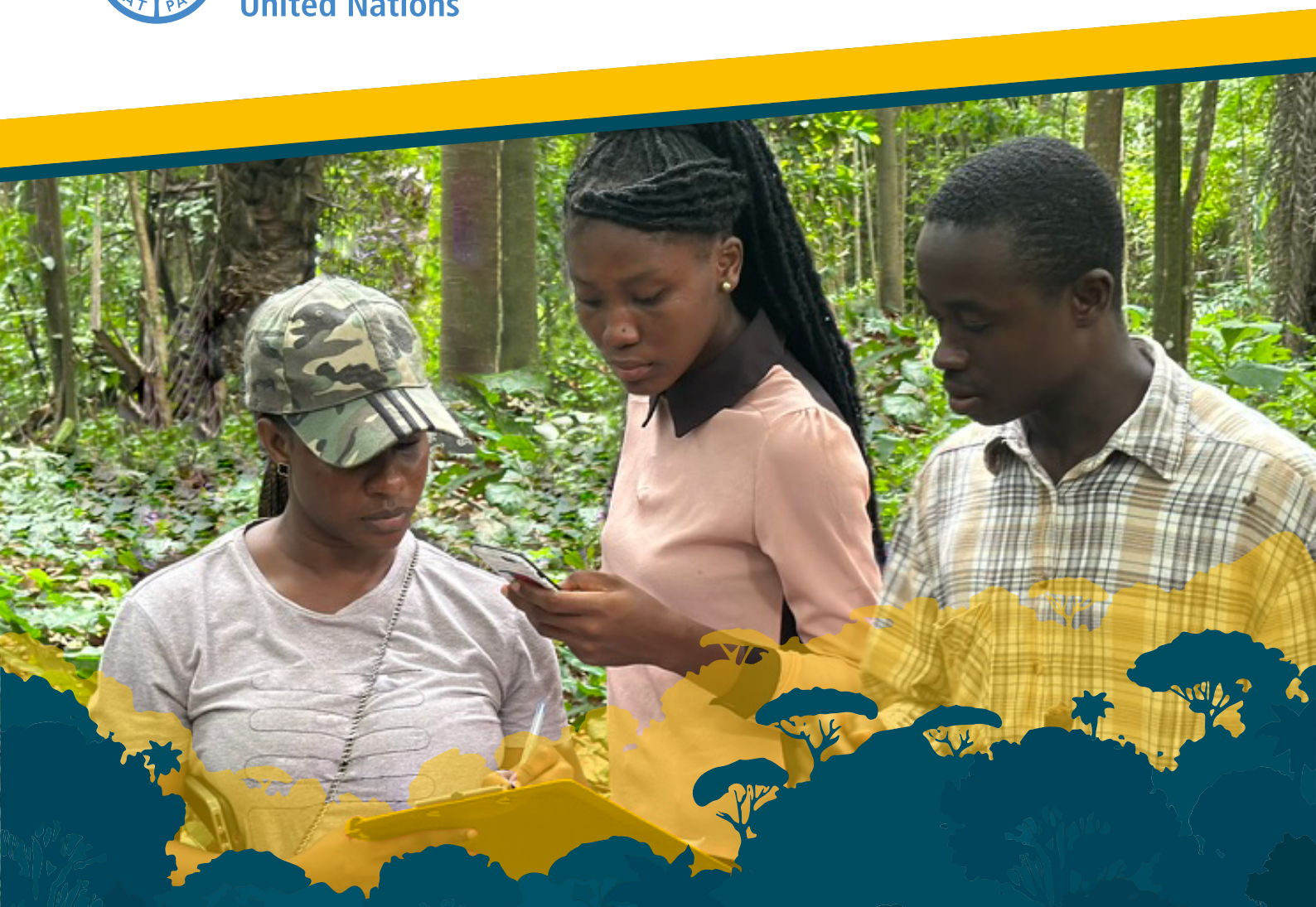
Food and Agriculture Organization of the United Nations



Assessment of forest data availability and related technical capacity needs in West Africa

In collaboration and with the financial support of

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Assessment of forest data availability and related technical capacity needs in West Africa

Wesley Jonathan Roberts

John Fonweban

Maria Ruiz-Villar

Rémi d'Annunzio

Rebecca Tavani

Mohamadou Aw

Food and Agriculture Organization of the United Nations
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Abbreviations

