NIGERIA NATURAL CAPITAL ACCOUNTING

PHYSICAL ASSET ACCOUNT FOR LAND

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WORLD BANK GROUP

GPS Global Program on Sustainability

Acknowledgements

This report was prepared jointly by staff of the World Bank, the United Nations Statistics Division, the Basque Centre for Climate Change, and independent experts, working with a multi-agency Technical Working Group led by the Nigerian National Bureau of Statistics.

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Foreword

Traditional economic indicators like GDP do not fully capture the environmental costs and benefits associated with economic activities and financial transactions but help to understand how the depletion of natural resources and degradation of the environment affect the economy and human well-being. Natural capital accounting fills this gap by quantifying the economic value of natural resources and ecosystems to offer a more holistic view of sustainability and economic health. It can support policymakers in understanding the trade-offs and synergies between economic policies and environmental goals.

The World Bank has supported the development of natural capital accounting in Nigeria through intersectoral cooperation among various government institutions alongside capacity-strengthening activities and policy dialogue, with the objective of building technical capacities to produce the accounts and increase understanding of the policy applications of natural capital accounting. This report presents the first set of land accounts for the nation as a whole and for Kaduna and Nasarawa states. It provides a physical asset account and land cover change matrix, leaving land use classification and monetary valuation to be undertaken in a future analysis. Reports on Ecosystem Accounts and Greenhouse Gas Accounts are published separately.

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Acronyms and abbreviations

ACReSAL	Agro-Climatic Resilience in Semi-Arid Landscapes
ARIES	Artificial Intelligence for Environment & Sustainability
BC3	Basque Centre for Climate Change
ESA-CCI	European Space Agency Climate Change Initiative
FAO	Food and Agriculture Organization of the UN
FREL	Forest Reference Emissions Levels
LULC	Land Use and Land Cover
NBS	National Bureau of Statistics
NCA	Natural Capital Accounting
SEEA	System of Environmental-Economic Accounting
TWG	Technical Working Group
UN	United Nations
UNSD	United Nations Statistics Division
WB	World Bank

Executive summary

The Global Program for Sustainability (GPS) has been supporting the government of Nigeria in developing natural capital accounts and modelling to inform policies, plans, and programs for low-carbon and climate-resilient development. This builds on previous work carried out with technical assistance from the WAVES[1] program, which focused on the mobilization of stakeholders and training for proof of concept to technical officers of relevant ministries, departments, and agencies. The key objective of GPS support was to help the government mainstream natural capital accounting (NCA) into its policies and plans, as provided for in the Climate Change Act (2021). The focus was on a carbon emissions account and the modelling of different carbon finance scenarios, which will help the Federal Ministry of Environment formulate evidence-based policies to achieve low-carbon climate development, and on land cover and ecosystem accounts and associated modelling, which will provide data and information to the Ministry for designing green bonds.

In collaboration with the United Nations Statistics Division and sector specialists, the World Bank supported the development of NCA in Nigeria through the training of government technical staff in the required methodology, to assist policymakers in understanding the trade-offs and synergies between economic policies and environmental goals to make more informed decisions that balance economic growth with environmental sustainability. Led by a multi-agency team and facilitated by the National Bureau of Statistics (NBS), the process generated Nigeria's first set of land accounts for the nation and two pilot states (Kaduna and Nasarawa). This program also supported the compilation of Ecosystem Accounts and Greenhouse Gas Accounts, which are published separately.

This report presents the first land accounts produced in Nigeria that cover:

(a) **Land cover maps** for 2015 and 2020, generated using satellite remote sensing datasets.
(b) **A physical asset account** for land cover, recording opening and closing areas (or stocks) for each land cover type, and the stock additions and reductions for each class between the two reference years.

[1] Wealth Accounting and Valuation of Ecosystem Services (WAVES) is a World Bank-led global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts. WAVES is now part of the broader World Bank umbrella initiative, the Global Program for Sustainability (GPS).

(c) **A land cover change matrix** shows the area of different land cover types and the net increases and decreases in each one over the reference period, according to the land cover type from which it was converted.

The main objective of the land accounts is to inform national plans such as the update of the Medium-term National Development Plan (2021-2025), sectoral action plans in agriculture and forestry, and policies for improving land use planning, land productivity and sustainable land use.

Members of the Technical Working Group were engaged in the process of dataset identification and technical staff at NBS, other federal agencies and two state-level teams were provided with the necessary training, software and code to generate additional land asset accounts for any two reference years, based on relevant land cover rasters. Limitations in the differentiation of tree cover using European Space Agency imagery were addressed by blending the analysis with a more reliable Global Forest Management dataset. This generated the best output available without a costly and time-consuming ground survey. Land use mapping and monetary valuation were not attempted at this stage but should be incorporated in future land accounts as national capacity and expertise in NCA are further developed.

Key findings

1. The development of the land accounts reveals significant changes from forested land cover classes to arable land and settlement between 2015 and 2020, indicating a reduction of forest cover in favor of farming and the expanding footprint of towns and cities. There are also changes from agroforestry to arable land and vice versa, indicating shifts between fallow and cultivation as well as changing patterns of agriculture in different areas, some with more trees, and some with fewer.
2. For analysis of this type, it cannot be assumed that good spatial data on land use and land cover exists at a country level and is ready to be applied. Investing in primary data collection to produce high-quality land use and land cover (LULC) maps is therefore vital to ensure accurate analysis of LULC dynamics and well-informed policy insights.

Further collaboration in generating LULC datasets between agencies in Nigeria (both governmental and non-governmental) would be very beneficial. While high-quality data have been generated by a number of publicly funded programs, these are usually one-time snapshots and are not publicly available in open data platforms, so could not be used to improve the LULC mapping process for NCA.

Recommendations on the next steps

The process of developing the land accounts has highlighted a need for a more consistent approach to the production of national LULC datasets for Nigeria. To ensure the production of reliable NCA outputs for future years it is necessary to:

i. Agree on a consistent national LULC classification system.
ii. Agree on a lead agency for national LULC mapping.
iii. Develop a strategy for better ground data collection and for sharing and centralizing data, especially for differentiating the most challenging land cover classes.

1. Introduction

Nature, and the services it provides, support almost every aspect of human well-being. However, traditional economic indicators like GDP do not fully capture the environmental costs and benefits associated with economic activities and financial transactions or help in understanding how the depletion of natural resources and degradation of the environment affect the economy and human wellbeing. Natural capital accounting (NCA) aims to fill this gap by quantifying the economic value of natural resources and ecosystems to offer a more holistic view of sustainability and economic health.

The World Bank (WB) has supported the development of NCA in Nigeria using the System of Environmental-Economic Accounting (SEEA) framework. The SEEA is the international statistical standard for NCA. It integrates environmental data with economic data consistent with the System of National Accounts, offering a comprehensive view of the interactions between the environment and the economy. The data provided by the SEEA can support policymakers in understanding trade-offs and synergies between economic policies and environmental goals. As a globally recognized framework adopted by the United Nations Statistical Commission. The SEEA also allows for consistent and comparable environmental-economic accounting across different countries.

