United Nations Collaborative Initiative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Developing Countries. The Programme was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and UN Environment). http://www.unredd.net/index.php?option=com_contentandview=articleandid=2082andItemid=515

Box 1: Ecosystem services

Ecosystem services are usually classified into the following main groups: provisioning services, regulating and supporting services, and cultural services (Millennium Ecosystem Assessment 2005). While provisioning services often involve tangible and easily quantified goods such as food and fuel, other ecosystem services (e.g. climate regulation, soil protection, nutrient cycling, pollination) are less easy to value in monetary terms, but are of crucial importance for human well-being.

- **Provisioning services**
  Forest goods include timber (which is still the most highly valued economic product from most forests worldwide), fuelwood (a significant part of the world's energy comes from biomass) and non-timber forest products such as food, fibre and medicinal plants. For example, a study of 51 case studies from 17 developing countries found that forest environmental income on average makes up 22% of total household income in rural communities (Vedeld et al. 2007, in Hicks et al. 2014).

- **Regulating and supporting services**
  These services arise from the natural function of healthy ecosystems, and include climate regulation (including through carbon storage), soil services and water services. Forests regulate water quality and quantity, and are a moisture source for downwind/downstream ecosystems. Forests serve as a carbon sink: as much as 45% of the carbon stored on land is found in the world's forests (NASA Earth Observatory 2012). Forests also give shade and shelter, and help to preserve soils.

- **Cultural services**
  Forests have non-material cultural, spiritual, religious and recreational values, which can be described as cultural services. Some forests are sacred sites, and others have recreation and amenity values. Living near to forests can improve people's physical and mental wellbeing. Forests support nature tourism, camping and hiking.

1.4 This study

The goal of this study is to support the development of national and State-level REDD+ strategies in Nigeria and Cross River State that take into account the potential benefits and risks of REDD+ actions. It uses spatial analysis to explore the potential for promoting multiple benefits from selected REDD+ actions in Cross River State, as well as other REDD+ related planning factors, such as changes in forest and land cover and particular pressures on forests.

This study was conducted as a part of Nigeria's National UN-REDD Programme. The spatial analyses were jointly developed during 2014-2016 by a working group made up of government and non-government representatives in Cross River State, with technical support from UN Environment's World Conservation Monitoring Centre (UNEP-WCMC) and guidance from the Federal Ministry of Environment (FME). The study draws on existing local, national and international datasets where possible, including other analyses that have been conducted through the Nigeria National UN-REDD Programme.

The report is presented in five main sections:

- Forests and their status in Cross River State
- Forests, biodiversity and ecosystem service values
- Forests and socio-economic values
- Pressures on forests and opportunities for REDD+
- Mapping potential REDD+ actions and their multiple benefits

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2 Forests in Cross River State

2.1 Forests in Nigeria

Nigeria's forests cover around 9.6 million hectares, about 10% of the country's land area. However, there is a lack of recent forest data at the national scale, with the last national forest inventory conducted in 1997 (FAO 2015). The country's main forest types include: the mangrove forests of the Niger Delta and southern coastline; rainforests and montane forests, together known as tropical high forest; woodlands and derived savannah in the north of the country; plantations; and trees on farmlands (FAO 2015; Nigeria REDD Readiness Project 2015). More than 50% of Nigeria's remaining tropical high forest is found in Cross River State (Nigeria REDD Readiness Project 2015).

The country's forest area is shrinking, due to exploitation for agricultural development (both subsistence and commercial), unsustainable harvesting for fuelwood and timber; infrastructure development; exploitation of oil, gas and solid minerals; urbanization and population growth, amongst other factors (Nigeria REDD+ Programme 2016b). Nigeria has lost more than 50% of its forest cover since 1990 and has one of the highest deforestation rates in the world (FME 2013). Nigeria's most recent National Communication to UNFCCC notes that land-use change and the forestry sector are a high net source of GHG emissions in Nigeria, accounting for 40% of the country's total GHG emissions in the year 2000, mainly due to losses of forest and other woody biomass stocks, indicating a high rate of deforestation (FME 2014). Pressures on forests in Nigeria and Cross River State are discussed in more detail in Section 2 of this report.

2.2 Forests in Cross River State

The ecological zones of Cross River State include lowland rainforest, freshwater swamp forest, mangrove vegetation, coastal vegetation, montane vegetation, savannah-like vegetation and wetlands. Although significant areas have been converted to farmlands, and natural forests have been disturbed by human activities, forests still cover extensive areas in the centre, north and east. The State is still home to one of the largest contiguous fragments of natural forest in the country (Mfon et al. 2014; NASRDA and FAO 2015).

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The largest area of forest in the analysis of land-use change conducted by NASRDA and FAO in 2015 is tropical high forest, consisting of evergreen tree species and a canopy averaging 40-60 m in height. Montane vegetation is predominant in the northeastern parts of the State, with the highest peak in the Sankwala Mountains reaching 1,819 m above sea level. A wide belt of freshwater swamp forest occurs to the north of the mangrove vegetation zone. This forest type is flooded during the wet season but the flood recedes during the dry season. Original swamp forest remains mainly on alluvial sites along the major rivers - Cross, Calabar and Great Kwa - but much of this vegetation type has been converted for other uses such as agriculture. Mangroves can be found along the coast and in the estuary of the Cross River. Other wetlands are found at the Cross River Estuary and the Cross River Flood Plains at Obubra, as well as scattered back-swamps and flood plains. Savannah-like vegetation occurs in the central and northern areas of the State (NASRDA and FAO 2015).

Forest cover in Cross River State can be explored using a number of different datasets and definitions of forest, and several studies have been conducted to estimate forest cover and trends (see Table 1). The precise definition of forest used has implications for assessing the State's level of forest cover (Map 2). For example, the Nigerian draft national definition of forest formulated in 2016 uses the following criteria: a minimum 15% canopy cover; a minimum area of 0.5 ha; and a minimum of 3 m in height. Using this canopy cover figure (15%) and data from Hansen et al. (2013)[3], a large proportion of land in Cross River State is covered by forest (Map 2). A comparison between the Hansen et al. (2013) derived tree cover map and the map from the NASRDA and FAO (2015) study shows some correlation; for example, areas with high tree cover in the Hansen et al. (2013) derived map align with areas of tropical high forest in the NASRDA and FAO (2015) map. However, the tree cover in the delta region of the south differs, with less cover apparent in the Hansen et al. (2013) layer, due to the relatively sparser tree cover provided by mangroves.

The main categories for the management of forests and forest tenure in Cross River State, are federal and state protected areas and forest reserves, community-managed forestlands and concessions managed by private companies (Map 3). The largest areas of forest in the State fall within the Cross River National Park, a protected area established by the Federal Government of Nigeria. Cross River State's 14 forest reserves, which are gazetted lands held by the State government for conservation and the production of forest resources, cover more than 2,700 km², though the majority have experienced significant deforestation (Muthui and Adedoyin 2016). Concessions to plantation and agricultural companies make up a relatively small proportion of the land area in Cross River State. All lands outside these categories are either managed communities or under private tenure (although few communities have formal title to these lands). For example, the NASRDA and FAO data shows that more than 40% of the State's natural forests are outside of forests reserves, the national park and plantation/agricultural concessions. Muthui and Adedoyin (2016) report 18 community forest management initiatives in Cross River State, covering approximately 600 km².

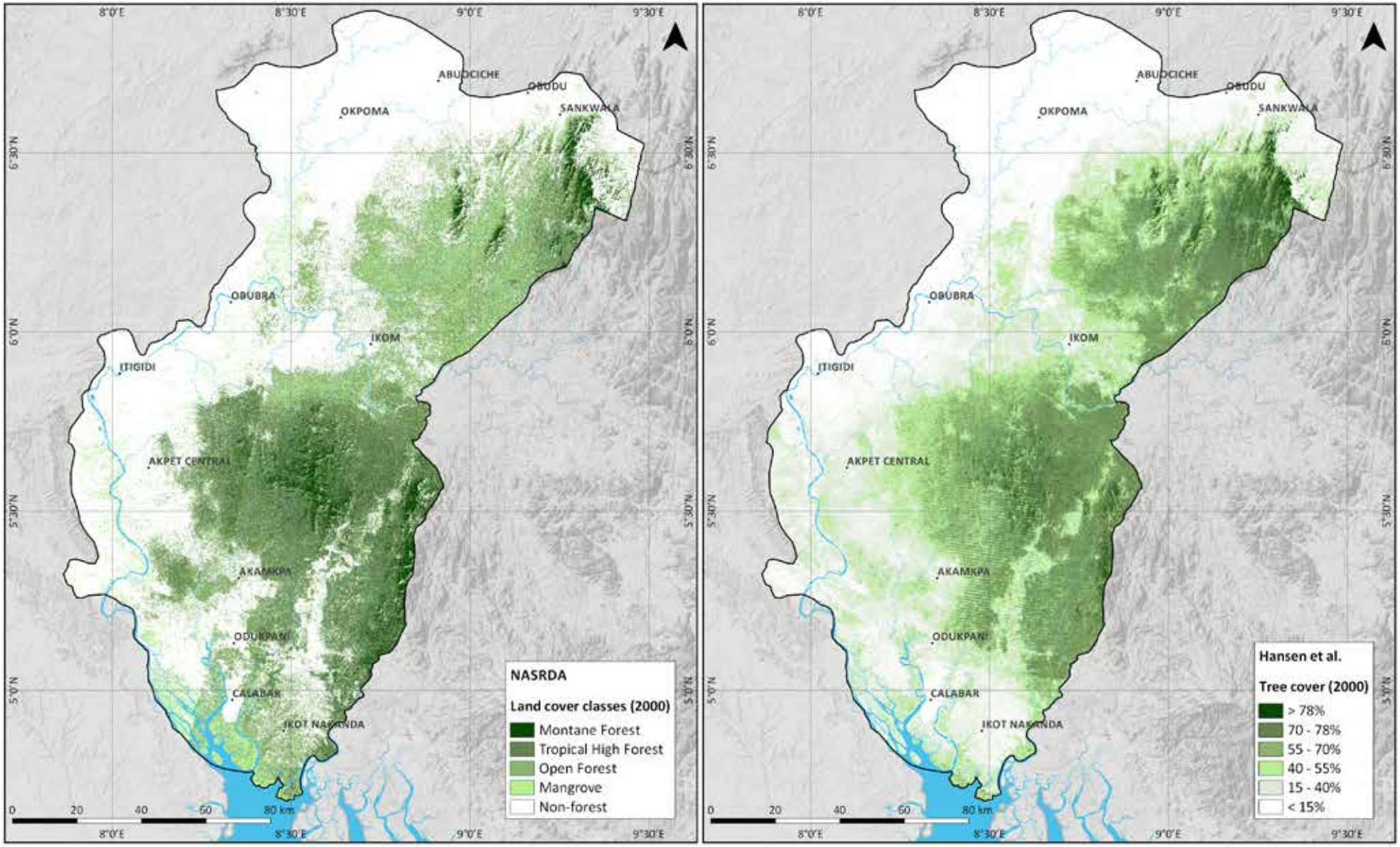
Table 1: Forest Cover in Cross River State from 1978 to 2014 (NASRDA and FAO 2015)

Study	Year	Forest Cover (ha)
FORMECU (Forestry Monitoring, Evaluation Coordination Unit)	1978	968,200
FORMECU	1995	842,000
NASRDA and FAO	2000	849,485
Cross River State Community Forestry Project Rapid Appraisal of Forest Resources from Remotely Sensed Data[4]	2002	772,961
NASRDA and FAO	2007	809,578
NASRDA and FAO	2014	642,195

[3] Hansen et al. (2013) is an international dataset, based on global satellite data, on tree cover loss, which is defined here as the disturbance or complete removal (from any level of tree cover to zero) of tree cover canopy.

[4] Cross River State Community Forestry Project's Rapid Appraisal of Forest Resources from Remotely Sensed Data conducted by Flasse Consulting (2002), supported by the U.K. Department for International Development (DFID) (NASRDA and FAO 2015).

Map 2: Forest cover in Cross River State

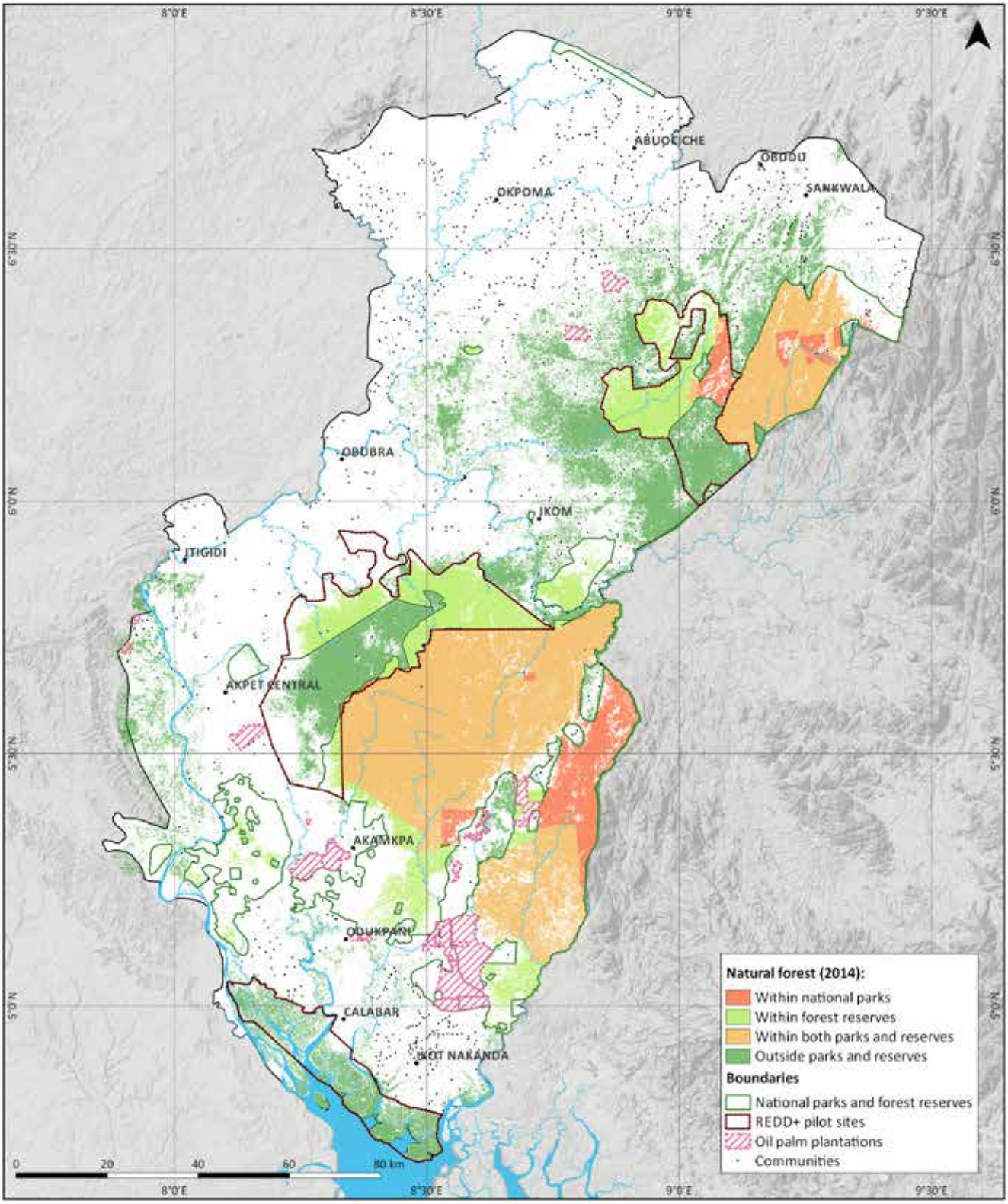


Data sources:

Forest cover (NASRDA): NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State.

Forest cover (Hansen): Global Forest Change 2000–2014 - Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://earthenginepartners.appspot.com/science-2013-global-forest.

Map 3: Forest management and tenure types in Cross River State



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery.

Cross River State, national park, forest reserve, plantation and REDD+ pilot site boundaries: Cross River State Forestry Commission and Flasse Consulting (2002) Cross River State Community Forestry Project: Rapid Appraisal of Forest Resources from Remotely Sensed Data. Submitted to ERM – Environmental Resources Management and DFID – Department for International Development

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2.3 Forest carbon stocks

Forests, in particular tropical forests, are vast carbon stores and sinks. Forest carbon stocks include both the carbon stored within living organisms (biomass carbon) and that stored in soils. Biomass carbon is mainly present in woody materials growing above ground (in leaves, branches, and stems) and below ground (in roots) (Trumper et al. 2009; Walker et al. 2011). The biomass and carbon content of forests and other vegetation varies considerably, depending on the type of land cover and ecoregion, and can be influenced by physical factors (e.g. precipitation, temperature, topography), biological parameters (e.g. species composition and age of the vegetation layer), as well as anthropogenic factors (such as the degree of disturbance or the land use history of the area) (GOFC-GOLD 2013).

The GHG emissions reduction potential, and enhanced removal potential, of forests depends on the biomass carbon present within these forests. Understanding the distribution of forest biomass carbon, therefore, is an important part of REDD+ planning. Initial estimates of the above- and below-ground biomass (in CO_2 equivalent) in the main land cover types in Cross River State range from around 189 t/CO_2e in swamps to around 1,790 t/CO_2e in montane forests (National MRV Working Group, cited in Nigeria REDD+ Programme 2016b). To produce an indicative map of carbon stocks (Map 4), a pan-tropical map of biomass carbon produced by Saatchi et al. (2011), was used to estimate stocks in Cross River State[5]. While different data sources and approaches are available (e.g. Ruesch and Gibbs 2008; Baccini et al. 2012), the Saatchi data source was chosen for the present study because it includes below-ground biomass, and because the working group felt it more accurately represented areas in the State and areas further afield, e.g. around Lake Chad.