AGB	above ground biomass
BCEF	biomass conversion and expansion factor
BEF	biomass expansion factor
BGB	below ground biomass
circular plots	circular-shaped sample plots
DBH	diameter at breast height
DW	dead wood
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
FCPF	Forest Carbon Partnership Facility
FRA	Global Forest Resources Assessment
FRA 2020	Global Forest Resources Assessment 2020
FREL	Forest Reference Emissions Level
IPCC	Intergovernmental Panel on Climate Change
MRV	measurement, reporting and verification
NFI	national forest inventory
NFMS	National Forest Monitoring System(s)
NTFP	non-timber forest product
PSP	permanent sample plot
REDD+	Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RP	rectangular-shaped sample plots
SEPAL	System for Earth Observation Data Access, Processing and Analysis for Land Monitoring
Sida	Swedish International Development Cooperation Agency
SOM	soil organic matter
SRP	subrectangular plot
SSP	square subplot
TSP	temporary sample plot
UN-REDD Programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNFCCC	United Nations Framework Convention on Climate Change

Units and formulae

cm	centimetre
CO_2	carbon dioxide
DBH	diameter at breast height
ha	hectare
km	kilometre
m	metre
m^2	square metre
r	radius
Vt	tree volume

Executive summary

The assessment of forest data and technical capacities was conducted as part of the five year project "Global Transformation of Forests for People and Climate: a focus on West Africa", which aims to provide quality data to support decision-making and sustainable management of forest and land resources at both national and sub-regional levels. It also seeks to develop processes that could be replicated in other sub-regions within Africa and outside the region. This document is one of the outputs of the project and provides information on existing forest data in the Economic Community of West African States (ECOWAS) countries, critical information gaps on forest condition and land use and land cover dynamics, and capacity development needs.

The forest data assessment (Activity 1.1.1) was primarily a desktop review, compiling and analysing available forest datasets, and a series of online surveys targeted at stakeholders in the subregion. Data for specific variables of interest were collected and coded at the country level to provide a comprehensive assessment of available forest data. The following 14 countries participated in the gap assessment: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, the Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal and Togo. Sierra Leone was included in the assessment, but a lack of country-level data made it impossible to assess the country. Fortunately, Sierra Leone will soon have its own national forest inventory (NFI) and National Forest Monitoring System (NFMS), funded by the European Union delegation in Freetown. The results of the forest data assessment identified the countries with the largest data gaps (Guinea and Niger) and recognized the forest inventory metrics missing from most country datasets (carbon pools).The report provides a number of recommendations to close the identified gaps, including:

1. Most countries have information on forest extent and structure, but spatial and temporal differences make it difficult to combine data at the regional scale. Earth observation data should be used to harmonize forest cover data in the region and to update and improve forest biomass data. Harmonized maps and approaches (biomass models) at the regional level will support the implementation of the Convergence Plan for the Sustainable Management and Utilization of Forest Ecosystems in West Africa, as well as the assessment of the countries' potential contributions to climate change mitigation. While most countries have access to inventory data, only a handful of countries have collected data in the last decade.

2. Emerging forest-related climate finance requires robust measurement, reporting and verification (MRV). Currently, none of the countries included in the gap assessment have conducted more than one inventory in the last 20 years. If countries are to benefit from forest-related climate finance, the region needs accurate, up-to-date forest cover and biomass maps to support reporting. This is particularly true for data-poor countries such as Guinea and Niger.

3. With respect to the carbon pools assessed, most countries do not have access to a comprehensive soil carbon dataset, which is a cause for concern. It is recommended that regional networks be used to establish soil laboratories and inventory methodologies to assist countries in collecting relevant soil data, which will provide invaluable information for emissions assessments, land use planning and successful agricultural adaptation programmes.

4. The ECOWAS countries included in the forest data assessment have access to national-level inventory data, but lack the skills to properly analyse these data, particularly with regard to biodiversity assessments. It is recommended that a capacity development programme be established to assist countries to update the analysis of their inventory data using improved tools and methods. The additional information will be invaluable for forest management planning and will also open up new climate finance opportunities for participating countries.

5. Based on the forest data assessment, there is a strong relationship between countries' participation in international mitigation programmes, such as the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme) and the Forest Carbon Partnership Facility (FCPF) and the availability of high-quality forest data. The importance of country participation in these programmes cannot be overstated.