NCA requires close collaboration between national statistical offices and other government agencies. In Nigeria, the process was led by the National Bureau of Statistics (NBS) through a Technical Working Group (TWG) representing some federal and state ministries and agencies. External support was provided by the United Nations Statistics Division (UNSD), the Basque Centre for Climate Change (BC3), and independent experts. The priorities for the NCA process were to develop land accounts, ecosystem accounts, and greenhouse gas accounts, to represent a minimum set of information that countries should aim to compile and report upon under the SEEA. This report is concerned specifically with the land accounts, while the ecosystem accounts and greenhouse gas accounts are published separately.

2. Rational and applications of land accounts

Land accounts can help identify the best approaches for managing landscapes to maximize benefits from ecosystem services such as climate regulation, soil and sediment retention, water

regulation and identify where reductions in greenhouse gas emissions from land use, land use change, and forestry would be most cost-effective. This aligns with Nigeria's National Climate Change Policy, which aims to "build a climate-resilient society through implementing mitigation measures that will promote low carbon as well as sustainable and high economic growth". Land accounts may also be used for monitoring changes in land cover and ecosystem services and for determining the effectiveness of investments and demand for additional resources for schemes that use performance-based payments for land management. Land accounts can additionally provide information on the potential for and constraints to agricultural growth and help analyze government performance targets for sustainability. When integrated with other sectoral data, land accounts can also provide insights into potential effects on water use and food production. Finally, including land accounts in the national accounting system contributes to good governance and institutional strengthening, as higher quality, standardized data becomes publicly available and can be applied in the formulation of national development plans and setting of targets.

3. Key outputs

Land accounts focus on the physical and economic aspects of land use, including land cover, land use change, and the monetary value of land resources. They are concerned about how land is allocated, owned, and utilized for economic activities.

The physical land account first requires mapping of land cover, which includes the physical and biological cover on the Earth's surface such as vegetation and non-living surfaces. For monetary land accounts it is also necessary to identify and land use, reflecting the activities and institutional arrangements for economic production or for maintaining and restoring environmental function. Monetary valuation necessitates valuing both the land and the assets situated upon it, to provide a comprehensive assessment of their combined economic worth.

For this first attempt at NCA in Nigeria, the land account focusses only on land cover and changes over time. Monetary valuation was not attempted at this stage.

The desired outputs for Nigeria's initial land accounts were as follows:

(a) **Land cover maps** for two reference years, generated using satellite remote sensing.

(b) **A physical asset account** for land cover, recording the opening and closing areas (or stocks) for each class, and the stock additions and reductions for each class between the two reference years.

(c) **A land cover change matrix** to show the area of different land cover types and the net increases and decreases in each type over the reference period, according to the land cover type it was converted from or to.

These outputs are intended to inform national policies and plans such as the update of the Medium-term National Development Plan (2021-2025), the Energy Transition Plan and sectoral action plans in agriculture, forestry, energy and transport; and to inform state-level investment prioritization in WB-financed programs such as Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL). Land accounts were therefore required both for the country as a whole and for the two pilot ACReSAL states of Kaduna and Nasarawa.

4. Datasets

Finding the appropriate datasets for preparing national land accounts can be challenging, especially in a country such as Nigeria where certain land cover types have similar spectral signatures and are therefore hard to differentiate using remote sensing alone. It is especially difficult using satellite imagery to distinguish different types of tree cover, including natural forests, timber plantations, tree crops and agroforestry systems.

During an NCA training week led by a UNSD team in Abuja in April 2023, research into data availability found a lack of consistent and reliable time series land use and land cover (LULC) imagery, and uncertainty over which agency is responsible for generating such imagery and carrying out LULC classification for cross-sectoral applications such as NCA. The issue of dataset selection was therefore discussed at meetings of the TWG in July and August 2023. Four options were presented for consideration, as summarized in Table 1 below.

Table 1: Potential sources of land cover information for preparation of Nigeria's land and ecosystem accounts

Source	Description	Available yrs	Resolution	Classes	Pros	Cons
Globeland 30	Global dataset developed by National Geomatics Centre of China using Landsat & Chinese HJ-1 imagery	2000, 2010, 2020	30 m	10 classes incl. cropland, trees, grassland, wetland, waterbody, built-up & bare surface	• Good resolution • Reasonable accuracy	• One 'tree' category covering many variations of forested land • Savanna not differentiated
European Space Agency Climate Change Initiative (ESA-CCI)	Global dataset from ESA	annually 1992-2020	300 m	22 classes incl. those in Globeland 30	• Annual series • Accessible through ARIES for SEEA Explorer • Reasonable accuracy	• Tree crops mixed within 'tree' category • Lower resolution
Nigeria Forest Reference Emissions Levels (FREL) report	Dataset nationally commissioned through FAO	2006, 2016	30 m	12 classes: undisturbed forest, mangrove, forested freshwater, forest plantation, disturbed forest, tree crop plantation, savanna, grassland, arable land, settlement, bare surface & water body.	• Good resolution • Differentiates four types of tree cover plus savanna	• Questionable accuracy • Latest year available is 2016 and training data not available, so cannot be extrapolated to later dates
Global Forest Management assessment	Global dataset using Belgian PROBA-V imagery	2015	100 m	7 classes with forest differentiation: naturally regenerating (both with and without signs of management), planted forest, plantation forest (up to 15 yr rotation), oil palm plantation & agroforestry.	• 8,136 training points in Nigeria • High accuracy for tree cover • Training dataset & model available	• Only considers tree cover categories in detail • One-off product; requires extra work to extrapolate to other years

From the four datasets considered, the TWG initially decided to adopt the FREL. This was seen as a locally validated product, having been generated in 2018 by the Federal Ministry of Environment through a collaboration with the Food and Agriculture Organization of the UN (FAO). The Federal Department of Forestry was able to supply the FREL rasters[2] for the years 2006 and 2016.

It became apparent, however, that the FREL data had significant inaccuracies, evidenced by a few implausible LULC transitions between 2006 and 2016. This being the case, the TWG agreed during a November 2023 meeting that ESA-CCI datasets should be adopted instead for production of the land and ecosystem accounts. While this dataset has fewer forest classification classes, it has the significant benefit of being available for all years since 1992 and shows good accuracy outside forest areas.

It was agreed by the TWG to use 2015 as the reference year and to produce the accounts to 2020, the latest year for which classified ECI-CCI imagery was available. It was initially thought that this could be accomplished via the online interface known as the Artificial Intelligence for Environment & Sustainability (ARIES) for SEEA Explorer, an open-source modelling platform developed by BC3 that has automated functionality to generate pre-formatted land and ecosystem accounts.[3] But the SEEA Explorer generates 22 land cover classes from the ESA-CCI imagery, some of which do not appear in Nigeria, and a simpler product was desired that would be more closely aligned with the land cover classes used in the FREL. So the original ESA-CCI rasters were manually re-coded using opensource QGIS to generate simplified imagery for 2015 and 2020 with just nine classes, aligned with those from the FREL.