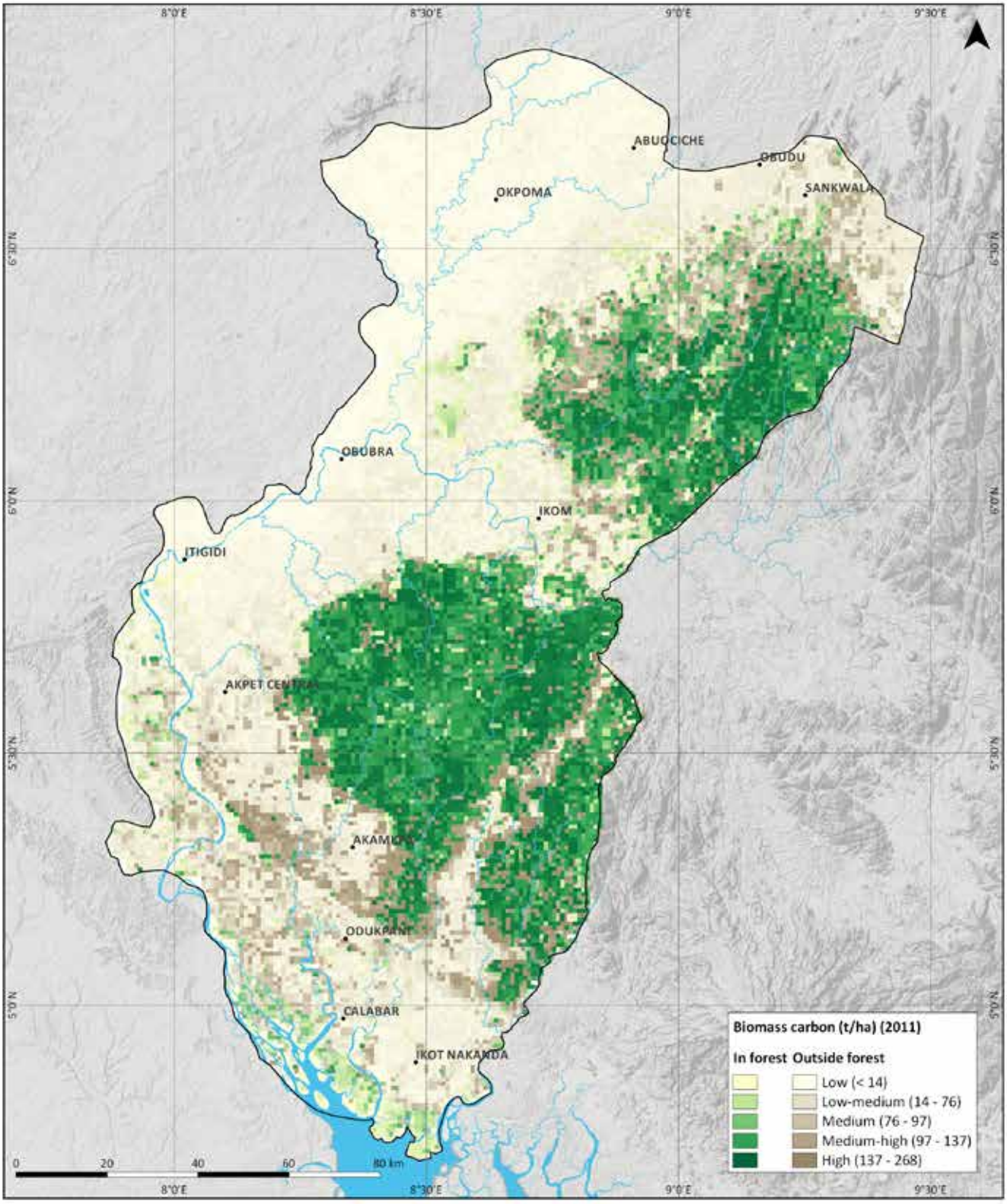
Overlaying the biomass carbon stocks estimation with the area of natural forest (according to NASRDA and FAO 2015) shows that the State's main concentration of forest carbon stocks is in the mountainous forest areas of the Cross River National Park (Map 4). There is also a band of high carbon across the south of the Oban division and north of Obudu/Mbe, and some forest carbon stocks are also contained in the mangrove areas.

Several areas outside the mapped natural forest areas, particularly around the national park, show up as having relatively high carbon stocks. This is likely to represent areas that have recently become deforested or degraded, and so in reality have had their carbon stocks degraded. The carbon layer and forest cover layer were created three years apart, with Saatchi et al. modelling biomass carbon in 2011 and NASRDA and FAO classifying land cover in 2014. Although a simple difference in methods and data sources can account for some of these differences, the pattern of high-carbon areas outside natural forest corresponds quite closely to areas that changed from forest to non-forest between 2000 and 2014 (Map 9). The similarity between these patterns suggest that carbon-rich forests, especially on the fringes of the core areas of natural forest, have been converted to other land-uses within the last decade.

The natural forest class in Map 4 includes a number of different forest types, which were identified as 'natural' through consultation with mapping working group members in Cross River State (as there is no formal State or Federal definition of 'natural forest'). The classifications designated as natural forest are: tropical high forest; montane forest; open forest; derived savannah (a type of open forest or savannah that has evolved due to human disturbances); and mangroves. However, for the purposes of the spatial analyses in this study, two caveats apply: First, the classification of 'swamp' in the original NASRDA and FAO (2015) data is considered a special category, as it includes natural forest areas, such as flooded forest, as well as non-forest areas, such as swamps and rice-fields. Second, in the main datasets used to assess land cover and land-cover change (such as NASRDA and FAO 2015), the savannah areas are classified as 'grassland' or 'other land' rather than forest. This means that some natural forest areas are still extant outside of the areas shown as natural forest in this map layer.

[5] The Saatchi et al. (2011) dataset maps the total carbon stock in live biomass (above- and belowground) using data from in situ inventory plots, satellite light detection and ranging (Lidar) and samples of forest structure.

Map 4: Carbon stocks in Cross River State



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery.

Biomass carbon: Saatchi, S., Harris, N., Brown, S., Lefsky, M., Mitchard, E., Salas, W., Zutta, B., Buermann, W., Lewis, S., Hagen, S., Petrova, S., White, L., Silman, M. and Alexandra Morel (2011) Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS 2011 108 (24) 9899-9904. doi:10.1073/pnas.1019576108.

3 Forests, biodiversity and ecosystem service values in Cross River State

Cross River State's forests, both natural and planted, are rich in biodiversity and provide a wide range of ecosystem goods and services to communities. The protection and enhancement of forests can help to ensure these ecosystem services are retained, so that REDD+ meets multiple policy objectives and is more beneficial to local communities. Consultations in Cross River State in 2013-2014, as well as subsequent studies, have highlighted a number of biodiversity and ecosystem values that are of interest to the State's emerging REDD+ programme. In addition, in a recent study commissioned to inform the preparation of REDD+ Strategies at State and national level, Muthui and Adedoyin (2016) include ecosystem health criteria, comprising conservation of biodiversity and ecosystem functions (for soil and water), in their assessment of potential REDD+ actions for consideration.

3.1 Natural forests

Information on the definition and distribution of natural forest is needed to inform planning for REDD+. In addition to supporting planning for REDD+ actions that aim to protect or manage natural forests, understanding the distribution of natural forests is vital in promoting and supporting the UNFCCC's Cancun Safeguards for REDD+, in particular safeguard 'e'. This safeguard states that REDD+ actions 'are not used for the conversion of natural forests but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services'. As discussed in section 2.3, Nigeria does not have a formal definition of natural forest. However, based on discussions with working group members in Cross River State, the forest classifications designated as natural forest in this study are: tropical high forest; montane forest; open forest; derived savannah; and mangroves (Map 4).

This designation of natural forest may have implications for what types of REDD+ actions can be implemented where, and how they are designed. For example, actions to enhance forest carbon stocks in derived savannah, a natural forest type, may focus on natural regeneration or assisted natural regeneration using native species, in order to address the REDD+ safeguards (avoiding conversion to planted forest) and support the restoration of natural forests. When examining the distribution of natural forest in the State, it is essential to consider the limitations of available spatial data, as discussed in section 2.3, which mean that some areas of natural forest may not appear on the maps. The 'swamp' category from the NASRDA dataset includes natural forest areas, such as flooded forest, and the savannah areas – considered by the working group to be degraded natural forest - have been classified as 'grassland' or 'other land'.

3.2 Biodiversity

Nigeria's forests are part of the Guinean Forests of the West Africa Biodiversity Hotspot[6] that extends across the southern part of West Africa and into Central Africa, north of the Congo Wilderness Area. It covers 621,705 km², and includes two subregions: the 'Upper Guinean Forests' subregion, which stretches from Guinea in the west, through Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo and, marginally, into Benin. The 'Lower Guinean Forests' subregion covers much of southern Nigeria, extends into southwestern Cameroon, and also includes São Tomé and Príncipe and the offshore islands of Equatorial Guinea. The Guinean Forests support impressive levels of biodiversity including numerous endemic species and are ranked among the world's foremost regions for mammalian diversity. Threatened primate species in the Lower Guinean Forests include western gorilla (*Gorilla gorilla;* CR) and drill (*Mandrillus leucophaeus;* EN) (Carr et al. 2015).

Cross River State is home to a national park, established in 1991, which contains high levels of diversity and endemism (Wildlife Conservation Society (WCS) 2016a). It has two divisions, Oban and Okwangwo, which are separated by the Cross River Valley. The whole park covers more than 3,600 km², and the Oban division has the largest area of closed-canopy rainforest in Nigeria. The area is a biodiversity hotspot with threatened species such as the Cross River gorilla (*Gorilla gorilla diehli*), found mainly in the Okwangko division, as well as Nigeria-Cameroon chimpanzee (*Pan troglodytes ellioti*), drill (*Mandrillus leucophaeus*), Preuss's red colobus monkey (Procolobus preussi), leopard (*Panthera pardus*), forest elephant (*Loxodonta cyclotis*) and the grey-necked picathartes or rockfowl (*Picathartes oreas*). The Oban division is one of the most ornithologically

[6] One of 36 Biodiversity Hotspots identified globally, which are considered the world's most biologically rich and threatened areas (http://www.cepf.net/resources/hotspots/Pages/default.aspx).

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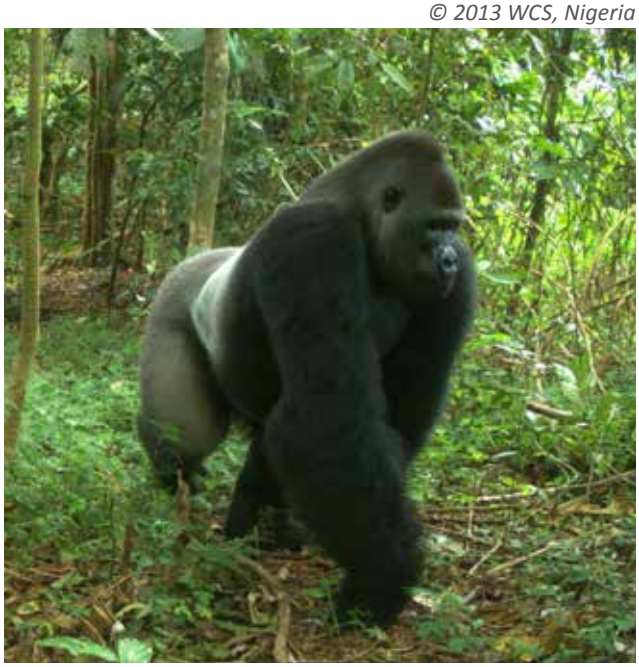


diverse areas in the country and may be the richest site in Africa for butterflies. However, hunting, illegal logging and other pressures threaten the Park's biodiversity (WCS 2016b; WCS 2016c).

The IUCN Red List (IUCN 2016) categorizes plant and animal species according to their risk of global extinction. Species distribution maps associated with the IUCN Red List data can be used to show spatial patterns of the potential richness of threatened species (those listed as Critically Endangered, Endangered and Vulnerable) that are found in forest habitats. This simply involves an overlay of the overall distribution ranges[7] of these species (Map 5). In this study, this map is combined with other information, such as the location of priority areas for biodiversity conservation (such as Key Biodiversity Areas, KBAs[8]) and locally generated data on gorilla distribution. In Cross River State, there is a clear concentration of threatened species ranges in the forested areas of the national park, and in the mangroves and delta area of the State's south east. The KBAs in Cross River State are all identified as Important Bird Areas, and are largely found in the national park. There is an 'unprotected' KBA in the northwest of the State.

Cross River Gorilla (*Gorilla gorilla diehli*), a subspecies of Western gorilla, is classified as Critically Endangered and so is considered a priority for conservation in Cross River State and internationally[9]. It is the world's rarest great ape, with fewer than 250 mature adults (Bergl et al. 2016; WWF 2016). The gorillas live in forests along the Nigeria-Cameroon border. Locally collected data from 1998-2008, provided by WCS[10], show clusters of gorilla nest sites in four main areas in and around the Obudu division of the national park (Map 5). The map of conversion of forests to other land uses (2000-2014) indicates that these forest areas are being fragmented, and connectivity between the nest sites and other forest patches is being lost (Map 9). This may affect the gorilla's ability to travel between nest sites and forage areas. It is especially problematic because gorillas prefer to use forests with good availability of their staple food plants and low human disturbance (Dunn et al. 2014)

REDD+ actions that reduce deforestation and forest degradation where threatened species are concentrated may support biodiversity conservation in addition to providing climate change mitigation benefits. Information on species richness, priority species for conservation and potential threats to habitat therefore provide an initial basis for identifying priority areas for REDD+ actions in relation to biodiversity benefits, and can indicate areas of priority for conservation investment, to which a REDD+ programme could contribute.

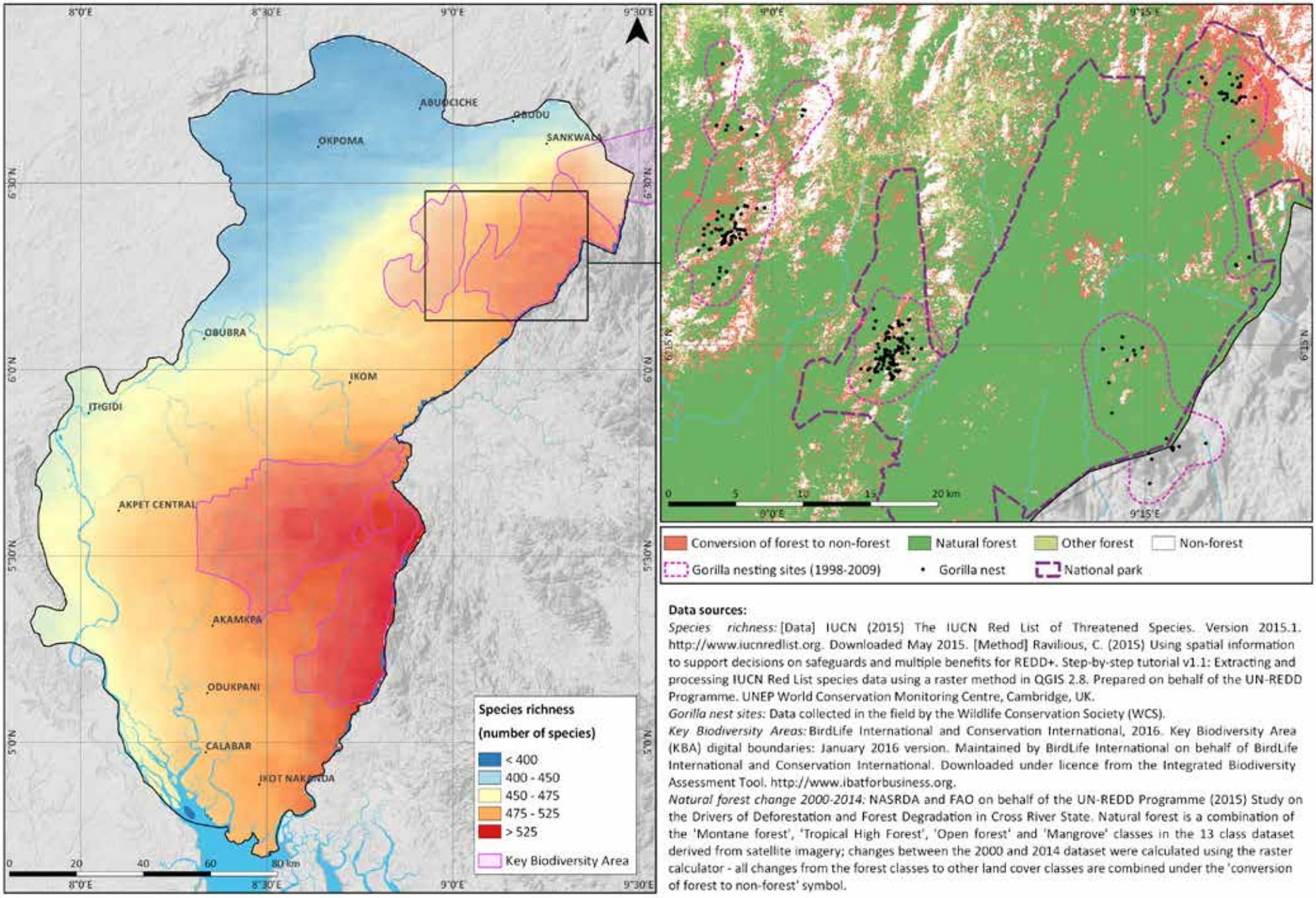
[7] These ranges represent the area of occurrence, which will include areas not presently occupied by the species, hence 'potential richness'.