6. The importance of non-timber forest products (NTFPs) is highlighted in this study and most countries have access to this data. However, the capacity to analyse this information and exploit the important non-carbon benefits associated with NTFPs is lacking and countries would benefit from targeted activities to improve the value chains associated with these products.

The forest data assessment was partnered with a capacity development programme, implemented online due to the global COVID-19 pandemic. The training programme focused on the status of forest inventories in West Africa, forest carbon assessment techniques, allometric equations and data analysis, the Land Cover Classification System (LCCS) and relevant earth observation data sources, and the System for Earth Observation Data Access, Processing and Analysis for Land Monitoring (SEPAL) platform. The initial desktop analysis, the literature review and the online survey to project stakeholders informed the capacity development programme. A post-training online survey measured the efficacy of the capacity development interventions, showing positive results, despite the difficulties of the online format.

Recommendations from the outcomes of the training are as follows:

1. Participants in the training activities are familiar with basic analogue inventory equipment such as diameter at breast height (DBH) tapes and clinometers but are not familiar with advanced electronic measurement devices. Future training activities in the region must focus their attention on digital data collection tools. Capacity to use digital tools will enhance the speed and accuracy of future inventory activities.

2. Participants who took part in the training are familiar with the regular NFI methods and techniques but lack an understanding of the methods relating to carbon assessments. Future inventories and capacity development activities must include components covering the measurement of soils, standing and dead wood (DW) and litter. Future opportunities for climate finance will require these metrics to be computed and reported.

3. Geospatial tools play an important role in the lifecycle of a forest inventory. The project's capacity development interventions spent several sessions introducing relevant tools to the participants. While many had experience with these tools, it is recommended that future capacity development activities should expand upon the work undertaken by this project and provide participants with the opportunity to apply the tools and methods in their own countries using their own data. This is especially relevant in countries where field inventories were last undertaken before the year 2000.

4. Within the context of the Convergence Plan for the Sustainable Management and Utilization of Forest Ecosystems in West Africa, it might be useful for the region to establish regional cooperation agreements, whereby countries with advanced NFIs and NFMS in place mentor and lead other countries that are yet to benefit from the collection of national-level forest statistics.

The report concludes with a review of the importance of forest data for countries wishing to access climate finance and reflects on the positive role that readiness funds associated with both the UN-REDD Programme and the FCPF have on the availability of forest data.

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1. Introduction

Countries with significant forest resources require forest data for multiple evolving purposes at the national and international level, including:

- development of national forest policies;
- decision-making related to the sustainable management of forests and timber, and NTFP production;
- participation in international climate change mitigation programmes;
- reporting to the United Nations Framework Convention on Climate Change (UNFCCC);
- reporting to the Convention on Biodiversity (CBD);
- reporting on sustainable development goals (SDGs), such as SDG 15; and
- reporting to the Global Forest Resources Assessment (FRA 2025).

Typically, these data requirements are provided by an NFMS owned and operated by the relevant government agency. Data from these systems are used to facilitate informed decision-making on the sustainable management of forest resources and to facilitate international reporting requirements. National forest monitoring systems may include MRV functions and aim to produce high quality and reliable data on forests, including forest carbon estimates, which are critical for mitigating the adverse impacts of climate change, including through deforestation and forest degradation (FAO, 2018).