Test outputs comparing 2015 and 2020 indicated reliable results for most land cover classes but curious results for the forest categories, as the ESA-CCI imagery has limited accuracy in differentiating types of tree cover. A third dataset was therefore introduced, namely the Global Forest Management (GFM) dataset from 2015, which has reliable forest cover information for Nigeria based on over 8,000 training points located within the country (see Table 1). The GFM data convincingly differentiates forests with signs of management from forests with no such signs, and also identifies a variety of mixed agriculture and tree cropping systems collectively

[2] In satellite remote sensing, a raster refers to a grid of pixels, each representing spatial information such as colour, light intensity or other spectral data, captured by the satellite's sensors.
[3] For more information visit https://seea.un.org/content/aries-for-seea

categorized as ‘agroforestry’. This broad class includes areas with tree crops (such as cocoa and oil palm), cropland and pasture with scattered trees or denser tree groupings, and areas under shifting cultivation.[4]

5. Methodology

The final methodology for the LULC mapping combines the best elements of the ESA-CCI and GFM datasets. Starting with the re-coded nine-class ESA-CCI image for 2015, a simple rule was applied that if a pixel was classified as agroforestry in the 2015 GFM dataset, while being classified by ESA-CCI as class 30 up to 153 (see
Table 2 below for class descriptors), then it was re-coded as agroforestry. Otherwise, the ESA-CCI class was maintained (i.e. either arable land (classes 30 and 40), dense forest (classes 50 and 60), or woodlands and sparse forest (class 62).

To avoid a potential problem of falsely identified forest gain, a second rule was introduced that when a pixel appeared to have changed between 2015 and 2020 from any type of land cover to a ‘forest’ category (ESA-CCI class 50 or 60), this was taken instead to be a change to agroforestry (as the large majority of increases in tree cover will fall under agroforestry, including fallow land and tree crop plantations). All other ESA-CCI land cover changes from 2015 to 2020 were accepted.

The main implication of the chosen approach was that no forest gain was recorded between 2015 and 2020, because the analysis adopted the reliable GFM classification for 2015 and the adopted methodology did not accept forest additions (due to the limitations of the ESA-CCI classification in that regard and a lack of more recent data in the GFM dataset). The second implication is that no area under forest in 2015 changed to agroforestry in 2020, as the GFM dataset was a snapshot from 2015 and could not support speculative changes to the agroforestry extent in 2020. The methodology may therefore have resulted in underestimation of the transition from natural forests to agroforestry, as would be seen during the progressive conversion of natural tree cover to cocoa or other tree crops.
These rules and the re-coding protocols, which were presented to the TWG for discussion and agreement, are summarized in

[4] For the GFM class definitions see https://www.nature.com/articles/s41597-022-01332-3/tables/2 Oil palm monoculture was merged with agroforestry for simplification.

Table 2 below. The final list of ten classes included in the land account is as follows:

a) Dense forest
b) Woodlands and sparse forest
c) Agroforestry
d) Arable land
e) Grassland
f) Settlement
g) Bare surfaces
h) Freshwater swamp
i) Mangrove
j) Water bodies

6. Data and interpretation

Based on the re-coding system and analytical methodology described, national land cover maps of Nigeria were produced for 2015 and 2020. See Figure 1 and Figure 2 below. The physical asset account is provided in Table 3 and the land cover change matrix is in Table 4.

Table 2: Re-coding matrix from ESA-CCI to land cover map for land and ecosystem accounts

ESA-CCI original		Rule for 2015 and 2020 images		Additional rule for 2020 image
		Classified as agroforestry in GFM 2015?		Change from non-forest to forest in ESA-CCI between 2015 and 2020?
		No	Yes	Yes
10	Cropland rainfed	Arable land	Arable land	Agroforestry
11	Herbaceous cover	Arable land	Arable land	Agroforestry
20	Cropland irrigated or post-flooding	Arable land	Arable land	Agroforestry
30	Mosaic cropland (>50%) / natural vegetation (tree shrub herbaceous cover) (<50%)	Arable land	Agroforestry	Agroforestry
40	Mosaic natural vegetation (tree shrub herbaceous cover) (>50%) / cropland (<50%)	Arable land	Agroforestry	Agroforestry
50	Tree cover broadleaved evergreen closed to open (>15%)	Dense forest	Agroforestry	
60	Tree cover broadleaved deciduous closed to open (>15%)	Dense forest	Agroforestry	
62	Tree cover broadleaved deciduous open (15-40%)	Woodland and sparse forest	Agroforestry	
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	Woodland and sparse forest	Agroforestry	
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	Woodland and sparse forest	Agroforestry	
120	Shrubland	Woodland and sparse forest	Agroforestry	
122	Shrubland deciduous	Woodland and sparse forest	Agroforestry	
130	Grassland	Grassland	Grassland	Agroforestry
150	Sparse vegetation (tree shrub herbaceous cover) (<15%)	Woodland and sparse forest	Agroforestry	
152	Sparse shrub (<15%)	Woodland and sparse forest	Agroforestry	
153	Sparse herbaceous cover (<15%)	Woodland and sparse forest	Agroforestry	
170	Tree cover flooded saline water	Mangrove	Mangrove	Agroforestry
180	Shrub or herbaceous cover flooded fresh/saline/brackish water	Freshwater swamp	Freshwater swamp	Agroforestry
190	Urban areas	Settlement	Settlement	Agroforestry
200	Bare areas	Bare surface	Bare surface	Agroforestry
201	Consolidated bare areas	Bare surface	Bare surface	Agroforestry
210	Water bodies	Water body	Water body	Agroforestry