[8] KBAs are 'sites that contribute to the global persistence of biodiversity', including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems, identified through a consultative, science-based process (http://www.keybiodiversityareas.org/what-are-kbas).

[9] For example, maps showing the distribution of species and migration corridors, including for gorillas, were prioritized for this study by stakeholders in consultation workshops in Cross River State in 2013 and 2014.

[10] Since 2001, WCS has helped produce regional action plans for the conservation of the Cross River gorilla and the Nigeria-Cameroon chimpanzee, two Critically Endangered subspecies of apes. The first landscape-level survey of Cross River gorillas was undertaken from 2006-2008 (https://nigeria.wcs.org/).

Map 5: Threatened species richness key biodiversity areas and gorilla sites in Cross River State



Data sources:

Species richness: [Data] IUCN (2015) The IUCN Red List of Threatened Species. Version 2015.1. http://www.iucnredlist.org. Downloaded May 2015. [Method] Ravilious, C. (2015) Using spatial information to support decisions on safeguards and multiple benefits for REDD+. Step-by-step tutorial v1.1: Extracting and processing IUCN Red List species data using a raster method in QGIS 2.8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Gorilla nest sites: Data collected in the field by the Wildlife Conservation Society (WCS).

Key Biodiversity Areas: BirdLife International and Conservation International, 2016. Key Biodiversity Area (KBA) digital boundaries: January 2016 version. Maintained by BirdLife International on behalf of BirdLife International and Conservation International. Downloaded under licence from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org.

Natural forest change 2000-2014: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery; changes between the 2000 and 2014 dataset were calculated using the raster calculator - all changes from the forest classes to other land cover classes are combined under the 'conversion of forest to non-forest' symbol.

3.3 Soil erosion

Soil erosion control was identified in consultation with stakeholder groups as an important benefit of retaining and restoring forest through REDD+ in Cross River State (Nkor et al. 2015). Forests can help to prevent soil erosion, particularly on slopes, with the physical structure of the forest intercepting rain, reducing its impact on topsoils and slowing runoff, well as through the roots stabilizing the soil. In deforested or degraded forest landscapes the land may be less able to absorb and hold water, resulting in increased run-off after heavy rains, and consequent problems for people and the environment, such as erosion and sedimentation, downstream flood risk and water shortages at other times of the year. Higher soil sediment loads carried by runoff can also reduce downstream water quality.

The role of forest in reducing erosion is most critical where high rainfall combines with steep slopes to increase erosion risk within catchments. Hence, this role is often estimated as a function of slope, rainfall and the presence of something important to people downstream that could be adversely affected by soil erosion, such as a water body. Our analysis in Cross River State combined only two layers: slope grade and rainfall patterns (Map 6). It indicates that tropical high forest and montane forests play a greater role in controlling soil erosion risk than other types of forest. The areas without forest cover in the north-east and south of the State have a higher risk of soil erosion. REDD+ actions that are carefully designed and targeted may help contribute to soil erosion control in these areas. Further analyses of deforested or degraded areas in catchments where erosion risk is high may help to identify potential locations for forest restoration with additional benefits for the stabilization of soils.

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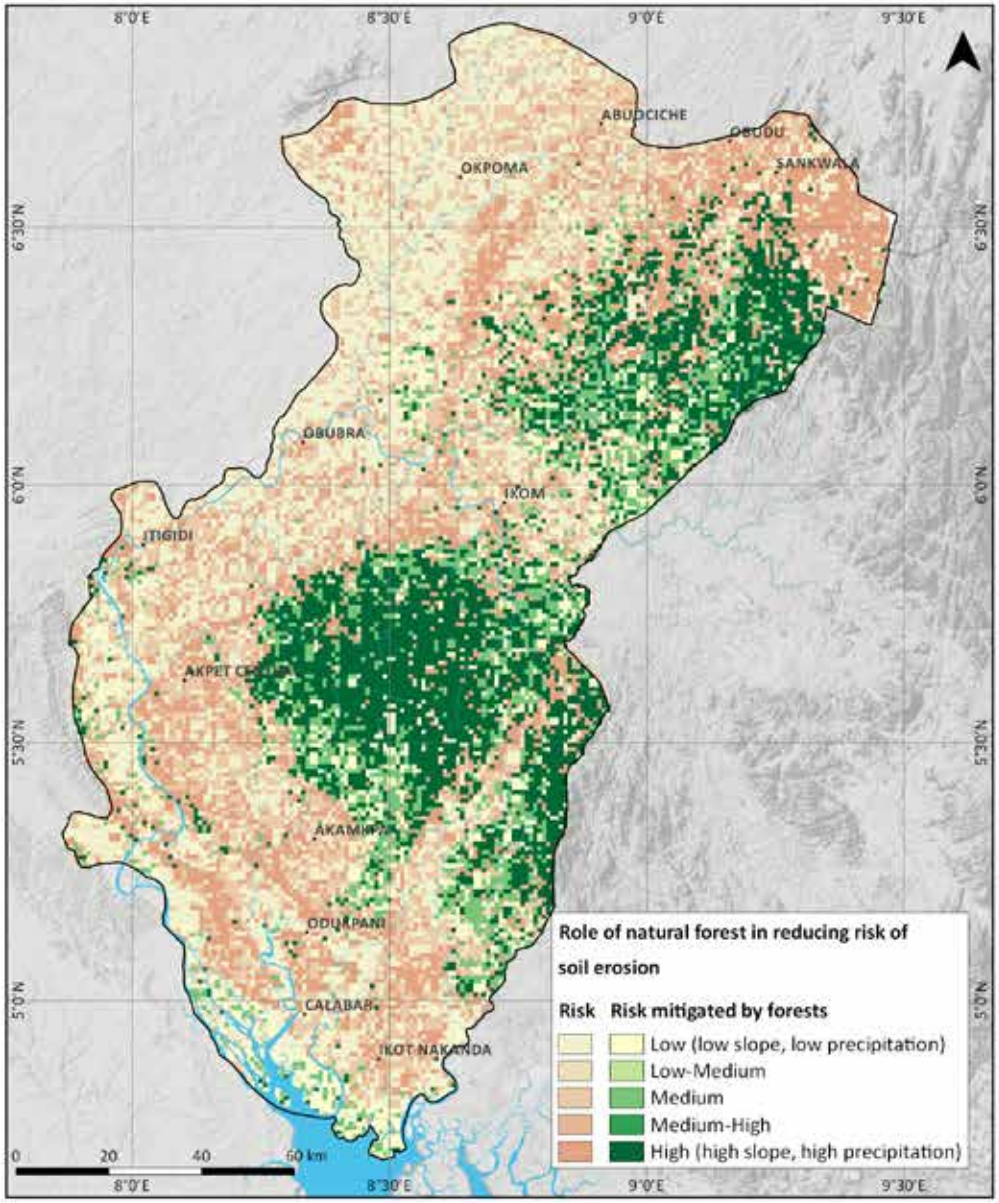
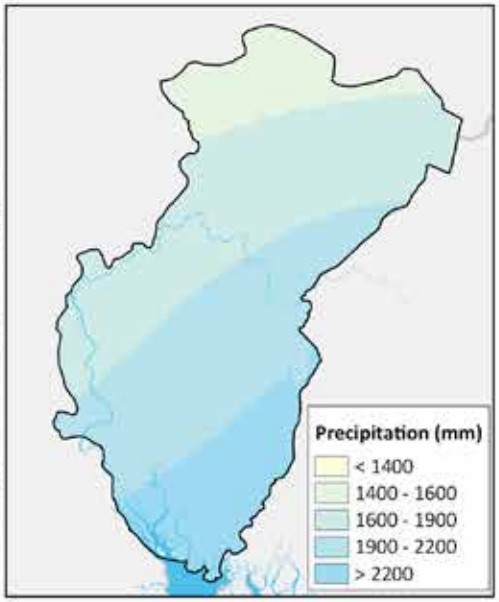
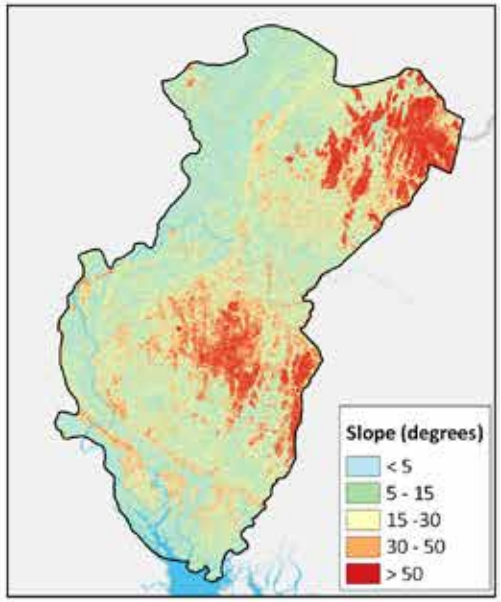
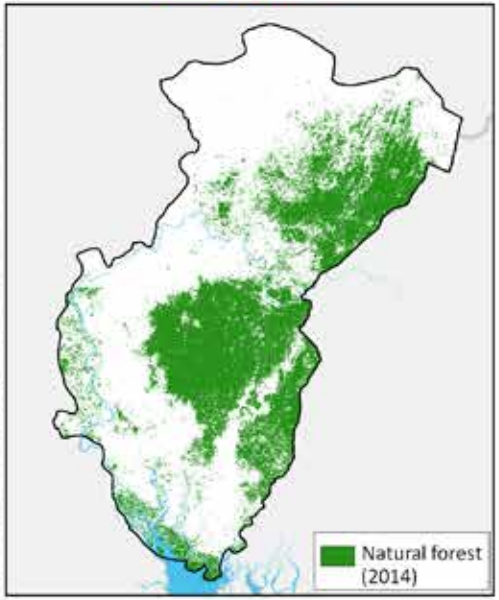
Map 6: Role of natural forest in Cross River State in reducing risk of soil erosion









Data sources:

Risk of soil erosion: [Method] Ravilious, C., Maukonen, P., Thorley, J. and van Soesbergen, A. (2015) Using GIS to help integrate biodiversity and ecosystem services into REDD+ decision making. Step-by-step tutorial: Evaluating the importance of forests for soil stabilization and limiting soil erosion, a simple approach using QGIS 2.8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Forest cover (NASRDA): NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State

4 Forests and socio-economic values in Cross River State

Nigeria's forest resources account for about 2.5% of its Gross Domestic Product (FAO 2015). The ecosystem goods and services provided by forests in Cross River State make a significant contribution to the economy of the State, particular through their role in supporting livelihoods and people's well-being. Potential socio-economic benefits of REDD+ implementation in the State, as prioritized for further analysis by consultation workshop, included the role of forests in supporting ecotourism and the provision of non-timber forest products (NTFPs) (Nkor et al. 2015).

4.1 Ecotourism

Besides supplying a vast amount of natural products, forests and their associated biodiversity also have the potential to successfully contribute, through ecotourism, to the sustainable development of the tourism industry. In 2008, an estimated 284,000 tourists visited Cross River State, while expenditure receipts amounted to N22.9 billion (USD176 million) (Ajake 2016). In Nigeria, and in Cross River State in particular, development of this industry has been a priority for government. Funding improvements to resorts and tourist sites, such as Agobokim Waterfalls, the Monolith sites[11] and the Cross River National Park, has allowed the State to position itself as a major tourist destination in Nigeria (Inyang and Esu 2008; Ajake and Amalu 2012), as has investment in, and development of, cultural celebrations such as the Calabar Carnival[12]. This is reflected in the increased number of tourists visiting Cross River State - from 2,210 people between October and December 2000 to about 8,162 tourists between October and December 2009, visiting from both outside and inside the country (Eja and Out 2015).

Feasible and sustainable ecotourism is dependent on high-quality landscapes, diverse and abundant wildlife and rich culture (Ofen et al. 2012). With its substantial regions of tropical forest and associated endemic species (in particular primates), Cross River State is recognised as having strong potential for further ecotourism development. Existing ecotourism sites and facilities in the state are mainly in and around its forested areas (Map 7). A number of sites are associated with rare primates such as the Cross River gorilla (*Gorilla gorilla diehli*), the Nigerian-Cameroon chimpanzee (*Pan troglodytes ellioti*) and the drill (*Mandrillus leucophaeus*) (which can be found in the Afi Mountain Sanctuary and the Mbe Mountains). The primate rehabilitation programme run at CERCOPAN focuses on monkeys that have fallen victim to trade. Rare bird species such as picathartes (*Picathartes oreas*) also provide ecotourism opportunities, as does the largest wintering roost site for swallows in Africa, located in the forests of the Boki Local Government Area. Other sites have capitalized on areas of natural beauty, such as the Agbokim Waterfalls and Kwa Falls, and areas of cultural importance such as the Ikom Monoliths to the north of the state.

It has been recommended that the Cross River State REDD+ strategy includes development of ecotourism as an alternative income generating activity (Muthui and Adedoyin 2016), and ecotourism opporunities may result from a number of REDD+ actions that conserve forests of interest. Ecotourism is considered a valuable way of promoting socioeconomic development and improved well-being of local communities, while simultaneously supporting the conservation of natural landscapes and species. The premise is that when local people receive income and employment from ecotourism, they are more likely to conserve and sustainably use those habitats. Ecotourism can generate benefits for local communities by bringing people into an area presenting opportunities for selling additional goods and services, and diversifying local economies while complementing main income activities (Ofen et al. 2012). In the vicinity of Cross River National Park, for example, villages closer to the tourism sites have greater opportunities for tourism-related employment and income than those further away (Ezebilo and Mattsson 2010b).

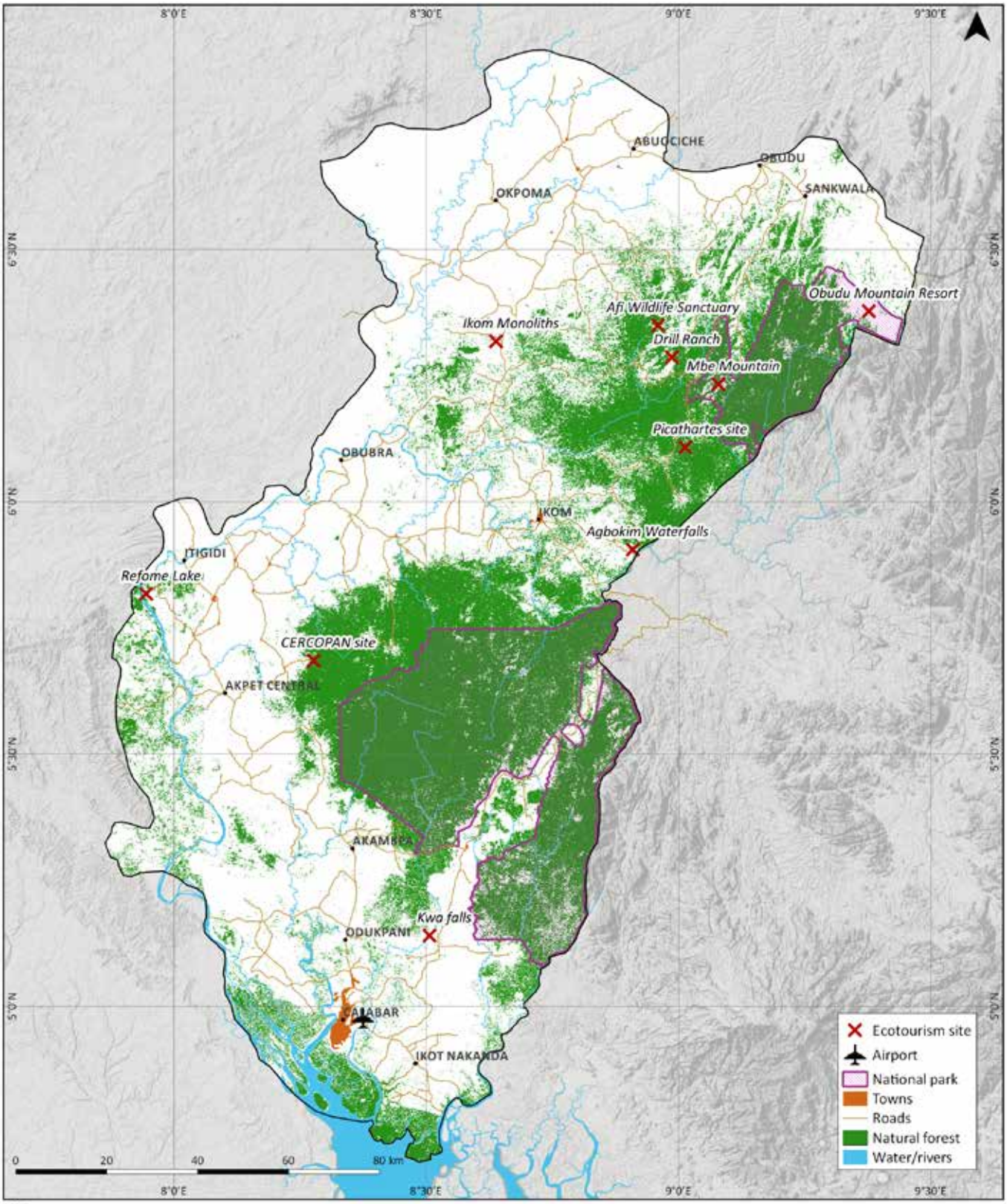
In Cross River State, ecotourism sites are mostly situated far from major cities like the state's capital Calabar, in more remote areas of the state (Map 7). Further development of ecotourism around such resources would therefore need to consider issues of accessibility of such sites, both in terms of ensuring economic viability, as well as any environmental

[11] The Ikom monoliths are more than 300 upright volcanic-stones decorated with carvings of geometric and stylized human features and are laid out in circles. Recognizing their cultural significance, they have been added to the World Monuments Fund's list of sites in danger and are being considered for inclusion onto UNESCO's World Heritage Site list. (World Monument Fund: https://www.wmf.org/project/ikom-monoliths-cross-river-state accessed 5/12/2016 and UNESCO: http://whc.unesco.org/en/tentativelists/5173/_accessed 5/12/2016).