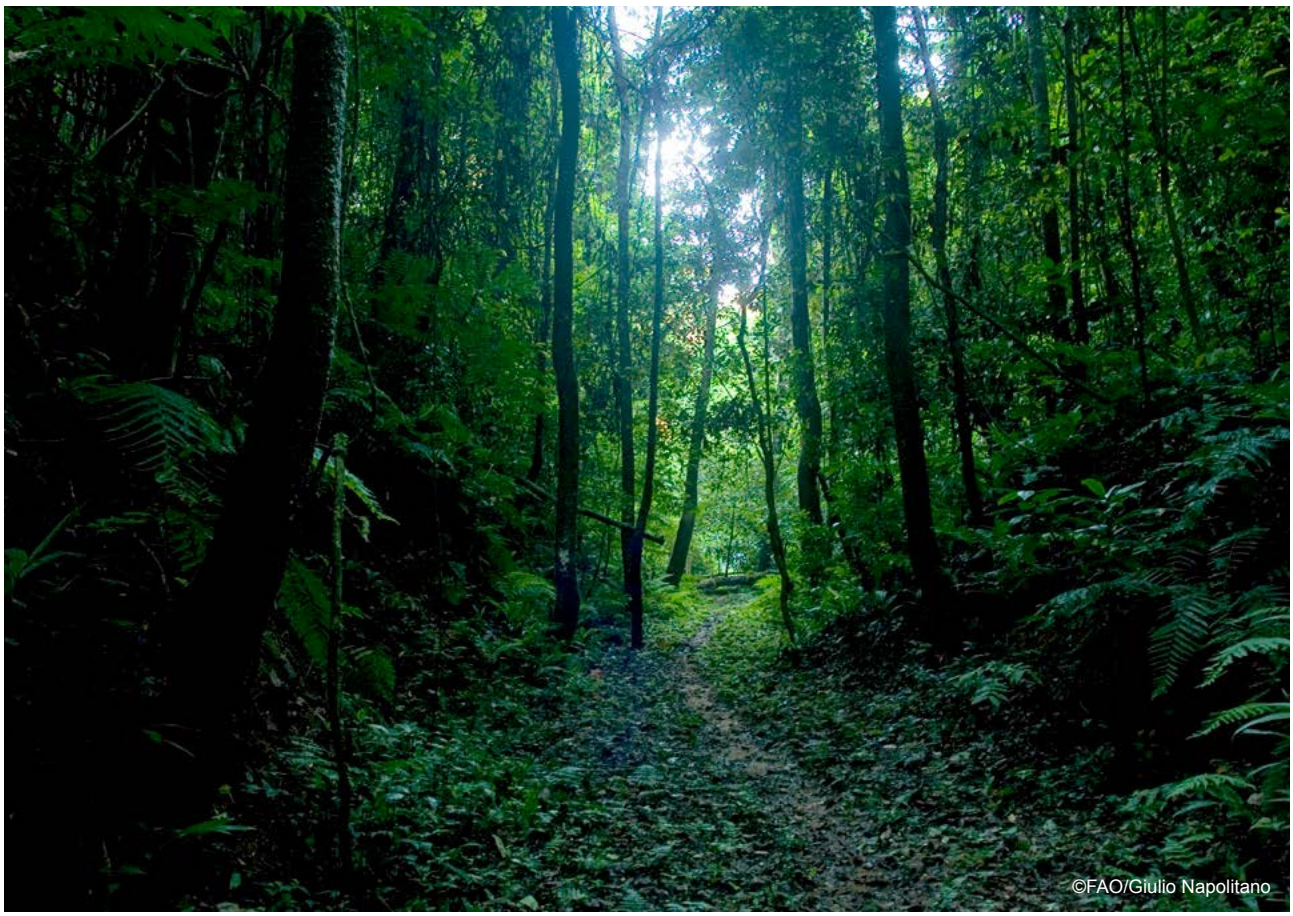
Countries that have opted to participate in the Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) programme and have completed their REDD+ Readiness Plan typically have the framework for an NFMS in place. Operational components of this system include a satellite land monitoring system and an NFI. The NFI provides forest management metrics relevant for monitoring and resource management, as well as additional information on carbon and other ecosystem services. The satellite land monitoring system facilitates the mapping of forest resources and their spatial extent, as well as locations where forest resources are threatened by unsustainable and illegal activities. In addition, using either space-based or airborne active sensors, the satellite land monitoring system can provide structural information on forests which, when combined with appropriate ground-based estimates, can improve regional mapping of climate-relevant resources such as tree biomass and carbon content. National and regional estimates of forest resources are critical for monitoring land use change and associated emissions. Countries with appropriate MRV systems in place are more likely to benefit from emerging climate finance opportunities.

Countries wishing to track and reduce their emissions associated with land use change are encouraged to report emissions to the UNFCCC (Decision 1/CP.16 and Decision 12/CP.17) using a Forest Reference Emission Level (FREL). The requirements for participating in the UN REDD+ programme and potentially benefiting from results-based payments are outlined in the Warsaw Framework for REDD+: an NFMS, together with a technically assessed FREL, are two of the four readiness requirements for participation in the programme. In addition, the NFMS also plays a critical role in the Enhanced Transparency Framework (ETF) for country monitoring and reporting of nationally determined contributions (NDCs) under the Paris Agreement (UNFCCC, 2015).