Figure 1: Nigeria land cover map, 2015

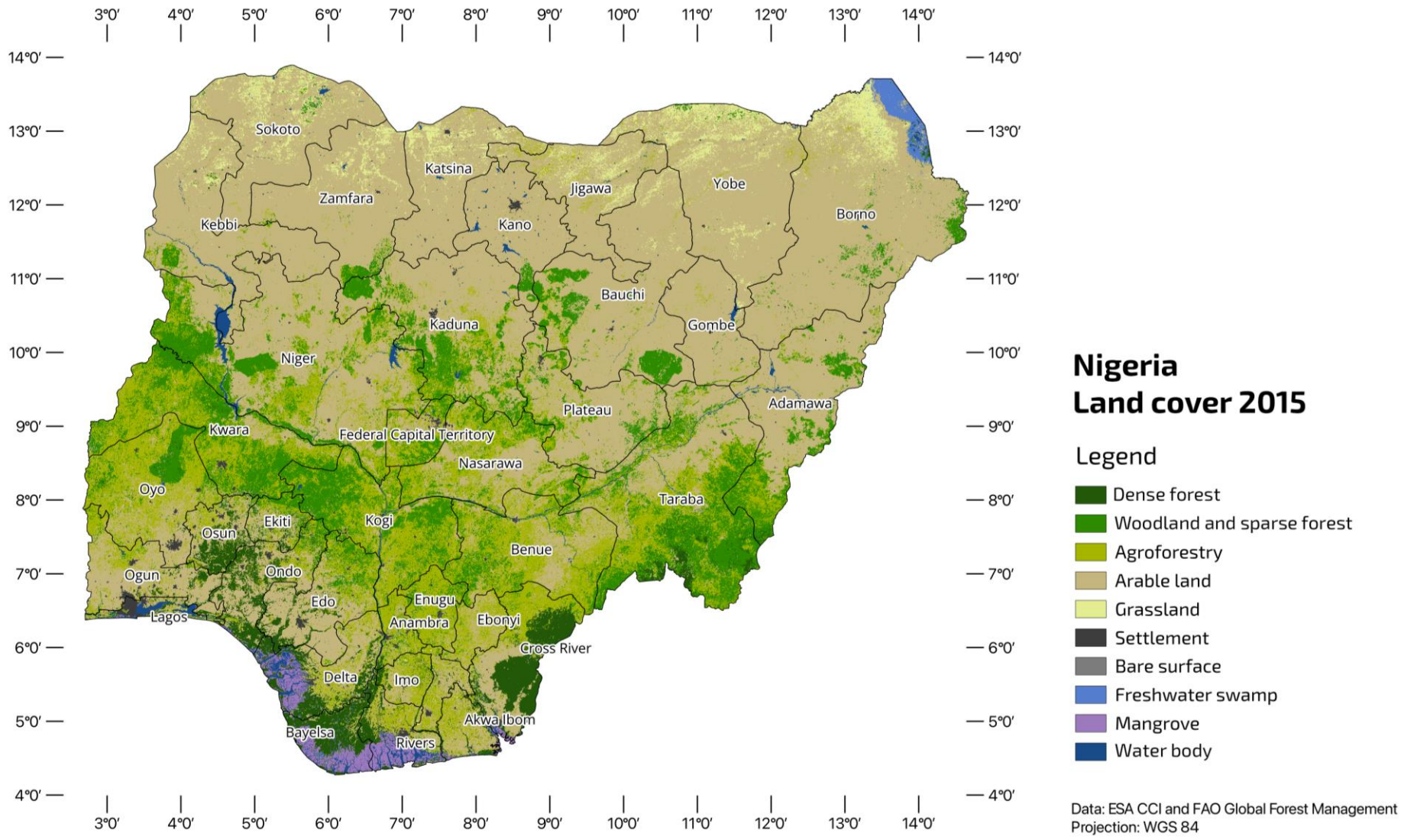

Figure 2: Nigeria land land cover map, 2020

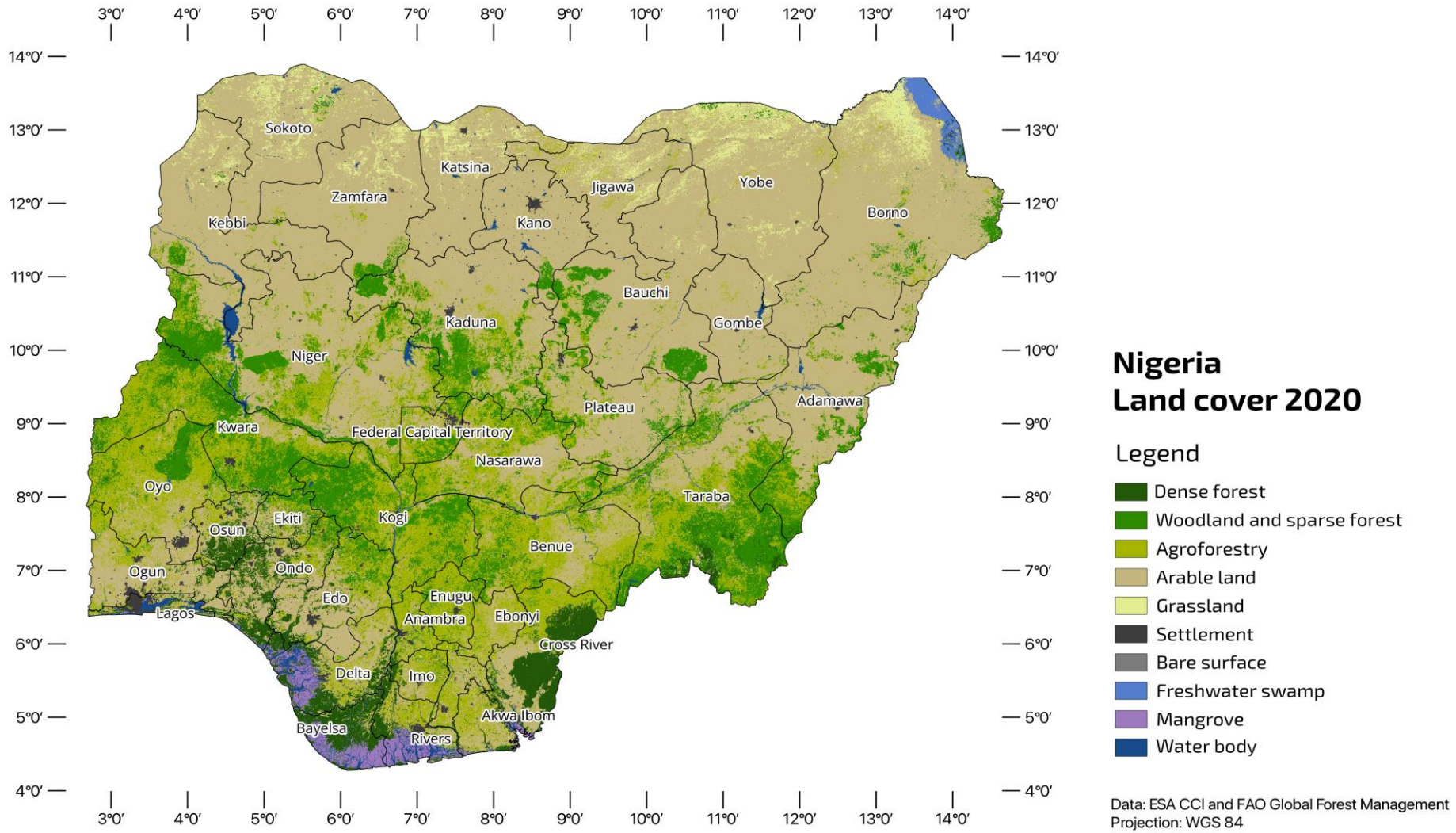

Table 3: National physical asset account (km^2)