[12] The Calabar Carnival is a month long event held each year in December.

and social implications of opening up access to these remote natural areas. Successful ecotourism development can provide local communities with valuable livelihoods coupled with motivation to maintain and protect wildlife. Involving these communities in planning that considers their needs, values and well-being will result in a more sustainable approach to ecotourism. Appropriate safeguards should be implemented to ensure that habitats are not overly disturbed, and that a large proportion of benefits is captured at the local level.

Map 7: Locations of ecotourism sites, protected areas and natural forest in Cross River State



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery.

Ecotourism sites: Geographical coordinates of important ecotourism sites compiled by Cross River State and UNEP-WCMC.

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4.2 Forest products

Timber and fuelwood

Forests in Nigeria are thought to provide employment for over two million people involved in the supply of fuel wood and poles, while more than 80,000 people work in the log processing industries, especially in the southern part of the country (FAO 2015). Forests are an important asset for Cross River State's economy (Dunn et al. 1994). Previous estimates made by the Cross River Forestry Commission (CRSFC) on the total potential value of tariffs for timber extraction in the State's standing tropical high forest areas at the time (excluding the Cross River National Park) were N5.6 billion (USD0.25 billion; based on December 1993 prices) (Ite and Adams 1998). Mangrove forests are also a rich source of wood for various domestic and industrial purposes, including for processing of fish and shrimps, for building materials and for energy needs (Oribhabor and Udo 2011; Holzlöhner and Nwosu 2014). However, due to high deforestation rates leading to rapid decline in forest cover in recent decades, a moratorium on timber extraction was declared in 2008 and is now extended indefinitely. To consider the socio-economic values of the forests in the Cross River State it is therefore necessary to look beyond timber production, to the diverse array of non-timber forest products (NTFPs) and other services that forests offer.

The State's forests are a source of fuelwood for communities, and the use of this resource has increased in recent decades, mainly as a result of population growth; however the lack of affordable alternatives, especially for the poorest consumer is also a contributing factor (Muthui and Adedoyin 2016). The majority of households in the State depend on wood for energy (for cooking and lighting), with some 64.4% of communities using fuelwood as a primary source of energy. It is estimated that some communities such as Buanchor use as much as 19.76 kg fuelwood per household per annum, while other communities use between 2.6 kg (e.g. in New and Old Ekuri) and 10.4 kg (Esuk Idebe) per household per annum (Muthui and Adedoyin 2016). In addition to domestic energy use, the 2015 study on drivers of deforestation and forest degradation found that fuelwood is used for preserving and processing agricultural produce, such as cassava flour (NASRDA and FAO 2015).

High dependence on traditional biomass energy sources, coupled with the unregulated nature of the fuelwood and charcoal industry, increases the risk of negative impacts on forests, as well as reducing capacity to mitigate climate change (Muthui and Adedoyin 2016; Nigeria REDD+ Programme 2016a). Options for reducing the impact of fuelwood extraction on forests should be explored, such as promoting the efficient production and utilization of fuelwood and charcoal, ensuring that the energy and infrastructure sectors take account of identified barriers to widespread uptake of clean cooking technologies, and exploring the scaling up of alternative renewable energy sources (e.g. ethanol, biogas, other biomass) (Muthui and Adedoyin 2016; Nigeria REDD+ Programme 2016a).

Non-timber forest products (NTFPs)

Forests contribute to society and the economy in many ways, meeting a wide range of needs, from aesthetics and recreation, to food, medicine, building materials, and as a source of employment and income through forest-based farming, coastal fisheries and foraging of NTFPs. NTFPs are non-timber products extracted from forest ecosystems and used within the household or sold, and may have social, cultural or religious significance (FAO 1990). A substantial portion of the forests in Cross River State are considered 'community forests' and are therefore easily accessible to communities for the harvest of NTFPs; in fact, all forests that are not protected areas, forest reserves or commercial plantations, are under community management or co-management (see Map 3, section 2.2).

Top and centre: © 2014 Bridget Nkor; bottom: © 2013 WCS Nigeria

In Cross River State, more than 700 different NTFPs have been identified, with harvesting of over half of these (around 430 species) recorded within the State. For instance, in the 1990s there were reported to be over 50 million mature large stems and 30 million small stems of rattan canes growing in the State, and over 2.5 million stands of bush mango (Dunn et al. 1994, in Mfon et al. 2014). Some of the most valuable forest products found in the State's forests include:

- *Gnetum africanum*, a leafy vegetable known locally as afang, which is a vegetable contributing to the livelihoods of people across the Nigerian rainforest.
- The leaves, fruits and kernels of *Elaeis guineensis* (oil palm) are all widely used and valued both as a food source and for its medicinal properties.
- The sap of *Raphia hookeri* is often distilled for alcoholic 'gin'.
- *Garcinia* spp. and *Randia* spp. have antibacterial properties and are used as chewing sticks for oral hygiene throughout southern Nigeria.
- Giant land snails (*Archachantina marginata*) are widely collected for food.
- Of the many medicinal plants found in the State's forests, *Drypetes flouribunda* is used in the treatment of heart diseases, and *Enantia chlorenta* and *Morinda lucida* for the treatment of malaria and/or fever (Adebayo and Krettli 2011).
- Bush meat, an NTFP which provides valuable protein and income. A variety of mammals, reptiles and birds are harvested for meat including *Antherurus africanus* (porcupine) and *Tregelaphus scriptus* (antelope). The wild meat is consumed locally or traded in rural and urban markets (Carter 1996; Fa et al. 2006; Ezebilo 2010; Fon et al. 2014; Offiong and Ita 2013). Demand for bushmeat has grown in recent decades and high rates of harvesting can have a negative impact not only on biodiversity but also on food security (Fa et al. 2006).

Sites in the forest inventory conducted in Cross River State in 2015-2016 that include records of key NTFP species (such as *Gnetum*, mushrooms and fauna) are found scattered across the State, in all forest types – these sites are within the national park and more remote forest areas, as well as in open forest and savannah areas in the north (Map 8).

The mangrove ecosystems to the south of the State also offer great value to coastal communities, such as those in Calabar Municipality, Calabar South, Odukpani, Akpabio and New Bakassi Local Government Areas (Holzlöhner and Nwosu 2014). Mangrove forests provide a varied and abundant supply of food for communities and a source of income through fisheries. Some important species caught for

consumption and trade in local markets include the bonga fish (*Ethmalosa fimbriata*) and the estuarine shrimp (*Nematopalaemon hastatus*) (Holzlöhner and Nwosu 2014). Forest inventory data for NTFP species in the mangrove area of the State includes records for periwinkles, crabs, prawns and shrimp (Map 8). Mangroves also contribute to fisheries production through the transfer of nutrients to the estuary and coastal waters. Many species of commercially traded marine organisms depend on mangroves for at least part of their life cycle. Mangroves serve as a feeding and nursery ground for coastal fish species.

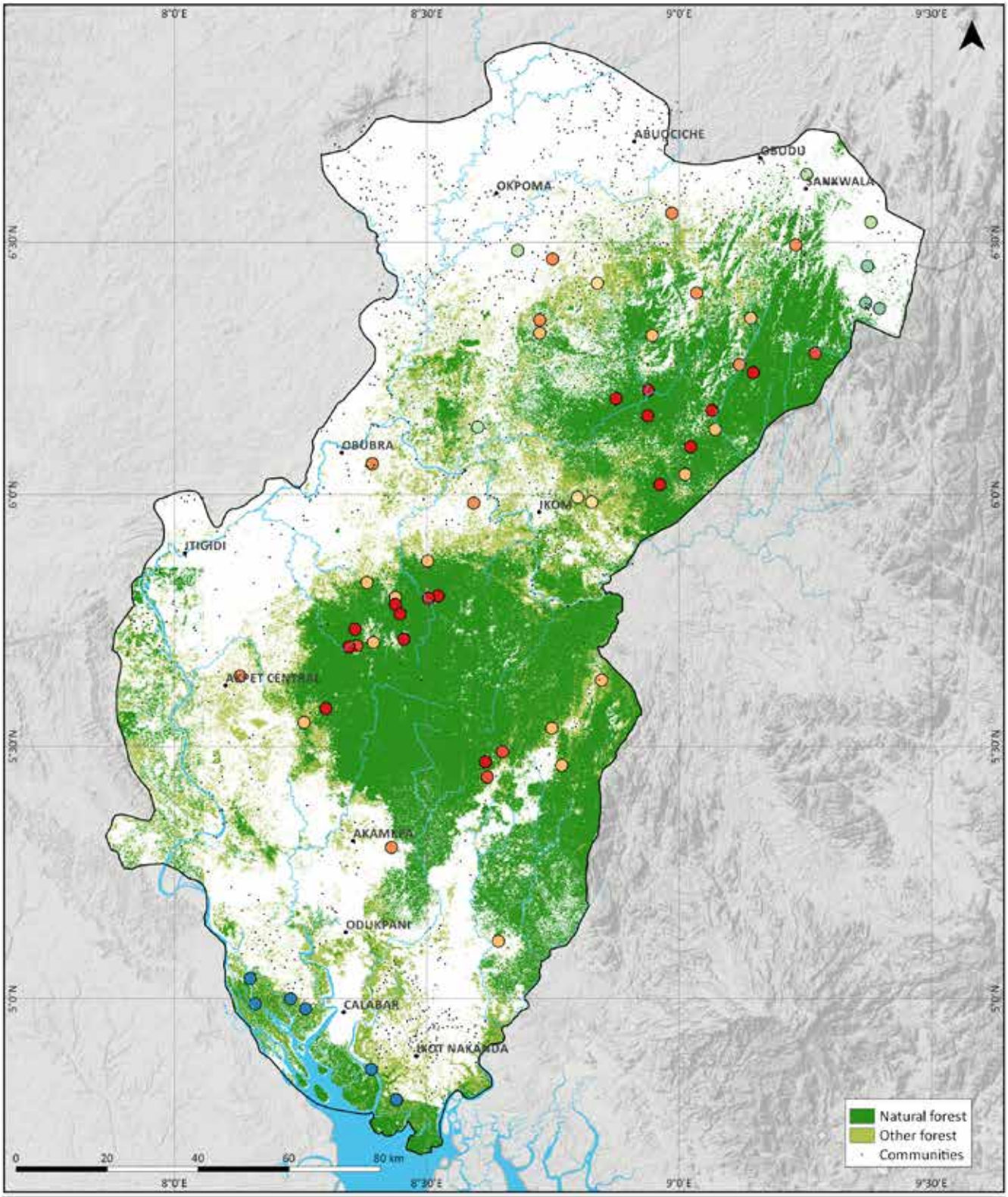
Although the value of financial and economic benefits can be difficult to estimate for many forest products, the potential of NTFPs is considerable in terms of creating and sustaining employment, provision of food, medicine and other products, and the generation of income (Jimoh 2006; Babalola 2011; Offiong and Ita 2013). The contribution that NTFPs make to rural livelihoods depends on variables such as the availability of forest resources and access to markets, as well as socio-economic factors like wealth and gender (Malleson et al. 2014). Income generated from NTFPs is particularly relevant for remote communities and poorer households, who depend on these resources to a much greater degree due to lack of opportunities for alternative income generation. NTFPs also provide societal groups that are more marginalized with an opportunity to earn money (Offiong and Ita 2013; Malleson et al. 2014).

The importance of income generated from NTFPs varies through the year, with much NTFP collection and processing following seasonal variations, and acting an economic buffer for rural communities by supplementing other income sources like farming. NTFPs thus make a significant contribution to the resilience of rural forest dwellers' livelihoods in the face of economic and climatic uncertainty (Malleson et al. 2014).

Seeking opportunities to allow communities to realise the benefits of NTFPs through sustainable harvesting has been recommended for consideration in Cross River State; for example in the buffer zones of protected areas (Muthui and Adedoyin 2016). As with other renewable resources, it is necessary to exploit these resources sustainably to avoid the risk of resource depletion (Ezebilo and Mattsson 2010a). Some approaches that may encourage sustainable use of NTFPs include domestication of highly valued NTFP species and use of sustainable harvesting techniques. This could be supported by cultivating the seedlings of valued wild fruit species (e.g. bush mangoes) that can be grown on farms as part of agroforestry (Ezebilo and Mattsson 2010a). Further, encouraging processing and further developing value chains for NTFPs would increase incomes and reduce pressure on forest products, including timber (Muthui and Adedoyin 2016).

© 2007 WCS Nigeria

Map 8: Distribution of forest inventory sites with NTFP species present



Non-timber forest products found at site

- G. africanum, G. kola, P. gueneansis, Lacosperma and Calamus, Archarchatina, L. africana, H. crenata, Randia, C. luttea, Hommallum, I. gabonensis, fauna
- G. africanum, G. kola, P. gueneansis, Lacosperma and Calamus, Archarchatina, L. africana, H. crenata, Randia, fauna
- L. africana, H. crenata, G. latifolia, F. aspirifolia, I. gabonensis, mushrooms, fauna
- G. latifolia, H. crenata, P. guineense, G. africanum, L. africana, mushrooms, fauna
- G. latifolia, H. crenata, P. guineense, L. africana, mushrooms, fauna
- P. gueneansis, Lacosperma and Calamus, mushrooms, fauna
- G. latifolia, Archachatina, mushrooms, fauna
- F. aspirifolia, mushrooms, fauna
- Mushrooms, fauna
- Periwinkles, crabs, shrimps, prawns

Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery.

Non-timber forest products: Cross River State Forestry Commission (2016) Data from sample plots visited during a forest inventory conducted by CRSFC between July 2015 and July 2016.

5 Pressures on forests and opportunities for REDD+

Understanding the past and potential future impact and distribution of the direct and indirect drivers of deforestation and forest degradation, and the barriers to conservation, enhancement and management of forests, is a key step in the development of REDD+ strategies at the national and subnational levels. An accurate picture of the most influential drivers of forest change helps to ensure that REDD+ strategies are addressing real and urgent challenges, and thus providing the greatest potential for emissions reductions.

In recent decades, Nigeria has experienced one of the highest rates of forest loss in the world. The country's forests are estimated to cover about 9.6 million ha; Nigeria has lost more than half its forest cover since 1990, and now has forest cover of less than 10% of its land area (FME, 2013). The deforestation rate was estimated to have increased from 2.7% during 1990-2000 to 4.0% in the 2005-period (FAO 2010, in NASRDA and FAO, 2015), and was estimated at 2.95% in Cross River State for the period 2007-2014 (FCPF and UN-REDD, 2013). Key drivers of deforestation and forest degradation, as identified in the country's REDD+ Readiness proposal of 2013, include agricultural development, fuelwood extraction, uncontrolled logging and urbanization.

The exact typology and impact of these drivers can vary significantly across the different regions of Nigeria. In order to better understand the direct and indirect drivers of forest change in Cross River State, a "Study on the Drivers of Deforestation and Forest Degradation in Cross River State" was undertaken in 2015. This study, building on previous assessments[13], shows that forest cover in Cross River State has decreased from an estimated 968,200 ha in 1978 to 642,195 ha in 2014. A linear model was used by NASRDA and FAO (2015) to further predict the forest cover into the future, indicating that under the current scenario, the State's forest cover will continue to drop from 642,195 ha in 2014 to 550,000 ha by 2040.

The 2015 study, as well as other analytical studies prepared for the development of the State's REDD+ Strategy, identify a number of key drivers of forest changes. A detailed discussion of the direct and indirect drivers of forest change in Cross River State can be found in these reports. The main direct drivers of deforestation and degradation identified by NASRDA and FAO (2015) are: subsistence agriculture; commercial agriculture; infrastructural development; logging and timber extraction; and fuelwood extraction. A final draft 'issues and options' paper developed to inform the Cross River State REDD+ Strategy further identified mining and quarrying as a key driver of forest loss and degradation, as well as the ineffective management of protected areas and community forests. The underlying causes or indirect drivers discussed include: demographic trends, such as population growth; economic causes, such as poverty and strong incentives to transform forests to other economic uses for short-term profits; technological factors, such as lack of access to more efficient agricultural technologies for farmers, and inefficient wood processing; policy and institutional causes, such as lack of clear institutional mandates and unclear property rights; and cultural factors, such as conflicting traditional beliefs about forests among local communities (Nigeria REDD+ Programme 2016a).