The Food and Agriculture Organization of the United Nations (FAO) has been assisting member countries to conduct national forest assessments and inventories for 50 years. The Global Forest Resources Assessment (FRA) programme, a flagship initiative led by FAO, enables these results to be reported to the international community. The latest FRA assessment was published in 2020 and represents a comprehensive collection of information on forest resources (FAO, 2020). While the FRA has been an ongoing initiative since 1948, FAO has recently developed new tools and methods to help countries generate high-quality forest data, including a suite of free, open-source forest monitoring tools and web portals to improve the accessibility and transparency of forest data. However, many countries still lack high-quality, up-to-date forest data, and some have never undertaken an NFI due to financial and technical constraints. Increasing national and international reporting requirements make the need for robust and accurate NFI data critical.

In line with the Convergence Plan for the Sustainable Management and Utilization of Forest Ecosystems in West Africa, countries have been consolidating their forest monitoring and management efforts, using collaborative activities and South–South cooperation to benefit from shared monitoring experiences. The Regional Action Plan for Collaboration on Forest Monitoring in West Africa provides for the strengthening of institutions for regional collaboration on forest monitoring, joint capacity building and research, harmonization of protocols and methodologies, exchange of data and analysis of data at the regional level.

The ongoing Sida-funded FAO–ECOWAS project, Global transformation of forests for people and climate: a focus on West Africa, is supporting the regional action plan, which was first launched in 2013, in particular through Focus Area 1: Knowledge of forest status and dynamics, including the development of a West African knowledge portal for forest resources monitoring. As a result of project Activity 1.1.1, Compilation and assessment of available data on forest and associated biodiversity status and dynamics in West Africa, this report describes existing forest data and data gaps in the region and capacity development needs, as well as the methodology used to conduct the assessment.



2. Methodology

The forest data assessment was undertaken as a desktop literature review, initially drawing on information produced by a nine-country assessment undertaken as part of the UN-REDD Programme in 2017. This report was revisited and updated with information from six additional countries making up the savannah component of West Africa. The assessment focused on the skills required for planning and implementing a forest inventory, including the post-inventory data processing and the geospatial analysis required to support forest management activities. In addition, a web-based survey was used to ascertain the general level of competence associated with these skills prior to the development of an online capacity development intervention undertaken in 2020. Following the completion of the webinar series, the same survey was readministered as a means of assessing the efficacy of the training interventions.

The data needs assessment used multiple criteria obtained from several variables estimated from inventory data (see Table 1). For each variable, a coding system was established and used for ranking the criteria assessed. The variables considered included year of inventory, type of inventory, method of above ground biomass (AGB) estimation, methods of dead wood (DW) biomass estimation, methods of litter and soil organic matter (SOM), information on major commercial species, information on NTFPs, and biodiversity indices.

Table 1. Gap assessment variables and codes

Inventory criteria	Code	Explanation
Year of inventory	1	More than 20 years
	2	More than 10 years
	3	Within the last 10 years
Type of inventory	1	Subregional
	2	National
AGB methods	1	Tier 1 IPCC methods
	2	Tier 2 IPCC methods
Dead wood methods	0	No dead wood estimation
	1	IPCC default value used
	2	Inventory-based estimates
Stump biomass	0	No inventory data
	1	Inventory data available
Litter biomass	0	No inventory data
	1	IPCC default value used
	2	Inventory data available
Soil organic matter	0	No inventory data
	1	Inventory data available
Allometric equations	0	Pantropical equations
	1	Country-specific equations
Wood density	0	Regional density estimates
	1	Species-specific estimates
Commercial species	0	No information reported
	1	Reported in FRA 2020
NTFPs	0	No information reported
	1	Reported in FRA 2020
Biodiversity indices	0	No indices available
	1	Indices available

Notes: Table created by Global Transformation of Forests for People and Climate: a Focus on West Africa. IPCC refers to the Intergovernmental Panel on Climate Change. FRA 2020 refers to Global Forest Resources Assessment 2020.

Source: Authors' elaboration.

3. Forest data gap assessment

The results of the gap assessment are presented in this section, along with three additional criteria that were assessed but not included in the final assessment (below ground biomass [BGB], permanent sample plots [PSPs], and shape of sample plots). A brief overview of the results of the assessment then follow with a discussion on the general trends and reasons for the trends, as well as recommendations to improve the overall quality and extent of forest inventory data in West Africa.