Land cover	Opening Stock 2015	Additions to stock	Reductions to stock	Net change	Closing Stock 2020
Dense forest	38,462	2,054	486	1,568	40,029
Woodland and sparse forest	119,457	72	3,678	-3,606	115,851
Agroforestry	169,773	6,113	1,226	4,887	174,660
Arable land	527,759	3,297	7,838	-4,541	523,218
Grassland	26,769	245	820	-575	26,194
Settlement	6,484	2,097	-	2,097	8,581
Bare surface	155	40	4	37	191
Freshwater swamp	3,851	9	56	-46	3,804
Mangrove	8,878	94	107	-14	8,864
Water body	10,523	210	16	194	10,716
	912,108				**912,108**

Note: Total areas may differ from official figures.[5]

The most significant stock change between 2015 and 2022 was a 32% increase in the area under settlement, which reflects a 23% increase in the urban population during the same period.[6] Other changes are relatively small, given the short time window, but there was a loss of 1% in forest area (combing dense forest, sparse forest and woodland) and a 3% gain in the area under agroforestry.

[5] The ARIES platform was used for the area calculations. Discrepancies with official areas may result from the inclusion of water bodies and projection inaccuracies.

[6] https://data.worldbank.org/indicator/SP.URB.TOTL?locations=NG

Table 4: National land cover change matrix (km^2)

		2020										
		Dense forest	Woodland and sparse forest	Agroforestry	Arable land	Grassland	Settlement	Bare surface	Freshwater swamp	Mangrove	Water body	**Total 2015**
2015	Dense forest	37,975	72	-	383	-	22	-	2	-	7	**38,462**
	Woodland and sparse forest	2,054	115,779	-	1,320	2	179	14	5	25	78	**119,457**
	Agroforestry	-	-	168,546	1,062	0	137	1	0	18	8	**169,773**
	Arable land	-	-	5,833	519,921	243	1,697	0	1	30	33	**527,759**
	Grassland	-	-	228	533	25,949	33	25	-	0	1	**26,769**
	Settlement	-	-	-	-	-	6,484	-	-	-	-	**6,484**
	Bare surface	-	-	3	-	0	0	151	-	0	0	**155**
	Freshwater swamp	-	-	48	-	-	3	-	3,795	4	1	**3,851**
	Mangrove	-	-	1	0	-	25	0	1	8,770	81	**8,878**
	Water body	-	-	0	-	-	-	-	0	16	10,506	**10,523**
Total 2020		**40,029**	**115,851**	**174,660**	**523,218**	**94**	**8,581**	**191**	**3,804**	**8,864**	**10,716**	**912,108**

Note: Total areas may differ from official figures.[7]

Changes can be observed from the two forested land cover classes to arable land and settlement, indicating a progressive reduction of forest cover in favor of farming and the expanding footprint of towns and cities. There are changes from agroforestry to arable land and vice versa, indicating shifts between fallow and cultivation as well as changing patterns of agriculture in different areas, some with more trees, some with fewer. The absence of recorded change from the two forests classes to agroforestry arises from the lack of 2020 data distinguishing forests and agroforestry.

[7] The ARIES platform was used for the area calculations. Discrepancies with official areas may result from the inclusion of water bodies and projection inaccuracies.

7. Kaduna and Nasarawa state land accounts

State-level physical asset accounts for Kaduna and Nasarawa are provided in Table 5 and Table 6. These are followed by state land cover maps (Figures 3 to 6), and land cover change matrices (Table 7 and Table 8). The total areas in the tables and maps may differ from official figures.[8]

Table 5: Physical asset account, Kaduna state (km^2)

Land cover	Opening Stock 2015	Additions to stock	Reductions to stock	Net change	Closing Stock 2020
Dense forest	78	218	-	218	296
Woodland and sparse forest	9,761	-	445	-445	9,315
Agroforestry	7,754	300	125	175	7,929
Arable land	26,672	348	426	-78	26,594
Grassland	2	-	-	-	2
Settlement	227	126	-	126	353
Bare surface	-	-	-	-	-
Freshwater swamp	-	-	-	-	-
Mangrove	-	-	-	-	0
Water body	191	4	-	4	195
	44,685				**44,685**

Table 6: Physical asset account, Nasarawa state (km^2)

Land cover	Opening Stock 2015	Additions to stock	Reductions to stock	Net change	Closing Stock 2020
Dense forest	81	115	0	115	196
Woodland and sparse forest	4,434	-	227	-227	4,207
Agroforestry	11,007	498	97	401	11,408
Arable land	10,726	194	528	-333	10,393
Grassland	2	0	-	0	2
Settlement	112	26	-	26	138
Bare surface	2	-	0	-0	2
Freshwater swamp	2	-	1	-1	2
Mangrove	10	4	1	3	13
Waterbody	211	16	-	16	227
	26,588				**26,588**

The largest change seen in Kaduna is the loss of 445 km^2 of woodland and sparse forest over the five years of analysis, and gains of 175 km^2 in agroforestry and 126 km^2 in settlement. There is some gain in dense forest from the woodlands and sparse forest category. Similarly to

[8] The ARIES platform was used for the area calculations. Discrepancies with official areas may result from the inclusion of water bodies and projection inaccuracies.

Kaduna, Nasarawa experienced loss of woodland and sparse forest and gains in agroforestry and settlement.