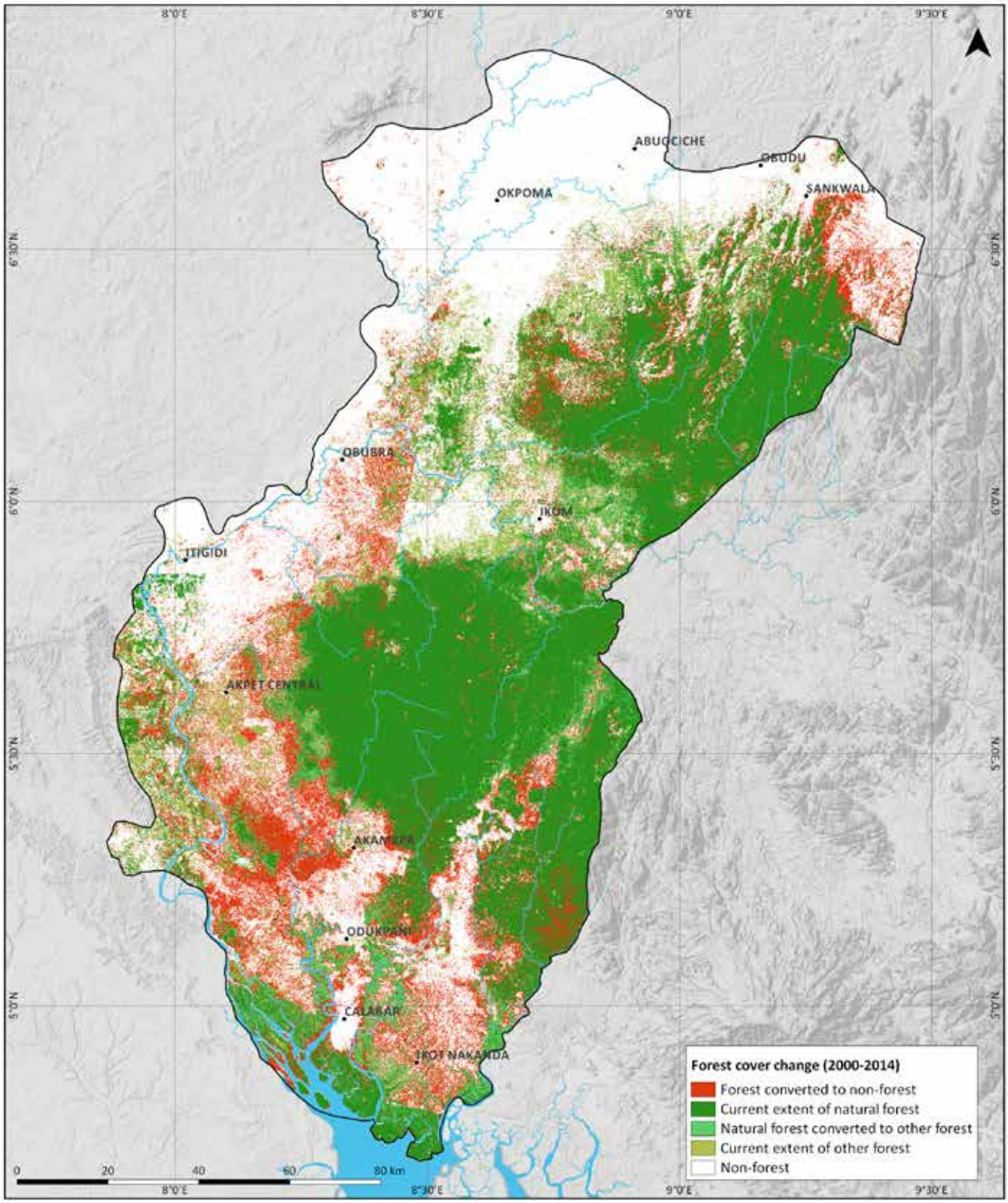
The following section presents and analyses the available spatial information on several of these key drivers: agricultural development, including cropland expansion and commercial plantation development; infrastructure, mining and quarrying; and population growth and urban development.

Spatial analysis using data from NASRDA and FAO (2015) shows a reduction in natural forest areas in Cross River State during 2000-2014[14]. This has affected montane and open forest areas. There has been an expansion of settlements into forest areas in Akamkpa and Odukpani in the period of 2000-2014, while the area around Calabar has stayed relatively the same (Maps 9 and 10). A significant conversion of forest into farmland, especially around the edges of the national park, has also occurred. Plantation expansion is focused in the south of the State, while derived savannah has decreased in area in the north (Maps 9 and 10). An expansion of swamp and wetland in the north and south is also recorded in the dataset, but this observation may be due to issues with the satellite imagery used for the analysis. For example if flooding took place during data collection, the apparent area of wetland could fluctuate.

[13] Noting that previous and current assessments of forest cover and forest cover change have used slightly different definitions of forest and land cover classifications.

[14] These maps are based on a dataset with originally 13 different categories of land cover. These have been regrouped into a smaller number of categories to create these maps. For example, mangroves have been placed in the "natural forest" category in this study, whereas in the original dataset they are classified together with swamps/wetlands.

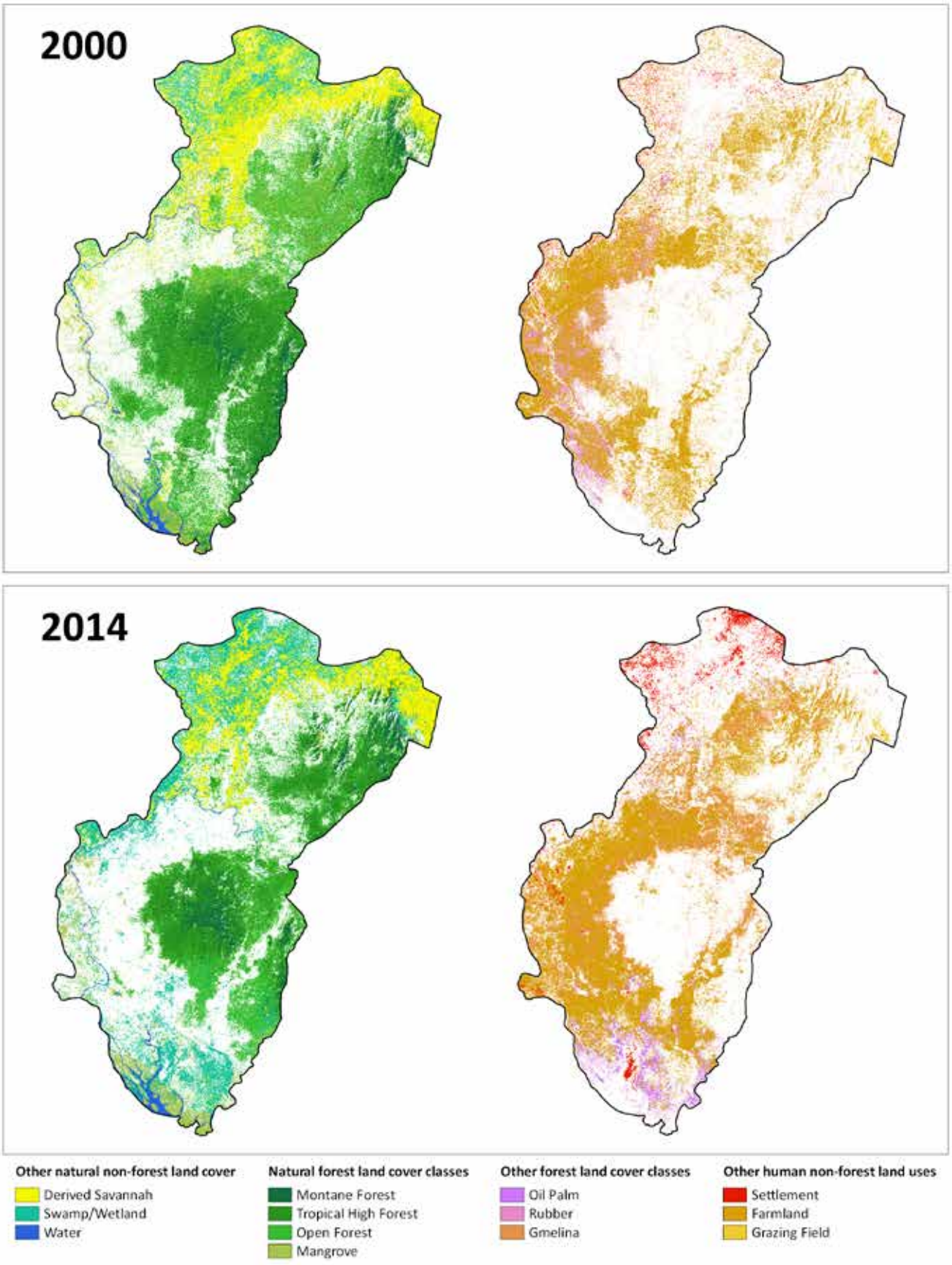
Map 9: Changes in forest cover in Cross River State, 2000-2014



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Based on the 13 land cover classes derived from satellite imagery: Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes; Other forest is a combination of the 'oil palm', 'rubber' and 'Gmelina' classes; the non-forest class is a combination of the farmland, grazing field, swamp, settlement and derived savannah land cover classes in the 13-class dataset.

Map 10: Distribution of natural and human-made land cover in 2000 and 2014 (based on NASRDA and FAO 2015 data)



5.1 Agricultural development

Agricultural expansion is considered to be the main driver of deforestation in Cross River State, and Nigeria more widely. The conversion of forests to agriculture involves clearing for both shifting subsistence cultivation by smallholder farmers (also known as slash-and-burn and bush fallowing) and for large scale conversion of forest to commercial agricultural plantations, such as oil palm, cocoa, rubber and pineapples (Nigeria REDD+ Programme 2016a). NASRDA and FAO (2015) estimated that the State lost 180,195 ha of forestland to cropland (including farmland, oil palm and rubber) between 2000 and 2007, and 181,179 ha of forestland to cropland between 2007and 2014. These figures indicate that agricultural expansion is the biggest driver of forest loss in terms of area converted. There is little information available on whether some of this converted land later regenerates, e.g. to secondary forest. According to NASRDA and FAO (2015), farmland (meaning land for crop cultivation, but not including tree crops and grazing fields) accounted for 25.22% of the State's area in 2000, increasing to 29.75% in 2014. Oil palm makes up a much smaller area, though this has doubled in the same period, going from 1.03% in 2000 to 2.25% in 2014. In contrast, other agricultural land types are estimated to have decreased, such as rubber plantations and grazing fields (NASRDA and FAO 2015).

NASRDA and FAO data on the conversion of forests to agriculture (including cropland and plantations) between 2000 and 2014 shows that this has predominantly occurred in and around forest reserves and the Cross River National Park, particularly the southern Oban Division of the park (Map 10). Although it is illegal for forest reserves and national parks to be converted to other land uses, it is legal for farmers to clear forest in community lands for agriculture. The expansion of swamps and wetlands evident in the spatial data over the past 15 years may also be related to the growth of rice-farming in the State (Map 10).

In Cross River State, agriculture and agro-based industry are the leading non-oil revenue-generating sectors in the State, employing about 45% of the State's labour force and contributing about 40% of the State's GDP (Muthui and Adedoyin 2016). This is higher than the national average, with agriculture accounting for around 20% of national GDP in 2014 (CountrySTAT 2016). As in other parts of Nigeria, most people in Cross River State live in rural areas and subsistence agriculture dominates production. More than 90% of the country's agricultural output is produced by small-scale farmers with less than two hectares under cultivation (NBS and CADP 2010); in

Cross River State, an estimated 70% of the population lives on subsistence farming (Omoregbee and Iyamu 2014). Smallholder, subsistence farmers grow crops such as cassava, yams and plantain, and practice both shifting and permanent cultivation (NASRDA and FAO 2015). The NASRDA and FAO study found that shifting cultivation is having negative impacts on the forests in Cross River State, with farmers in most of the communities visited typically clearing land, burning plant material, then planting and harvesting crops, with the land lying fallow for 2-4 years. Farmers then clear new plots of land, while vegetation re-grows on the old plots, which is later burned again. As in other parts of Nigeria, smallholder farmers also continue to face many challenges, including poor access to modern agricultural inputs and credit, poor infrastructure, inadequate access to markets, insecure land tenure and environmental degradation, and inadequate research and extension services (Muthui and Adedoyin 2016).

Although shown in the same category of land-use change, the expansion of smallholder subsistence agriculture and the expansion of commercial plantations are different drivers, associated with different agents. However, there are also some linkages between the two drivers; for example, stakeholders in Cross River State identified a potential risk from the continued expansion of large-scale, commercial plantations for cash crops that may result in smallholder farmers losing access to land and thus expanding agriculture into other forest areas (NSWG, 2016a).

Plantations of commercial cash-crops are also playing an increasingly important role in the economy of Cross River State. In previous decades, public and private investments have been made in the establishment of gmelina (*Gmelina arborea*, a pulpwood species) and rubber plantations. The area under gmelina increased by 7% during 1991-2001 (Flasse Consulting, 2002, in Oyebo et al. 2010). Based on data from NASRDA and FAO (2015) during 2000-2014 there has been conversion of natural forests to non-forest and other forests in and around plantation concession areas in the State. These are concentrated in the south of Cross River State, such as in the corridor and other areas to the south of the national park and in Akampka (Map 11).

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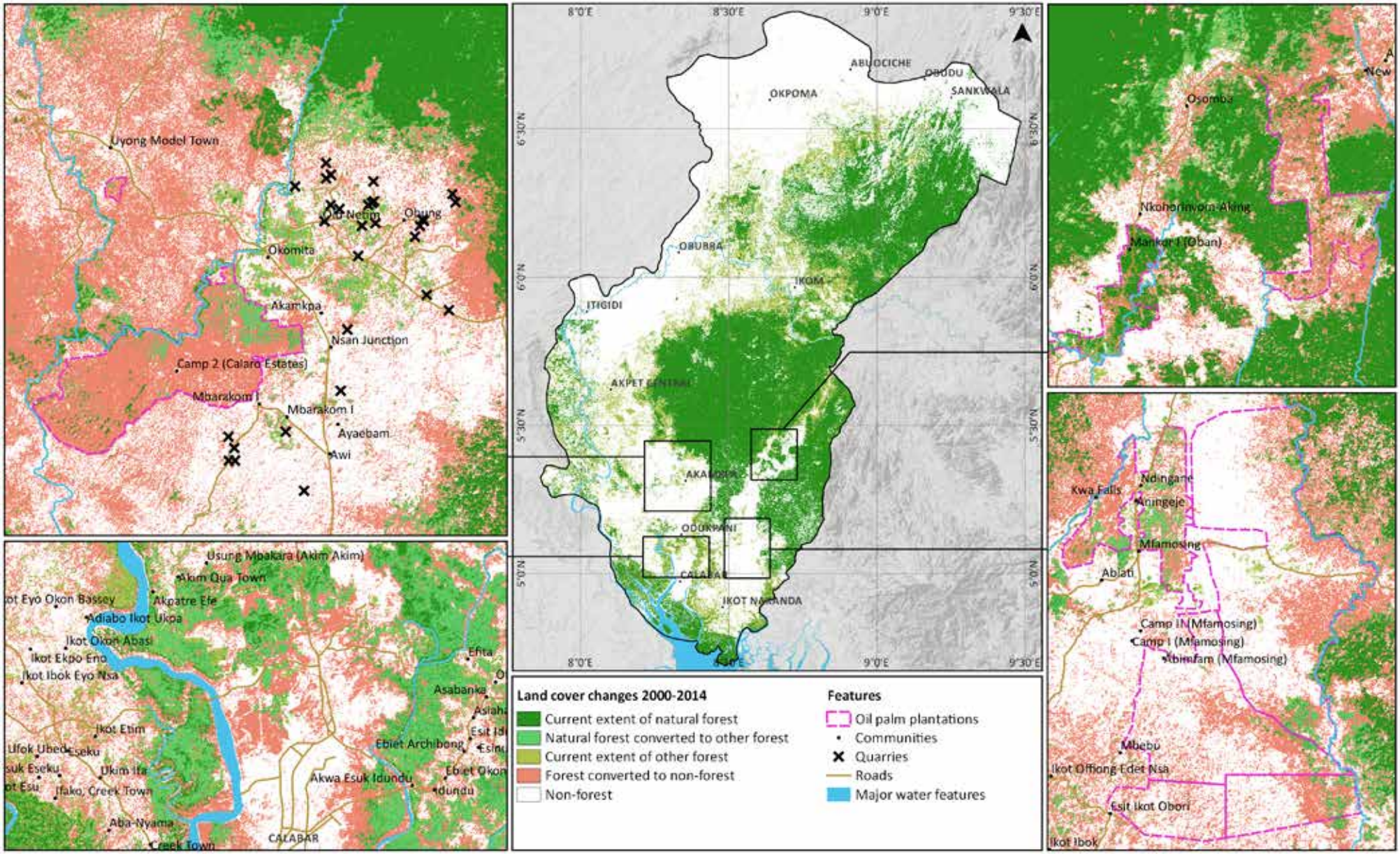
In recent years, focus has shifted to other high-value crops such as oil palm and pineapple, which may offer a higher return on land and labour. Oil palm is a traditional crop in West Africa, and from the early 1950s till mid-1960s, Nigeria was the largest producer of crude palm oil in the world, with a market share of 43%. Since then, palm oil production has steadily declined and the country is now a net importer (Omorogiuwa, Zivkovic and Ademoh 2014, in Muthui and Adedoyin, 2016). In the last decade, the oil palm industry has been revitalised in Cross River State, with international investments and partnerships with government helping to re-establish former plantations and expand the area under oil palm. Land for oil palm plantations have been acquired by Nigerian firms such as Sea Agriculture, by a joint venture between the state oil company Nigerian National Petroleum Corporation (NNPC) and the Brazilian energy company Petrobras (for biodiesel production), and by Wilmar (headquartered in Singapore), which purchased the Obasanjo Farms estates in 2012 (Schoneveld 2014). As noted by Schoneveld (2014), most new plantations have been established along the MCC Road that divides the southern Oban division of Cross River National Park into two; due to comparatively high rainfall intensity and low rainfall variability, this area is considered especially suitable for oil palm cultivation (Map 11).

With an investment of more than USD500 million and plantations of 50,000 ha, the NNPC-Petrobas venture is now the largest oil palm venture in Nigeria, and milling and refinery facilities are under development. The investment is expected to create jobs and contribute significantly to the Cross River State economy (Nwosu and Holzlöhner 2016, in Muthui and Adedoyin 2016). The partnership intends to increase the area under oil palm to one million hectares, so represents a potential driver of deforestation as well as an opportunity to enhance rural livelihoods and promote oil palm agroforestry (Muthui and Adedoyin 2016). Stakeholders in Cross River State have identified a number of risks related to commercial agriculture development, even if such developments may be intended to enhance rural livelihoods and reduce pressures on forests. These include the risk that the increased profitability of these land uses may in fact encourage further expansion into forests, especially in areas where forests are not under protection and may be legally cleared for agriculture (NSWG, 2016a). Production improvements are only effective in reducing deforestation where they are implemented hand-in-hand with improved land-use planning and protection measures.