Method of above ground biomass estimation

Above ground biomass from standing live trees is an important component of forest biomass from which forest carbon stocks are derived. This study indicated that inventories from all countries provide information on AGB estimates. However, six countries used biomass conversion and expansion factors (BCEFs) to convert volume estimates to biomass, also known as Tier 1 IPCC default methods (Benin, Burkina Faso, Cabo Verde, Guinea and Niger) (IPCC refers to the Intergovernmental Panel on Climate Change). Nine countries used inventory data and allometric equations which were mostly pantropical equations to derive biomass estimates (Côte d'Ivoire, the Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal and Togo).

Year of inventory

Of the 14 assessed countries, 3 have not had an inventory in the past 20 years (Benin, Guinea and Niger), while 9 have had national inventories within the past 9 years (Burkina Faso, Cabo Verde, Côte d'Ivoire, Ghana, Guinea-Bissau, Liberia, Mali, Nigeria and Togo). The more recent inventories have been supported through climate finance (REDD+ programmes) while a few received support through bilateral agreements. The Gambia and Senegal had their last inventories between 10 and 20 years ago.

Scope of inventory

All countries assessed have had at least one forest inventory. While 4 countries have had subnational inventories (Benin, Guinea, Niger and Nigeria [2015]), 11 have had at least one NFI in the past 20 years (Burkina Faso, Cabo Verde, Côte d'Ivoire, the Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal and Togo). None of the countries assessed have undertaken more than one inventory in the past 20 years.

Method of dead wood estimation

Conventional inventories do not generally consider dead wood (DW), however, standing and lying DW biomass estimations have become an important biomass pool for purposes of carbon accounting or quantification of carbon sequestration. This assessment found that inventories from five countries do not provide information on DW biomass (Cabo Verde, the Gambia, Guinea, Mali and Niger), while the rest provided estimates of DW biomass using inventory data (Burkina Faso, Côte d'Ivoire, Ghana, Guinea-Bissau, Liberia, Nigeria, Senegal and Togo). Benin used IPCC default values for DW. Countries that estimate DW are those that have undertaken inventories recently (after 2010); most of these estimates were made during the implementation of projects related to REDD+.

Stump biomass estimation

Stumps left after forest clearing contain a non-negligible amount of forest biomass (especially on large buttressed trees in tropical forests), and need to be included in carbon accounting. Only four countries assessed stump biomass during forest inventories (Côte d'Ivoire, Ghana, Liberia and Nigeria). These are mostly recent inventories (less than ten years old) that were focused on supporting the development of emissions factors for climate finance purposes. Inventories from 11 countries did not have information on stump biomass estimates (Benin, Burkina Faso, Cabo Verde, the Gambia, Guinea, Guinea-Bissau, Mali, Niger, Senegal and Togo).

Litter biomass estimation

Litter biomass is usually minimal compared to the other aforementioned carbon pools but could be significant in some ecosystems such as mangroves and peatlands, as well as casuarina plantations along the coastlines. Other areas include cool montane biomes where slow litter decomposition results in potentially significant litter accumulation. In this assessment, six countries have no information on litter biomass (Cabo Verde, the Gambia, Guinea, Niger and Togo), while five countries made use of default values (Benin, Burkina Faso, Guinea-Bissau, Mali and Senegal), and only four countries have reported information on litter biomass (Côte d'Ivoire, Ghana, Liberia and Nigeria). The latter countries with NFI-based litter information are also those that have submitted FREL reports to the UNFCCC, which may require the estimation of litter biomass.

Soil organic carbon matter

Very often, countries may not be able to undertake soil sampling during forest inventories, so estimates of SOM are derived from independent studies or default IPCC values. This assessment observed that nine countries do not have estimates for SOM (Burkina Faso, Cabo Verde, Côte d'Ivoire, the Gambia, Guinea, Liberia, Niger, Nigeria, Senegal and Togo), while only four countries provided information on soil organic carbon (Benin, Cabo Verde, Guinea-Bissau and Mali).

Existence of country-specific allometric equations

Allometric equations are used to convert field inventory data into forest biomass. Typically they are expensive to develop and require elevated capacities, which are not always available to West African countries. In most cases a pantropical equation is used in place of country or species-specific allometric equations. Alternatively, a regional allometric equation may be available for use. This review found that nine countries have used species-specific allometric equations for tree species of interest (Benin, Burkina Faso, the Gambia, Ghana, Mali, Niger, Nigeria and Senegal), while seven countries have not made use of country-specific allometric equations (Cabo Verde, Côte d'Ivoire, Guinea, Guinea-Bissau, Liberia and Togo).