Figure 3, Kaduna state land cover map 2015

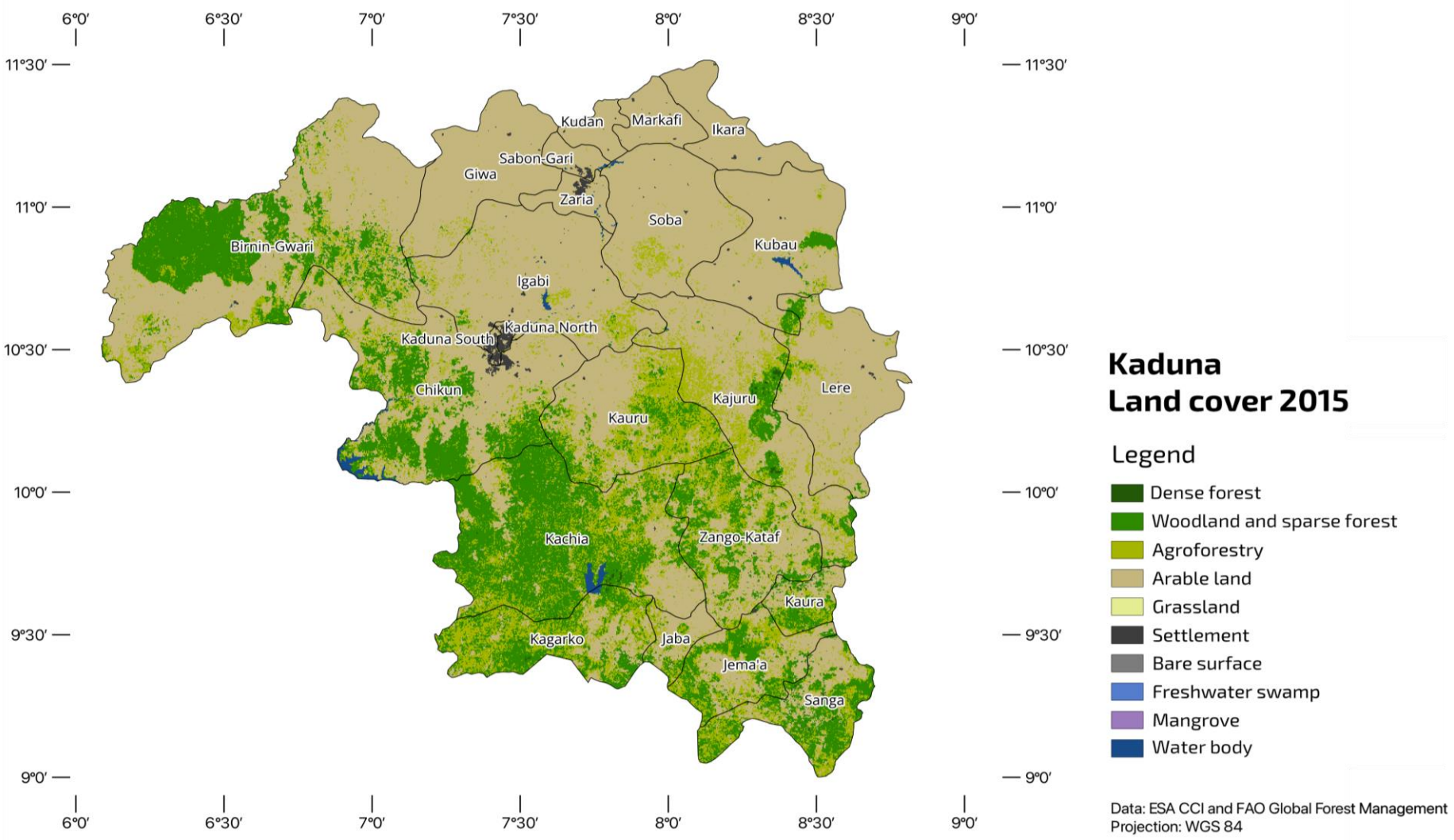

Figure 4, Kaduna state land cover map 2020

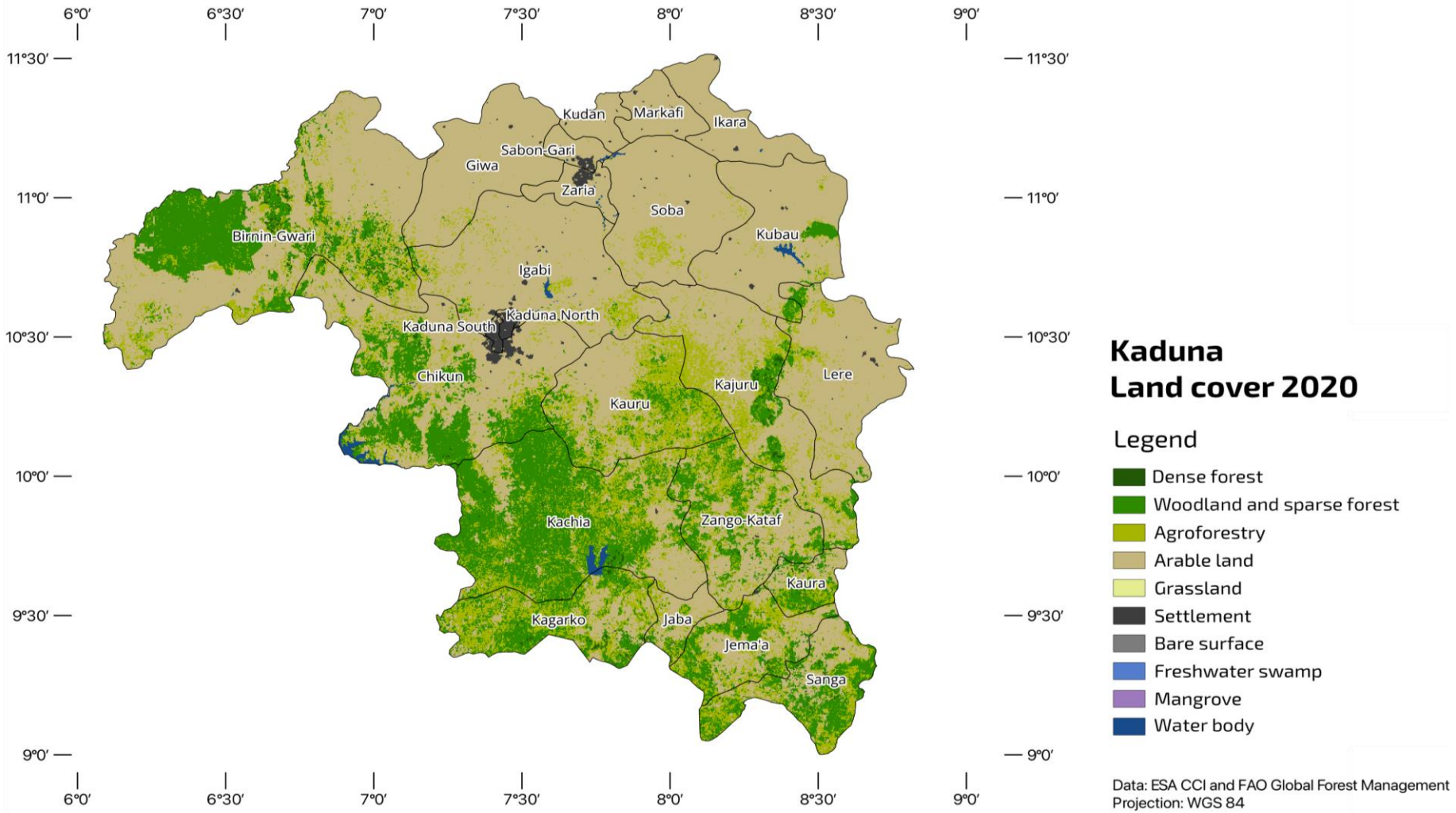

Figure 5, Nasarawa State Land Cover Map 2015

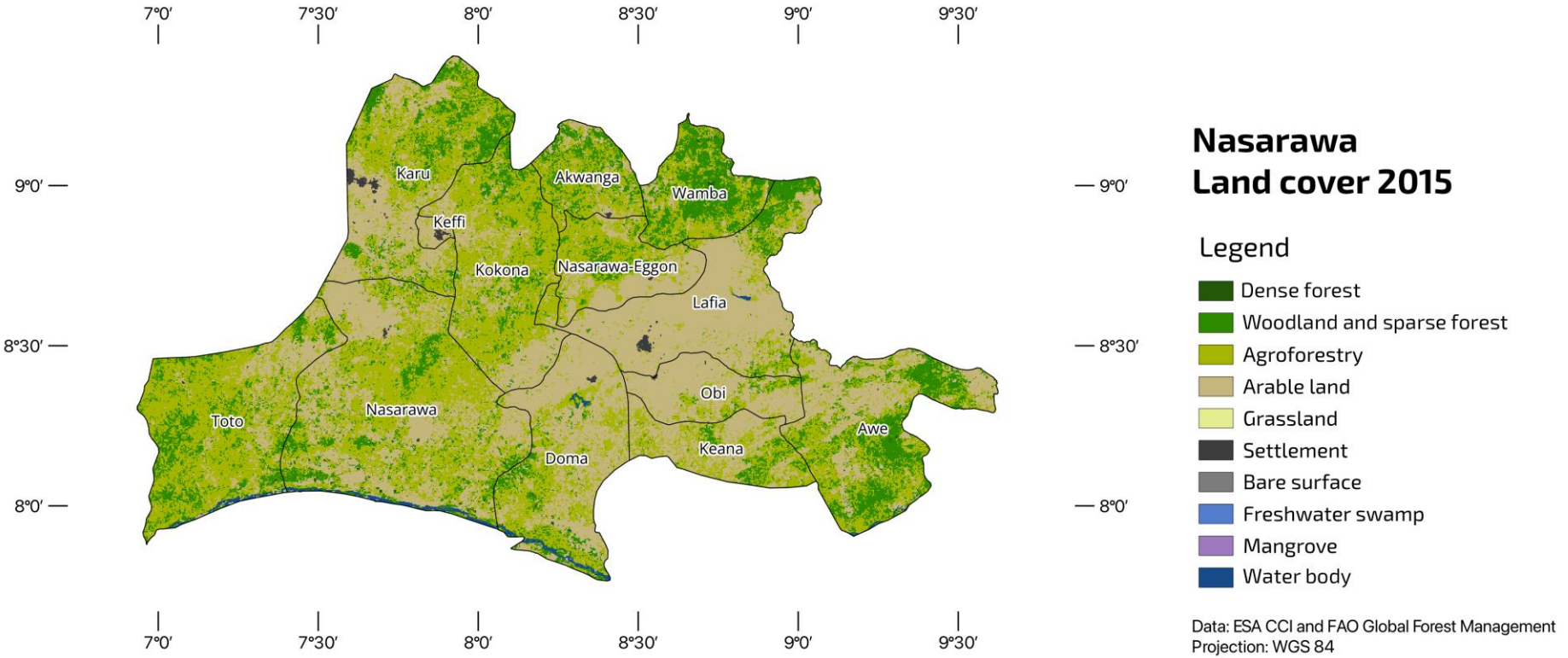

Figure 6, Nasarawa state land cover map 2020

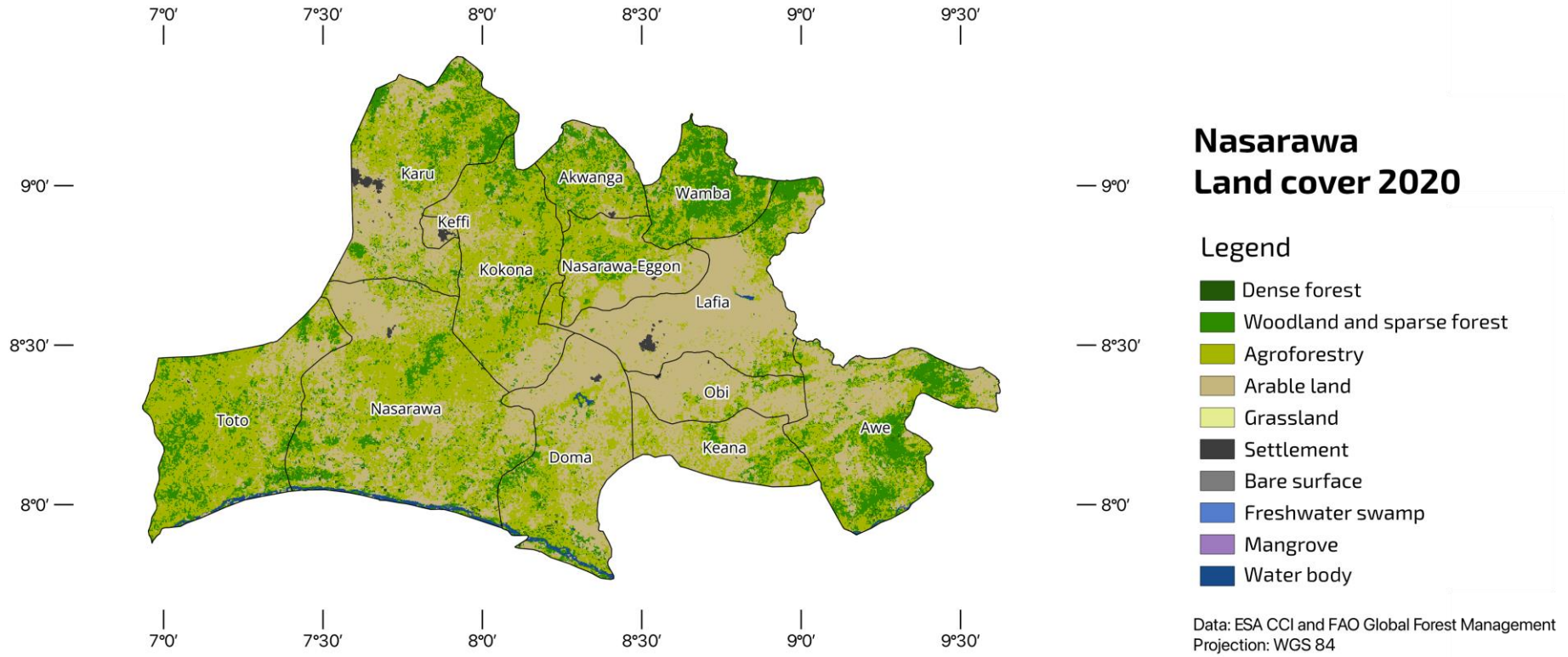

Table 7: Land land cover change matrix, Kaduna state (km^2)

		2020										
		Dense forest	Woodland and sparse forest	Agroforestry	Arable land	Grassland	Settlement	Bare surface	Freshwater swamp	Mangrove	Water body	**Total 2015**
2015	Dense forest	78	-	-	-	-	-	-	-	-	-	**78**
	Woodland and sparse forest	218	9,315	-	227	-	-	-	-	-	-	**9,761**
	Agroforestry	-	-	7,629	122	-	3	-	-	-	-	**7,754**
	Arable land	-	-	300	26,246	-	122	-	-	-	4	**26,672**
	Grassland	-	-	-	-	2	-	-	-	-	-	**2**
	Settlement	-	-	-	-	-	227	-	-	-	-	**227**
	Bare surface	-	-	-	-	-	-	-	-	-	-	**0**
	Freshwater swamp	-	-	-	-	-	-	-	-	-	-	**0**
	Mangrove	-	-	-	-	-	-	-	-	-	-	**0**
	Water body	-	-	-	-	-	-	-	-	-	191	**191**
Total 2020		**296**	**9,315**	**7,929**	**26,594**	**2**	**353**	**-**	**-**	**-**	**195**	**44,685**

In Kaduna state, there was a gain in arable land and settlement, at the expense of woodlands and sparse forests. As for the country as a whole, there were changes from agroforestry to arable land and vice versa, perhaps indicating a shift between fallow and cultivation, as well as both removals and additions of trees on farmed land.