Map 11: Changes in forest cover in and around plantation concession areas in Cross River State, 2000-2014



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Based on the 13 land cover classes derived from satellite imagery: Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes; Other forest is a combination of the 'oil palm', 'rubber' and 'Gmelina' classes; the non-forest class is a combination of the farmland, grazing field, swamp, settlement and derived savannah land cover classes in the 13-class dataset.

Quarries, communities and commercial plantations: Locations and shapefiles received from Cross River State Forestry Commission in 2016, and sourced from Rapid Appraisal of Forest Resources from Remotely Sensed Data by Flasse Consulting (2002) (DFID).

5.2 Mining and quarrying

Oil and gas exploitation has been a major economic sector in Nigeria for many decades, though it does not currently feature strongly in the Cross River State economy. The State oil wells were allocated to the neighbouring state of Akwa Ibom by the Federal government in order to avoid ceding them to Cameroon along with the rest of the Bakassi Peninsula in 2008 (Schoneveld 2014). However, the State may discover and exploit further oil reserves in the future (Nigeria REDD+ Programme 2016a), and a new Cross River State Department of Oil and Gas has reportedly been established (Asikong 2016). In contrast to oil and gas, mining in Nigeria contributed less than 1% of GDP in 2012 (Berger 2015). However, the Nigerian Government is aiming to expand this to over 5% of GDP, and the Minerals and Mining Act (2007) provides that the use of land for mining operations shall have priority over other uses of land, as it constitutes an overriding public interest (Matakala and Okonofua 2016).

Cross River State is richly endowed with mineral resources, particularly solid minerals such as limestone, barite, clay, salt, tin, granite basalt, quartzite, kaolin and feldspar (Table 2). Few of these resources are currently being exploited at commercial scale; only the United Cement Company of Nigeria (UNICEM) in Mfamosing community in Akamkpa is extracting limestone. However, there are 41 granite companies quarrying granite, especially in Akamkpa, and 22 sand/gravel mining associations, with activities all over the State (Muthui and Adedoyin 2016).

Discussions with stakeholders in Cross River State suggest that mining and quarrying, although often small-scale, is considered an important driver of forest loss and forest degradation for several reasons. As small-scale operations may lack in efficiency, modern technologies and post-mining restoration, they can result in negative social and environmental impacts. For example, there are numerous abandoned mine sites including six abandoned barite mines at Nde, Alese, Okumurutet, Iyametet, Akpet and Ibogo (Muthui and Adedoyin 2016). In addition, as the allocation of land and licenses for mining is controlled at the Federal level, there can be a lack of consultation and oversight of operations at the State level, as well as limited capacity to enforce compliance with regulations and best practice (NSWG 2016b; Muthui and Adedoyin 2016). The inset in Map 11, for instance, shows quarrying sites around Akampka, which have been associated with forest loss in the area.

Muthui and Adedoyin (2016) also note that mineral deposits in Cross River State are often found deep in forest areas with limited infrastructure, which has formed a key barrier to expansion of the mining industry; 'removing these barriers without careful planning for sustainability would likely expose the forests to further degradation and deforestation'. Beyond the immediate impact of mining and quarrying on forests, the need to clear land for settlements for mining workers and roads, and the influx of people into mining areas may place additional pressures on forests. Experience shows that this can include increased levels of hunting for bushmeat and of fuelwood extraction, unless companies develop and enforce mitigation strategies.

5.3 Infrastructure development

The Cross River State Government has laid out an ambitious infrastructure development strategy in an effort to accelerate economic growth (Muthui and Adedoyin 2016). Infrastructure, including roads, telecommunication networks, electricity grids and social amenities, plays an enabling role for economic development, allowing better access to markets, employment opportunities and services. There are often calls for improvements to infrastructure among local communities in Cross River State; for example, the Participatory Governance Assessment conducted by the Nigeria UN-REDD Programme found that communities had high expectations of infrastructure delivery by the REDD+ Programme in the State (UN-REDD Nigeria 2015). As noted by the African Development Bank (AfDB, 2013), only about 34% of the population in Africa has road access, compared with 50% in other parts of the developing world.

However, infrastructure development, especially if it is poorly planned and implemented, can generate negative social and environmental impacts. Muthui and Adedoyin (2016) note that road development, for example, often accelerates land use changes, resulting in permanent habitat loss. Studies conducted to inform the development of the State's REDD+ Strategy suggest that the current mechanisms for consultation and grievance redress are inadequate to fully protect the rights and interests of communities when major infrastructural developments are planned (Nigeria REDD+ Programme 2016a; Matakala and Okonofua 2016). Given that Federal projects can requisition land for projects considered to be in the public interest, environmental impact assessment (EIA) and other approvals and oversight may occur largely at Federal level, and local land tenure can be insecure. It would be particularly valuable to ensure robust assessment and consultation processes in these cases (Matakala and Okonofua 2016; NSWG 2016c).

The development of roads, or other linear infrastructure such as pipelines, has direct and indirect impacts on forests, their ecosystems services and biodiversity. Laurance (2012) believes that 'highways and roads are the single biggest factor determining the pattern and pace of tropical forest destruction'. Clearing for road-building results in the direct loss of forests; highways can require more than 10 ha of land per kilometre of road (Quintero 2015). Additional impacts can include soil erosion, increased discharge of pollutants, barriers to the movement of wildlife, invasions of exotic species,

and most significantly, the facilitation of further land clearing, logging, hunting and mining (Rajvanshi et al. 2001, in Quintero, 2015; Laurance et al. 2009). Paved highways can have especially significant impacts, as they provide year-round access, often attract land speculation, and lead to the development of network of secondary roads (Laurance 2012). Measures that can limit the negative impacts of road development include the use of comprehensive EIAs, community consultation, the careful design of routes, the promotion of railways over roads, establishment of checkpoints and rehabilitation of degraded areas (Quintero 2015; Laurance 2012).

In Cross River State, a pattern of forest loss and degradation appears to occur around the existing road network (Map 12), although more research is needed to confirm this and to draw conclusions about the impacts and causal mechanisms. NASRDA and FAO (2015) cite the example of the construction of a new road between Edondon and Old Ekuri, which led to previously remote patches of forest becoming more vulnerable to logging.

Infrastructure development, especially for transport, is emerging as a potentially significant driver of land-use change. The State's 30-year Growth and Development Strategy includes plans to develop a deep sea port and a super highway linking Cross River State to Benue State in the north (Map 12; Muthui and Adedoyin 2016). The Calabar sea port is currently under construction, and will cover an area of approximately 3,000 ha, with potential impacts on 2,430 ha of mangrove forests. The proposed super highway is 260 kilometres long, with anti-slip features, speed cameras and internet connectivity, and is aimed at opening new markets (expected to come through the Calabar deep sea port)[15]. Early reports of the project suggested that a 10 km wide strip of land on either side of the road route would be requisitioned. A public notice in February 2017 declared that this decision was reversed, so that land acquisition would be limited to the 70m span of the road corridor. The current design does still pass through both community forests and forest reserves, and close to the national park. It could still potentially affect more than 9,100 ha of forest, based on the forest area within a buffer of 1 km (500 m either side) of the proposed highway, which mapping working group members in Cross River State agree is typical of the buffer for impacts on forests from roads in the State.

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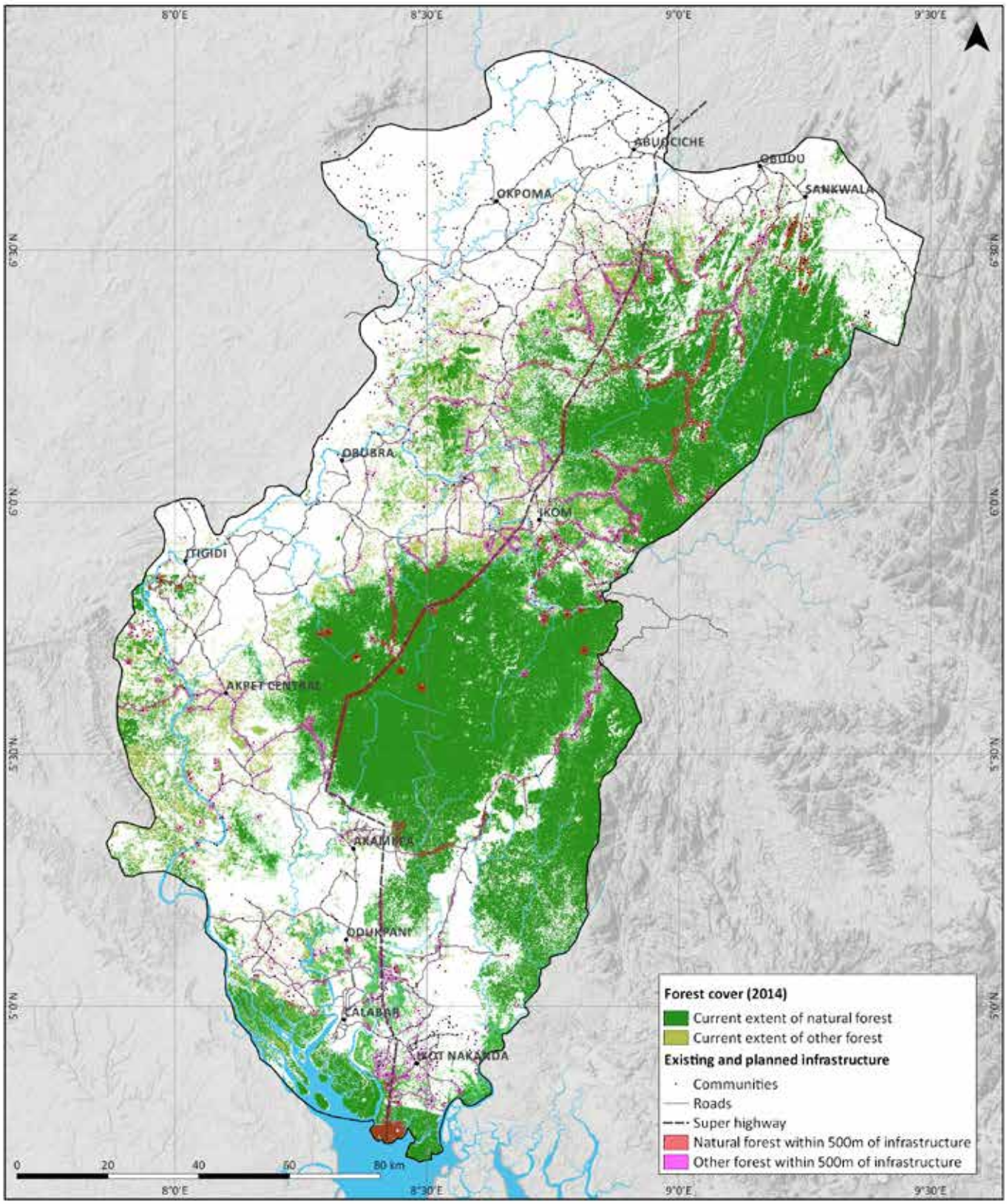
[15] See for example: https://ng.boell.org/super-highway-cross-river-state

Map 12: Existing and planned key transportation infrastructure in Cross River State



Data sources:

Natural forest mask: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State. Natural forest is a combination of the 'Montane forest', 'Tropical High Forest', 'Open forest' and 'Mangrove' classes in the 13 class dataset derived from satellite imagery.

Road and seaport: Cross River State Ministry of Public Works (2016).

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5.4 Urban development

The expansion of urban centres has been identified as one of the key drivers of deforestation and forest degradation in Cross River State (NASRDA and FAO 2015). Although settlement areas account for a relatively small area, according to NASRDA and FAO (2015) these have almost tripled in size between 2000 and 2014, increasing from 3,301 ha (0.15% of the State area) to 9,218 ha (0.43%). The underlying factors associated with urbanization in the State include high population growth and the increasing movement of people from villages to the cities, driven by the search for economic opportunities, the loss of land to development, and the attractiveness of urban infrastructure and services (NASRDA and FAO, 2015). Urban areas such as Calabar, Ugep, Ogoja, Ikom and Obudu are already experiencing such growth (Map 13, Figure 3), and projections show that the urban population of the State is expected to double by 2025 (Ottong et al. 2010, in NASRDA and FAO 2015). In addition to the potential for more land clearing for urban settlements, increased urbanization may also lead to increased demand for agricultural and forest products, and more concentrated infrastructure development.

Nigeria has one of the highest population growth rates in the world; by 2050 the population is projected to reach 398 million, a very large increase from 33 million people in 1950 (Muthui and Adedoyin 2016). Population growth is considered an important underlying factor in a number of the main drivers of deforestation and degradation in Cross River State, propelling the expansion of agriculture, infrastructure and fuelwood use. For instance, NASRDA and FAO (2015) report that fuelwood use forms a significantly higher share of forest product use than commercial logging.

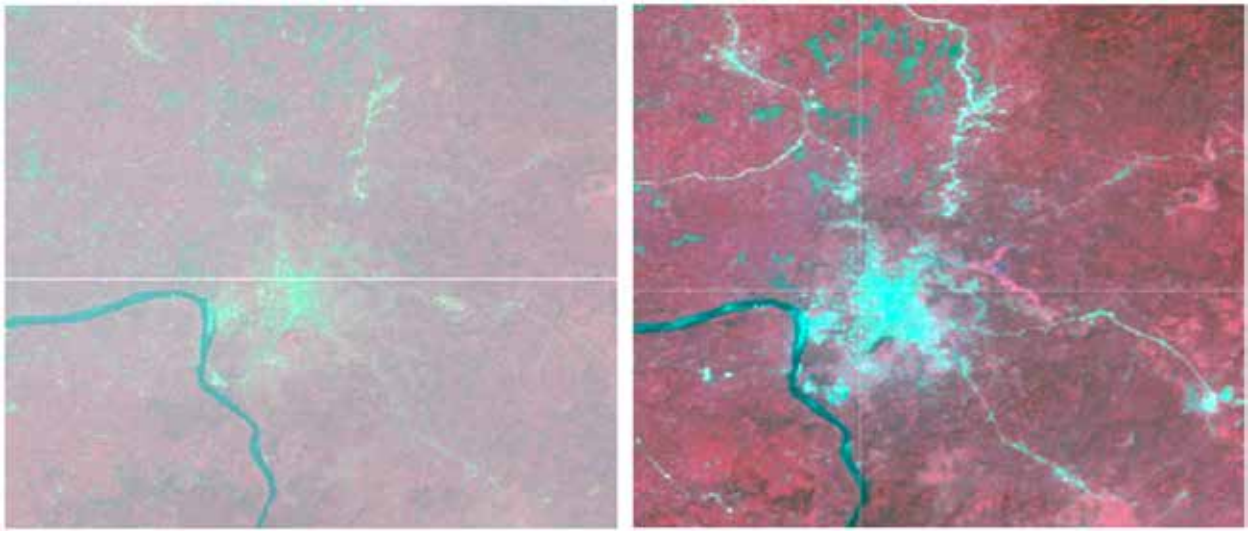
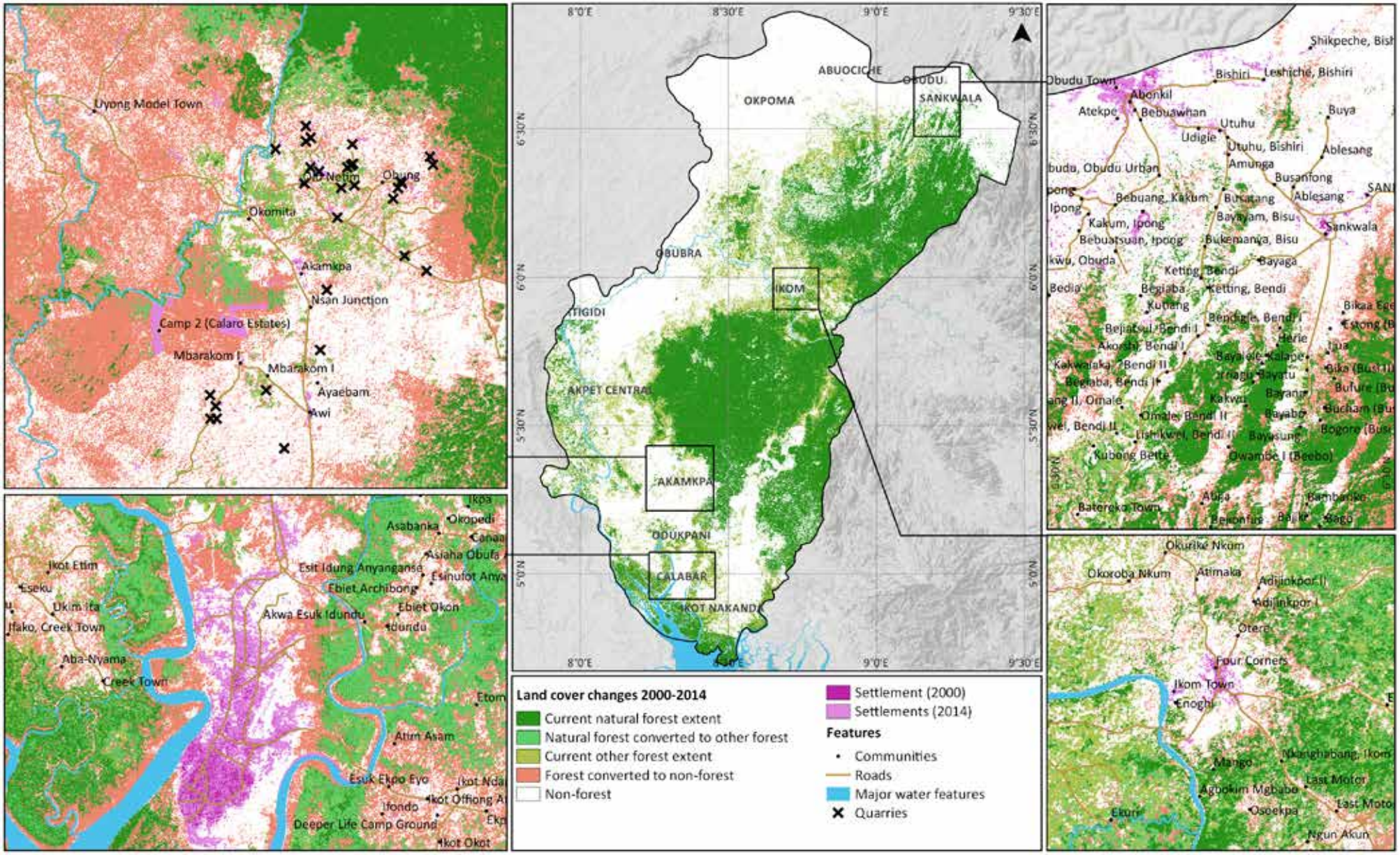


Figure 3: Satellite images showing Ikom Community in 2000 (left) and 2014 (right) (Source: NASRDA and FAO, 2015) (please note that differences in overall image colour between the two periods are the result of differences in the satellite image processing)

Map 13: Expansion of settlement areas in Cross River State, 2000-2014



Data sources:

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Quarries, communities and commercial plantations: Locations and shapefiles received from Cross River State Forestry Commission in 2016.