Species-specific wood density estimates

Wood density is an important variable in allometric equations typically used when converting tree volume to biomass. This assessment observed that nine countries have species-specific wood density estimates for tree species (Benin, Burkina Faso, the Gambia, Ghana, Liberia, Mali, Niger, Nigeria and Senegal), while five countries make use of regional or default values (Cabo Verde, Côte d'Ivoire, Guinea, Guinea-Bissau and Togo).

Timber production potential

For commercial purposes, knowledge of timber volumes and value for commercial species of interest is important. The information obtained from Global Forest Resources Assessment 2020 (FAO, 2020) reports indicates that 11 countries from West Africa (Benin, Burkina Faso, Cabo Verde, the Gambia, Ghana, Guinea-Bissau, Mali, Niger, Nigeria, Senegal and Togo) provided information on volumes of the ten main commercial species, while 3 countries did not (Côte d'Ivoire, Guinea and Liberia).

Non-timber forest products

There has been increasing interest in the role and value of NTFPs, especially by local forest-dependent communities. Information reviewed, mostly from the FRA 2020 reports, indicated that 11 countries have information on NTFPs and their uses (Benin, Burkina Faso, Côte d'Ivoire, the Gambia, Guinea, Liberia, Mali, Niger, Nigeria, Senegal and Togo), while 3 countries did not (Cabo Verde, Ghana and Guinea-Bissau).

Biodiversity indicators

Biodiversity indices (i.e. species biodiversity indices, relative abundance) are important for reporting to the CBD and as indicators of ecosystem potential in terms of diversity. Only five countries reported on diversity indices (Benin, Burkina Faso, the Gambia, Nigeria and Liberia), while nine countries did not (Cabo Verde, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Senegal and Togo).

Below ground biomass

Below ground biomass estimation is difficult and expensive to determine, so most countries resort to the use of ratios between BGB and AGB (root–shoot ratios), based on AGB estimates, according to recommendations by the IPCC.

Existence of permanent sample plots

Almost all countries have, at one point in time, established PSPs to study forest stand dynamics (species growth rates, mortality, recruitment, etc.). However, most of the plots have never been revisited or remeasured for monitoring purposes. Many of them have been entirely abandoned or cannot currently be located.

Shape of sample plots

Circular and rectangular, simple and nested plots were identified, with circular-shaped sample plots (circular plots) predominant in all savannah countries (Burkina Faso, Mali, Niger and Senegal), as well as in the Upper Guinean forest countries (Guinea, Guinea-Bissau and Liberia), as well as in the Dahomey Gap (Benin and Togo). Only Côte d'Ivoire, Ghana and Nigeria used square-shaped sample plots and/or rectangular-shaped sample plots (RPs). While circular plots have an advantage over plots that are square or rectangular, in that they may have fewer border trees for the same plot area, they can be difficult to establish in tropical dense forests with thick undergrowth and on steep slopes.

Country-level assessment on forest data

Table 2 provides a tabular breakdown of the rankings of countries included in the desktop forest data gap assessment. Results from the individual criteria are also included in the table with colour-coding used to highlight results. In addition to the criteria and the total score for each participating country, the table includes two extra columns documenting participation in the UN-REDD Programme and the FCPF, as well as the submission of a reference level to the UNFCCC. The additional two columns were included to provide insight on the role of international initiatives such as REDD+ on the quality of NFI data available in the assessed countries. The table is sorted according to the final score of the assessment, with countries with lower values and less reliable NFI data listed at the top of the table, while those countries with more recent assessments and more reliable data listed at the bottom. Each country had the possibility of scoring a total of 18 points.