Table 8: Land land cover change matrix, Nasarawa state (km^2)

		2020										
		Dense forest	Woodland and sparse forest	Agroforestry	Arable land	Grassland	Settlement	Bare surface	Freshwater swamp	Mangrove	Water body	**Total 2015**
2015	Dense forest	81	-	-	-	-	-	-	-	-	-	**81**
	Woodland and sparse forest	115	4,207	-	99	0	0	-	-	2	11	**4,434**
	Agroforestry	-	-	10,910	95	-	1	-	-	0	1	**11,007**
	Arable land	-	-	497	10,198	-	25	-	-	2	4	**10,726**
	Grassland	-	-	-	-	2	-	-	-	-	-	**2**
	Settlement	-	-	-	-	-	112	-	-	-	-	**112**
	Bare surface	-	-	-	-	-	-	2	-	-	-	**2**
	Freshwater swamp	-	-	0	-	-	-	-	2	-	-	**2**
	Mangrove	-	-	-	-	-	-	-	-	10	-	**10**
	Waterbody	-	-	-	-	-	-	-	-	-	211	**211**
Total 2020		**196**	**4,207**	**11,408**	**10,393**	**2**	**138**	**2**	**2**	**13**	**227**	**26,588**

In Nasarawa state there was again a gain in arable land from agroforestry and woodlands, sparse forests, and some conversion of arable land to settlement. There was a significant area that changed from agroforestry to arable land.

The NBS and partner agencies represented in the TWG at the federal and state levels must have the capacity to update these land accounts for future years and improve the accuracy of the land cover mapping that underpins the data. A land accounts training was therefore organized in November 2023 to show members of the TWG how to generate land accounts using digital land cover maps for any two reference years.

Participants were first shown how to generate a physical asset account and a land cover change matrix from the two FREL rasters using Python code in Jupyter Notebook. They were then trained to use the open-source QGIS software to extract shapefiles from the FREL rasters for individual states, to generate state-specific land accounts. They were also shown how to generate land accounts using the ESA-CCI dataset, a simplified version which is accessible through the ARIES for SEEA Explorer platform and can be replicated for the whole country or individual states for any reference period.

Participants were each given a copy of the Jupyter Notebook and QGIS software packages, the Python code for generating land account outputs, national and state shapefiles, and training slides. This will enable interested trainees to improve their familiarity with land account production. Those with more experience can modify the Python code to substitute alternative rasters or shapefiles for different years (provided these have been reprojected to 'equal areas' to match the country and state shapefiles).

8. Lessons learned

The first set of land accounts for Nigeria has been successfully generated. It provides an overview of the land cover changes that have taken place within the chosen reference period. Members of the TWG were engaged in the process of dataset identification and technical staff of NBS, other federal agencies and two state-level teams were provided with the necessary training, software and code to generate land accounts for any two reference years based on relevant land cover rasters.

Inaccuracies in the FREL datasets were recognized and the global ESA-CCI imagery was adopted instead of the TWG. Limitations in the differentiation of tree cover were addressed by introducing the 2015 GFM dataset to separate areas under tree crops, fallow lands and other

agroforestry land uses. This generated the best output available without a costly and time-consuming ground survey. However, it has limitations because the agroforestry data from 2015 was not updated in 2020.

An important lesson from Nigeria relevant to NCA processes internationally is that it cannot be assumed that good data exists at the country level and is ready to be applied. Investing in primary data collection to produce high-quality LULC maps is therefore important to ensure accurate analysis and well-informed policy insights.

Further collaboration between agencies in Nigeria (both governmental and non-governmental) would be very beneficial as high-quality data have been generated by number of publicly funded programs through organizations such as Ecometrica, the International Institute of Tropical Agriculture and others, but are not readily available or centralized in an open data platform, so could not be used to improve the LULC mapping process for NCA.

9. Way forward

Land use mapping and monetary valuation were not attempted at this stage but should be incorporated in future land accounts as national capacity and expertise in NCA is further developed.

The process of developing these accounts has highlighted a need for a more consistent and unified approach to the production of national LULC maps for Nigeria for multiple purposes, including producing and updating datasets for natural capital accounting. The requirements for the future improvement and updating of land accounts include the following:

a) **Agree on a consistent national LULC classification system:** There has been a tendency for each new land use/land cover map produced by government agencies or project-based experts to adopt a different classification system, according to their task requirements, technical capacity and the nature of the input data, which adds to the challenge of comparing datasets over time. Nigeria has a unique mosaic of land cover formations such as savanna, tree crops and tree plantations that require a country-appropriate set of land cover classes to fully represent the national situation. There is a need to agree on a consistent land cover classification system appropriate to the country's requirements.

b) **Agree on a lead agency for national land use and land cover mapping**: There is a need to invest more resources in spatial data collection and processing to produce higher-quality datasets for processes such as NCA. While considerable remote sensing and GIS expertise exist in Nigeria, this expertise is dispersed, and resources are thinly spread. There is a need to agree upon a designated lead agency/ies for LULC mapping, for them to be properly resourced to produce regularly updated spatial datasets and to work collaboratively to provide more accurate and consistent time-series than those that currently exist. This would avoid the continued production of one-off outputs that lack comparators for different points in time.

c) **Develop a strategy for better ground data collection and centralization for challenging land cover classes:** While much can be accomplished remotely through Collect Earth Online or similar platforms, improving the accuracy of LULC maps requires a significant increase in ground data collection. This is labor-intensive and potentially costly but remains essential for differentiating certain important classes, such as agroforestry. Costs could be reduced with a better compilation of existing spatial datasets available from research agencies, development organizations and government institutions within the country, to complement better and more targeted validation on the ground. Nigeria will then be in a better position to permanently integrate natural capital accounting in its economic statistics and policymaking processes. Existing data sets should be obtained and consolidated in a centralized repository.

d) **Develop a road map for producing land accounts for 2025 and beyond.** A government-led roadmap is needed to identify the resources needed for equipment, software, training, surveys and monetary evaluation, to enable regular spatial data collection, processing and compilation of the accounts in the future.

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