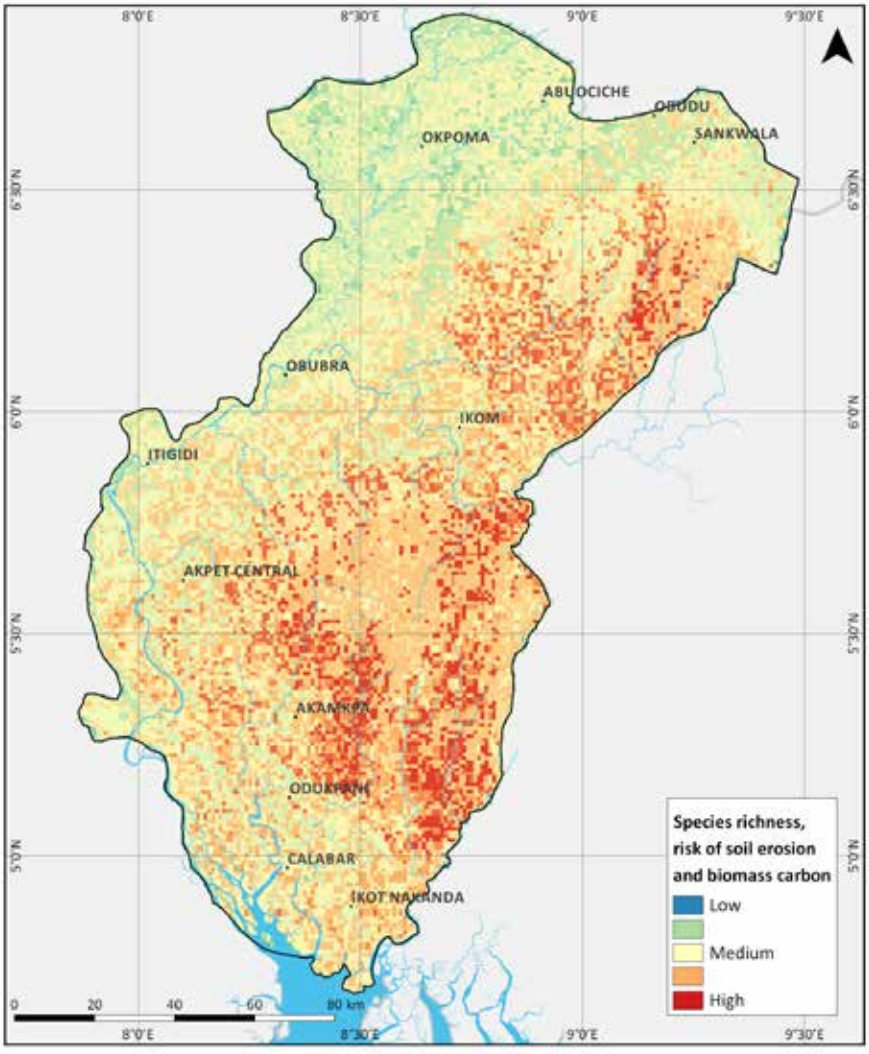
6 Mapping REDD+ actions and their potential multiple benefits

In addition to exploring the distribution of different environmental and socio-economic values provided by forests in Cross River State, these values can be analysed in the context of specific REDD+ actions – the policies and measures that are undertaken in order to achieve the objectives of REDD+. Depending on where and how these actions are implemented in the landscape, they may have the potential to promote the protection or enhancement of more than one of these forest values, contributing to the multiple benefits of REDD+.

In the spatial analysis of the distribution of potential multiple benefits from REDD+, three key values were selected: carbon stocks in forests; forest biodiversity; and the role of forests in limiting soil erosion. The three layers were reclassified from their original values (t/ha carbon, number of threatened species ranges, etc.) to bands corresponding to values between 1 (low values) and 5 (high values) in order to give them equal weighting; these bands are detailed in the legends of maps 4, 5 and 6 showing carbon values, species richness and the contribution of forests to controlling the risk of soil erosion respectively. They were added together to produce the final 'multiple benefits' layer (Map 14). While forests across the state will contain carbon and biodiversity, and limit erosion, the tropical high forests and montane forests of the Cross River National Park and mountainous areas of the State are likely to be providing high levels of these three selected values according to our analysis (Map 14).

The following section of the report uses the data shown in Map 14 to explore the potential benefits that may be provided by conserving or enhancing these forest areas through two particular REDD+ actions: forest restoration; and mangrove conservation.

Map 14: Distribution of three selected forest values in Cross River State



6.1 Forest restoration

One of the five main activities of REDD+ is the enhancement of carbon stocks. From 2000 to 2010, there was a net annual loss of about 7 million hectares of forest area in tropical countries (FAO 2016), along with their biodiversity and ecosystem services. Considering this, it is important not only to protect, but also to restore forest ecosystems; forest restoration can help to improve ecosystem functioning, support ecological and economic resilience, and also benefit human livelihoods (Lamb et al. 2005).

There are a number of options available for implementing the enhancement of forest carbon stocks, such as reforestation, forest restoration and afforestation. The definitions of forest restoration and reforestation in the country context are important, as forest concepts and definitions influence how forest and land-use transitions are interpreted (Chazdon et al. 2016). Gilmour et al. (2000), in a widely used definition, describe reforestation as 'the re-establishment of trees and understorey plants at a site previously occupied by forest cover' and restoration as an action 'to re-establish the presumed structure, productivity and species diversity of the forest originally present at a site' where 'the ecological processes and functions of the restored forest will closely match those of the original forest' (often known as ecological restoration).

In prioritizing areas for reforestation or forest restoration, a number of questions need to be taken into account:

- What were the original causes of forest loss and are they being addressed? Efforts to restore forest will be in vain if the restored areas are soon degraded or deforested again.
- Are soil and vegetation conditions in the area still suitable for forest growth, or would it be feasible to restore these as part of the REDD+ action?
- Are there any competing land uses? If so, local or key stakeholder support for forest restoration may be affected.
- What management status does the land hold? Restoration actions will be most feasible in the long term where the areas are under protection and/or sustainable forest management (such as community forestry).
- How high are the existing carbon stocks? Restoration may be more cost-effective in enhancing carbon stocks where the existing stocks are much lower than the potential stocks, (as long as drivers of carbon loss are addressed).

There are a number of large-scale forest restoration and reforestation programmes currently being implemented or under consideration in Nigeria. This includes Nigerian participation in the Great Green Wall for the Sahara and the Sahel Initiative, and in the case of Cross River State, the proposed '5 Million

Trees' programme (focusing on restoring degraded areas of forest reserves). Forest restoration is likely to form a part of Cross River State's REDD+ strategy in the long-term, and Muthui and Adedoyin (2016) recommend that the REDD+ Programme facilitates the government and other stakeholders to implement 'forest landscape restoration' (FLR) (linking to Nigeria's national targets).

For the purposes of this analysis, the mapping working group decided to focus on forest restoration actions involving the restoration of degraded forest areas, using primarily native species, in order to return the area to its natural state. The analysis is separated into two main parts:

1. Areas feasible for the implementation of forest restoration actions were first identified by excluding those areas that are likely to be unavailable: settlement areas; long established farmlands (since before year 2000) outside of natural forests; established plantation forests outside of natural forests; and areas within the current extent of natural forests. Areas within 1 km of infrastructure development, communities and commercial plantations were also excluded (composite layers in Map 15). There could be other forest landscape restoration options within these excluded zones.
2. The map of areas considered potentially suitable for restoration of forests was then combined with the map of key potential benefits (biomass carbon stocks in forest and non-forest areas, potential richness of threatened species, and role of forest in controlling soil erosion), to determine opportunity areas for forest restoration that may promote these multiple benefits (Map 15).

The areas of Cross River State that are potentially the best suited to restoration initiatives are areas of natural forest that have recently been converted to other land-uses. But while restoration could be possible in any of these areas, it is useful to identify where the potential benefits in terms of carbon, species richness and reducing the risk of soil erosion are the highest. The underlying assumptions of this benefits analysis are that: (1) conversion of natural forests degrades and fragments the habitats of many vulnerable species, therefore the restoration of natural forests that have only recently been converted to other land-uses in areas with a high species richness is likely to have a positive impact on vulnerable species; (2) Map 4 indicated a high likelihood that carbon-rich forests had been recently converted to other land-uses, therefore these areas are likely to deliver carbon benefits if restored; and (3) where there are steep slopes and a high average annual precipitation, the planting and restoration of forests can stabilise the soils and assist in reducing the risk of soil erosion.

The most widespread areas potentially suitable for forest restoration occur in the north of Cross River State, and these may include areas of natural non-forest ecosystems. According to stakeholders in Cross River State, the 'derived savannah' land-cover class includes large areas that were historically forest but have long since seen a transition to an open habitat; and the 'swamp/wetland' land-cover class includes areas of natural swamp forest that have been converted to other land uses (but is difficult to distinguish when interpreting satellite imagery). These potentially suitable areas also include land that has recently (between 2000 and 2014) been converted from natural forest to either farmland and

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grazing fields, or to planted tree crops such as palm oil, rubber or gmelina. The reasoning behind this is that restoration may be more successful on land that has more recently been natural forest, than it would be in areas of established farmland or plantations that have not had natural forest cover within the last 15 years. These areas identified as suitable for forest restoration would thus require further investigation to characterise the exact area available and the appropriate methods for restoration. For example, some areas may have once been forest but it may no longer be feasible to pursue forest restoration (i.e. the current land use may not be reversible). They also include areas of derived savannah, swamp and wetland, where the target species and techniques for forest restoration may vary considerably.

Areas with the potential to deliver higher levels of the selected multiple benefits from forest restoration are concentrated in and around the national park, as well as in the far southeast and northeast corners of the State. Forest restoration in these areas, if well-planned and implemented, could not only help to restore forest carbon stocks but may also contribute to biodiversity conservation (particularly in areas such as KBAs and priority sites for species such as gorillas) and limiting the risk of soil erosion, especially in the State's mountainous areas and along waterways.

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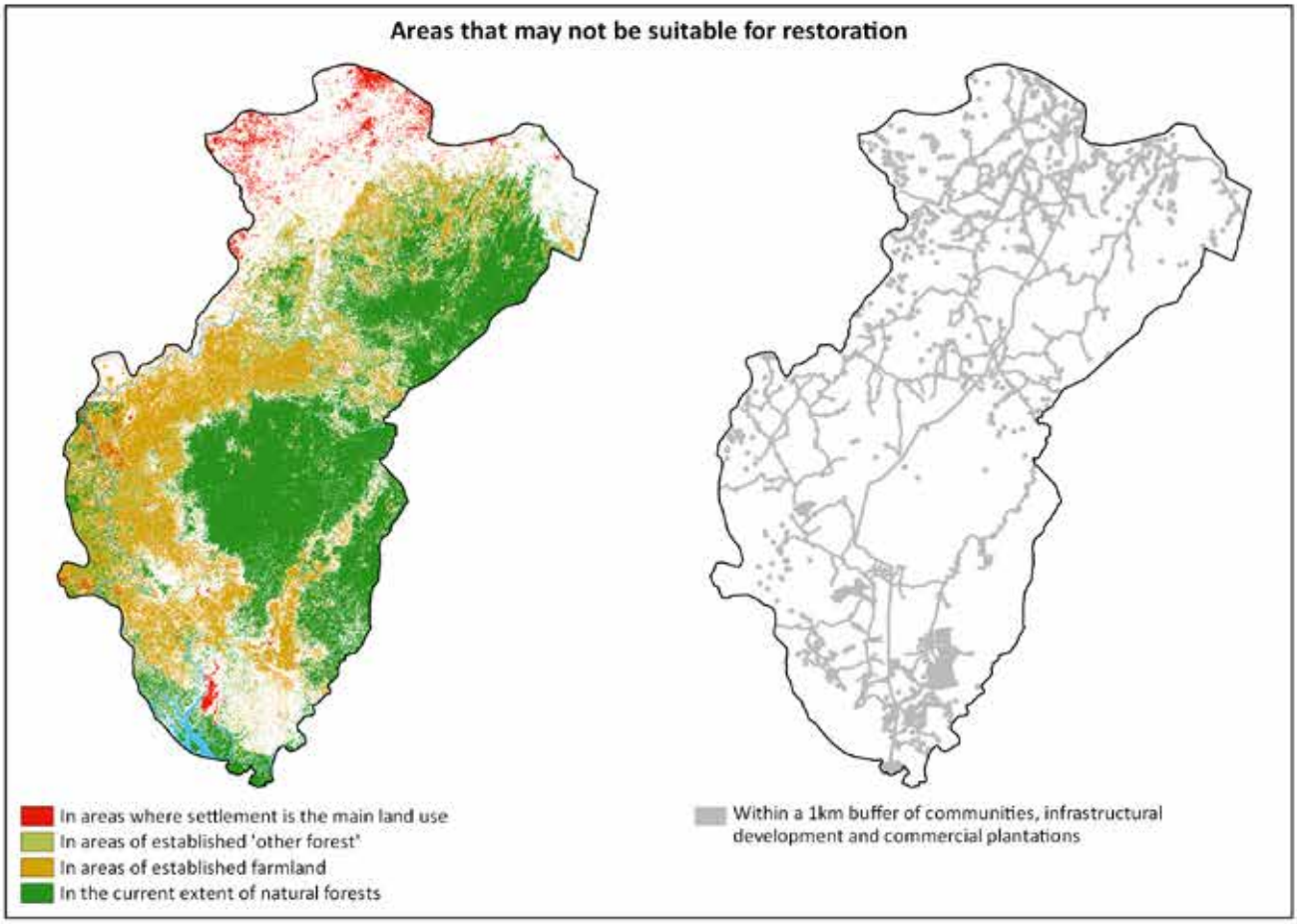
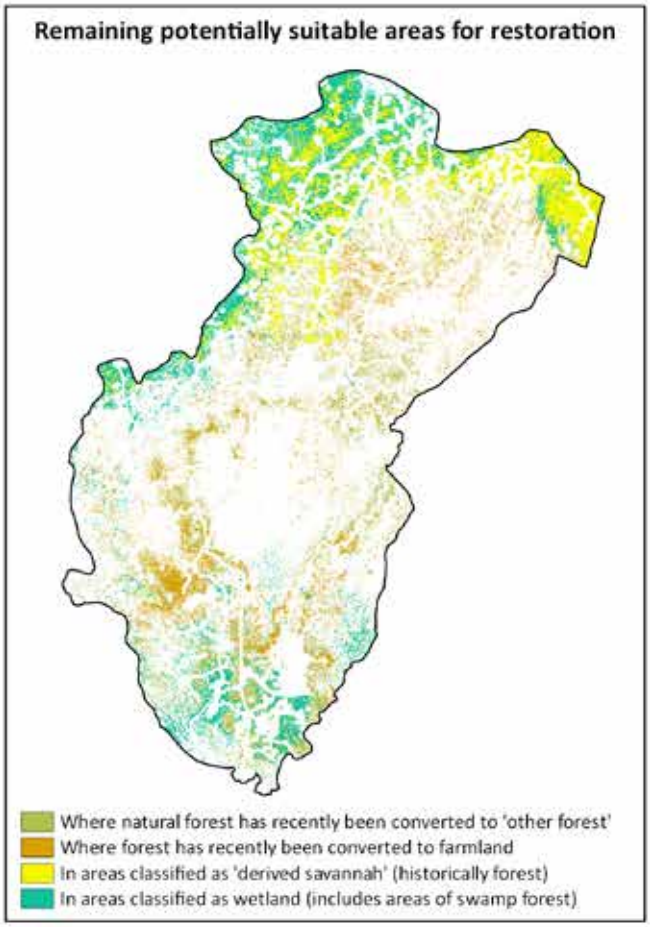
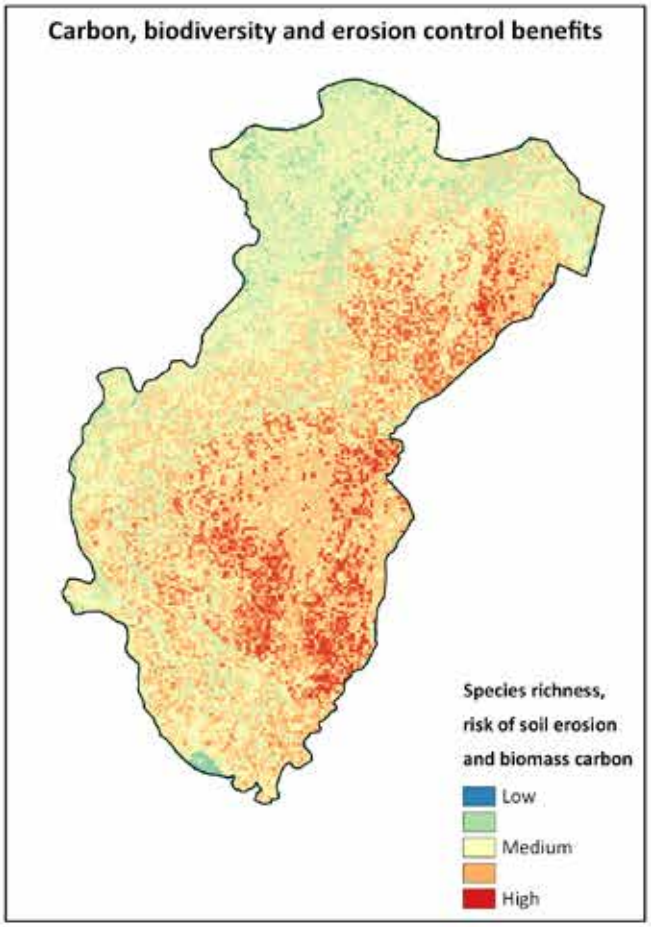
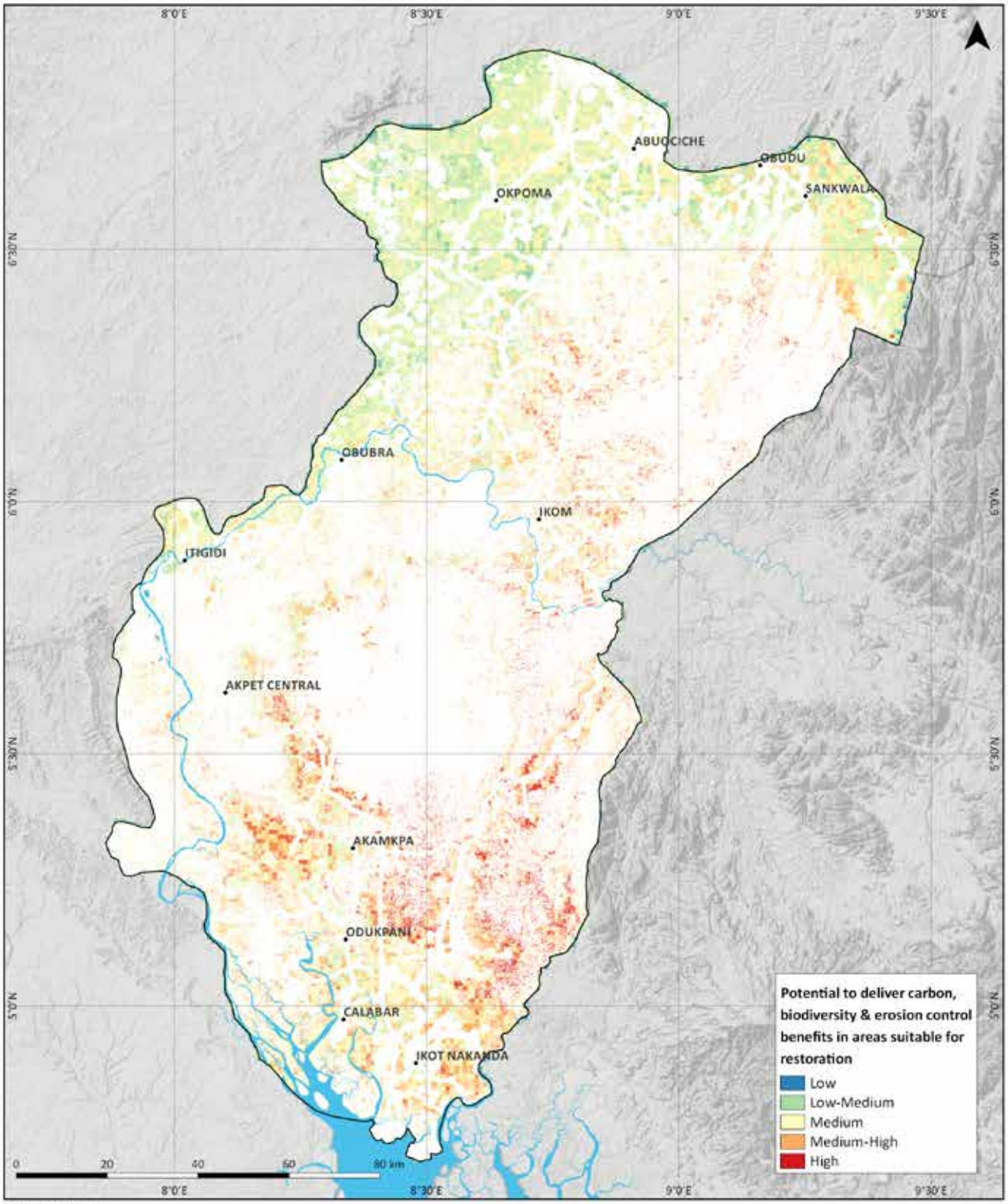
Map 15: Composite layers (left) and map of potential opportunity areas for forest restoration delivering multiple benefits in Cross River State









Data sources:

Biomass carbon: Saatchi, S., Harris, N., Brown, S., Lefsky, M., Mitchard, E., Salas, W., Zutta, B., Buermann, W., Lewis, S., Hagen, S., Petrova, S., White, L., Silman, M. and Alexandra Morel (2011) Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS 2011 108 (24) 9899-9904. doi:10.1073/pnas.1019576108

Species richness: [Data] IUCN (2015) The IUCN Red List of Threatened Species. Version 2015.1. http://www.iucnredlist.org. Downloaded May 2015. [Method] Ravilious, C. (2015) Using spatial information to support decisions on safeguards and multiple benefits for REDD+. Step-by-step tutorial v1.1: Extracting and processing IUCN Red List species data using a raster method in QGIS 2.8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Risk of soil erosion: [Method] Ravilious, C., Maukonen, P., Thorley, J. and van Soesbergen, A. (2015) Using GIS to help integrate biodiversity and ecosystem services into REDD+ decision making. Step-by-step tutorial: Evaluating the importance of forests for soil stabilization and limiting soil erosion, a simple approach using QGIS 2.8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Land-use: NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State.

6.2 Mangrove conservation

Mangroves are often rich in biodiversity and provide ecosystem goods and services such as fisheries production, shoreline stabilization, and nutrient and sediment trapping (see section 4.3). Additionally, they have high carbon storage and sequestration potential, making them important coastal forest ecosystems to consider in national REDD+ strategies (Ajonina et al. 2014), even if their area is low relative to other forest types. However, mangrove ecosystems are in serious decline worldwide (Godstime et al. 2013).

With an estimated mangrove area of 10,515 km², Nigeria ranks fourth among countries where large mangrove areas still exist, behind Indonesia, Brazil and Australia. With the exception of Nigeria, these countries have a significant number of mangrove protected areas (Nwosu and Holzlöhner 2016). Nigeria does not currently have a national park in the mangrove zone. Muthui and Adedoyin (2016) in their assessment of sustainable forest management initiatives relevant to the development of the Cross River State REDD+ strategy discuss the potential for establishing a mangrove protected area, in order to enhance carbon storage potential, protect provision of ecosystem services to communities, and improve biodiversity conservation. A community-based mangrove and fisheries management approach is also recommended.

Whatever approaches are taken, numerous factors may influence the design and location of mangrove conservation actions under REDD+. Our spatial analysis of the mangrove ecosystem in Cross River State considers several key planning factors, such as mangrove extent, past loss of mangrove cover, and potential pressure from communities and infrastructure. A substantial area, which has been affected by the conversion of mangroves to other land cover types in recent years, is covered by one of the State's REDD+ pilot sites (Map 16). Although some trends in the spatial data may be errors or require further investigation (for example, areas showing conversion of mangroves to forest), mangrove forest loss appears to be particularly concentrated around the islands and banks of the Cross River Estuary (Map 9). Although few communities are located directly within the mangrove area, infrastructure development is a driver of loss, with the Calabar sea port now under construction in the southwest section, just south of Ikot Nakanda. A buffer of 500 m placed around existing and planned infrastructure and communities can help to determine where mangrove conservation may be most feasible in the future. Further assessment of the extent and condition of the mangrove areas in the State should be carried out to validate the spatial information and inform the development of appropriate measures.

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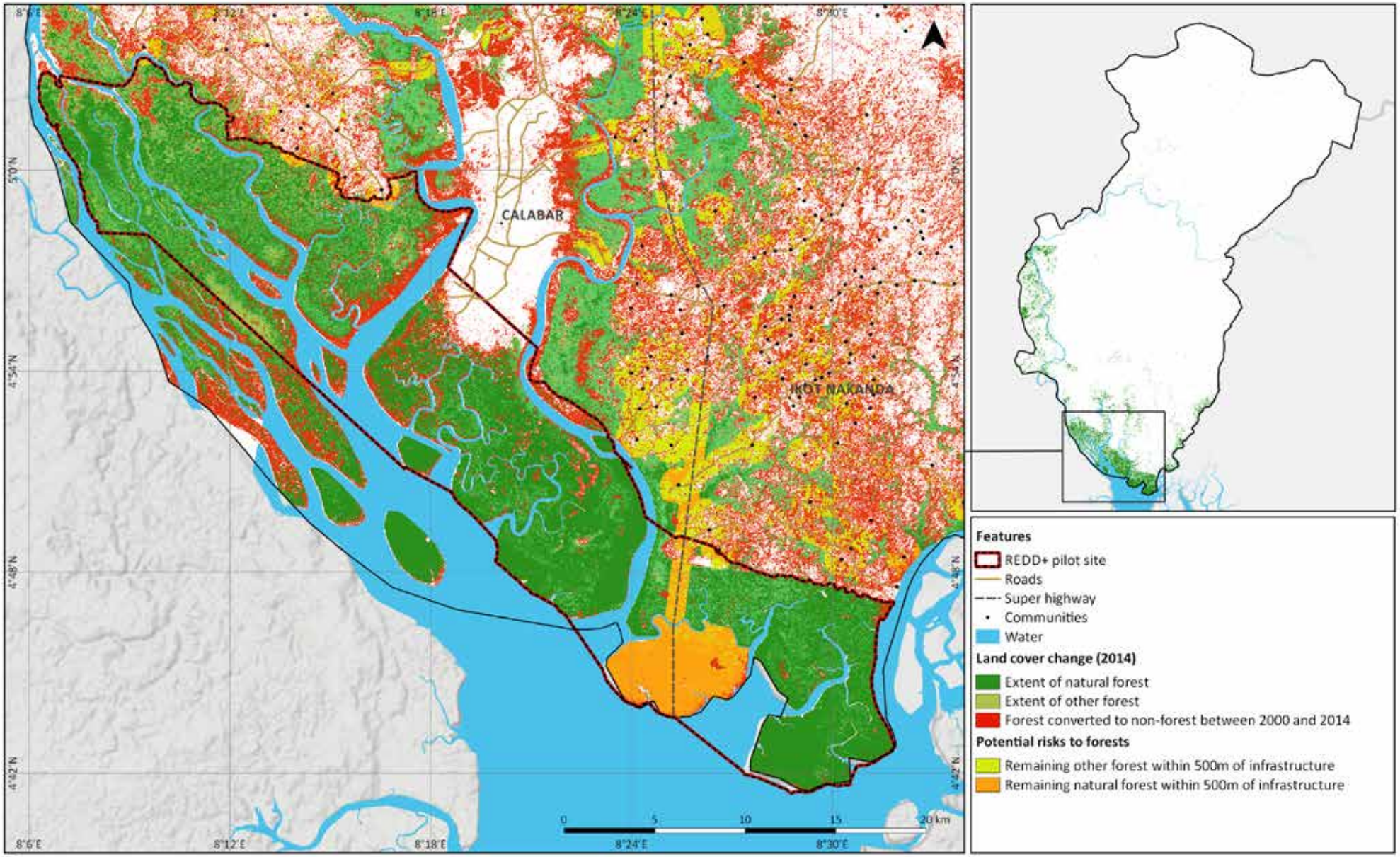
Map 16: Selected factors affecting conservation of mangrove area in Cross River State



Data sources:

Forest cover (NASRDA): NASRDA and FAO on behalf of the UN-REDD Programme (2015) Study on the Drivers of Deforestation and Forest Degradation in Cross River State

7 Conclusions and outlook

The forests of Cross River State provide essential goods and services to people within the State and beyond. In addition to their role in storing and sequestering carbon and thus contributing to the mitigation of climate change, the State's forests support people's livelihoods and well-being through the provision of forest products, support for an emerging ecotourism industry and a role in limiting the negative effects of soil erosion. These forests are also home to biodiversity of local and international conservation importance.

The use of spatial analysis can help to highlight the distribution of these forest values across the landscape in an accessible format. Maps can thus form a valuable input to REDD+ planning, indicating areas where the potential for promoting multiple benefits from selected REDD+ actions may be higher. Spatial analysis can also indicate where forests and their values have been affected by deforestation and degradation, and where these values may be most under threat in the future.

The maps in this study show that the forest areas that provide a series of potential multiple benefits from REDD+ in Cross River State – carbon stocks, NTFPs, biodiversity conservation, control of soil erosion risk and others - are largely concentrated in the State's natural forests. This is particularly true for the tropical high and montane forests of the Cross River National Park, but forests valuable for biodiversity and ecosystem services are also found outside of areas with formal protection status, such as community forests and the mangrove area in the south of the State. In addition, forests across the State may be providing a range of benefits that are not captured in these maps, such as fuelwood production and spiritual values.

This study has also explored recent trends in forest cover and several of the main drivers of deforestation and forest degradation identified in Cross River State. As in other parts of Nigeria, recent decades have seen significant forest loss in the State, particularly in its forest reserves, and in the fringes of the national park. The spatial analysis shows that the conversion of forests to farmlands, including croplands, commercial plantations and grazing lands, has been an important driver of this change. Population growth and the promotion of agricultural development suggests that this driver will remain significant into the future, along with new pressures from infrastructure development, urbanisation, and potentially mining and quarrying.

Combining the available spatial datasets, this study has explored opportunity areas and factors influencing the prioritization of areas for two selected REDD+ actions: forest restoration; and the

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conservation of mangrove forest. Spatial information provides an indication of areas where these actions are feasible – for example, where deforestation has occurred, excluding settlement areas and commercial plantations – and where higher levels of multiple benefits may be promoted – such as protecting carbon stocks and enhancing the role of forests in controlling soil erosion. In the case of forest restoration, depending on the definitions applied, the most widespread opportunity areas occur in the north of the State, while areas with the potential to deliver higher levels of the selected multiple benefits are concentrated in and around the national park, as well as in the State's far southeast and northeast corners. In the case of mangrove conservation, areas outside of the buffer zones of the Calabar sea port, proposed superhighway route, existing road network and villages may be best suited for the implementation of this action.

With pressures such as the rapid promotion of economic development and a growing population in the State, detailed land-use analysis and planning, using spatial information, is critical to reduce threats and impacts, and to better understand where sustainable development opportunities may be best pursued. We encourage that the analyses presented here are used to inform the design of interventions and the selection of areas for REDD+ implementation in Cross River State. Next steps could include field validation of the modelled priority areas for forest restoration and conservation, and the development of area targets for REDD+ implementation in the State drawing on these spatial analyses.

Future REDD+ planning efforts in Nigeria, as more states join the country's REDD+ programme, may capitalize on the enhanced in-country capacity for spatial analysis and use of decision support tools. Future work to incorporate multiple benefits in REDD+ planning nationally could include:

- Wider stakeholder analysis of the priority values of forests (and therefore potential multiple benefits of REDD+ that could be targeted);
- Extension of the use of easily accessible GIS tools and available datasets to planners and technical staff in other states;
- Fine-scale analyses of the distribution of potential multiple benefits in other states and landscapes seeking to implement REDD+.

These activities will further increase the overall positive impact of Nigeria's future REDD+ programme and inform decision-making on sustainable land use more widely.

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REDD+ is centred on the key principle that through more sustainable forest management practices, it is possible to both reduce GHG emissions produced by deforestation and by the forestry sector, and enhance the capacity of the forestry sector to act as a carbon sink. In addition, REDD+ can provide advantages to countries, such as results-based payments for each ton of carbon emissions reduced or removed, international recognition for mitigation results, and other, non-carbon benefits to the environment, economy and society. The full range of benefits that may be achieved through REDD+ are known as 'multiple benefits'.

The goal of this study is to support the development of national and State-level REDD+ strategies in Nigeria and Cross River State that take into account the potential benefits and risks of REDD+ actions. It uses spatial analysis to explore the potential for promoting multiple benefits from selected REDD+ actions in Cross River State, as well as other REDD+ related planning factors, such as changes in forest and land cover and particular pressures on forests.

The forests of Cross River State provide essential goods and services to people within the State and beyond. In addition to their role in storing and sequestering carbon and thus contributing to the mitigation of climate change, the State's forests support people's livelihoods and well-being through the provision of forest products, support for an emerging ecotourism industry and a role in limiting the negative effects of soil erosion. These forests are also home to biodiversity of local and international conservation importance.

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