Table 2. Gap assessment summary

Country	Year of inventory	NFI	ABG	DW	Stump	Litter	SOM	Allometric equations	Wood density	Timber	NTFPs	Biodiversity indices	REDD+ programme	FREL submission	Total score
Sierra Leone	Data not available at time of publication												–	No	–
Guinea	3	1	1	0	0	0	0	0	0	0	1	0	UN-REDD	No	6
Cabo Verde	3	2	1	0	0	0	1	0	0	1	0	0	–	No	8
Niger	1	1	1	1	0	0	0	1	1	1	1	1	–	No	9
Togo	3	1	1	2	0	0	0	0	0	1	1	0	FCPF, UN-REDD	Yes	9
Gambia	2	2	2	0	0	0	0	1	0	1	1	1	–	No	10
Mali	3	2	2	0	0	1	1	1	0	1	1	0	–	No	12
Guinea-Bissau	3	2	2	2	0	1	1	0	1	1	0	0	UN-REDD	Yes	13
Senegal	2	2	2	2	0	1	0	1	1	1	1	0	UN-REDD	Yes	13
Burkina Faso	3	2	1	2	0	1	0	1	1	1	1	1	FCPF	Yes	14
Côte d'Ivoire	3	2	2	2	1	2	0	0	0	1	0	1	FCPF, UN-REDD	Yes	14
Benin	3	2	1	1	1	1	1	1	1	1	1	1	UN-REDD	No	15
Ghana	3	2	2	2	1	2	0	1	1	1	0	0	FCPF, UN-REDD	Yes	15
Liberia	3	2	2	2	1	2	0	0	1	1	1	1	FCPF	Yes	16
Nigeria	3	2	2	2	1	2	0	1	1	1	1	1	FCPF, UN-REDD	Yes	17

Notes: Table created by Global transformation of forests for people and climate: a focus on West Africa. The countries in the table are ranked according to the assessment results, with the lowest score at the top and the highest score at the bottom.

Source: Authors' elaboration using data and capacity needs assessment.

Forest data gap assessment: results and recommendations

All countries included in the assessment have completed at least one regional, national forest survey in the past 20 years, indicating that all countries have PSPs that can be revisited in the future and that basic information on forest extent, as well as standard inventory metrics, are available. This is an overall positive result from the assessment and bodes well for climate activities related to mitigation and adaptation. However, none of the countries assessed have undertaken more than one inventory in the past 20 years and the approach to quantifying biomass is still inconsistent within the region. This is a concern as the role of forests in mitigating future climate change is being encouraged by the international community and ongoing monitoring activities are key to measuring the impacts of policies and measures associated with mitigation activities. In addition, forests have the potential to act as natural buffers against changing climatic conditions, and also protect communities and reduce their vulnerability to floods, droughts, and other weather-induced crises. A sound knowledge of the extent and the general structure of the forests is key to planning climate adaptation strategies.

Moving towards requirements that are more specific, it is evident that many of the countries in West Africa do not have the necessary information to take part in international climate finance initiatives. While biomass data is available, the age of this data and the methods used to generate the information result in inconsistent results throughout the region. This is especially true for carbon pools such as DW, litter and SOM. Few, if any, countries have comprehensive data on these pools and therefore stand to lose out on international finance opportunities associated with emissions reductions and removals. Knowledge of all carbon pools, as well as the fluxes they contribute to, is key to planning and implementing a successful country-level climate mitigation programme. A significant data gap is associated with SOM where only a handful of countries have comprehensive information on soil characteristics. While it is well known that the soil carbon pool can have significant impact on emissions, detailed information on the characteristics of soils provides invaluable information for land-use planning and ultimately for successful agricultural adaptation programmes. The lack of provision for continuous monitoring is also having a negative impact on access to climate finance.

As indicated, most countries have undertaken some sort of forest inventory activity since the turn of the century, and many countries in West Africa have benefited from the technical and methodological developments associated with undertaking an inventory of forest resources. Two areas where the industry has seen significant improvement is the development of species-specific allometric equations and wood density estimations.[1] These international developments are reflected in several countries' past work, with almost 50 percent of participating countries using some form of species-specific allometric equations; the rest make use of regional or pantropical tools. There is now an opportunity to harmonize the approaches to biomass estimation, making use of both regional and pantropical models, in association with state-of-the-art earth observation data. Should this opportunity be exploited, it would be useful to develop models for all regions in West Africa, including arid regions, semi-arid regions and sub-humid regions.

All countries participating in the gap assessment have reported forest-related information to the FRA published in 2020 (FAO, 2020). More than 90 percent of countries assessed have reported information on the value and volume of commercial timber species available, with only Guinea not providing this information as they lack the necessary data to undertake basic reporting on forest resources and their extent. Several countries do however report on the presence of NTFPs. The role of NTFPs in the lives of local communities is well known and the prevalence of this type of information in West Africa indicates that most countries are in a position to leverage non-carbon benefits.

The final criteria included in the assessment was the presence of biodiversity information. Less than 50 percent of countries taking part in the assessment have reported information on forest biodiversity. The lack of reporting is related to a skills shortage as opposed to a lack of actual data. Typically, forest biodiversity metrics are derived from the tree species recorded in the inventory and therefore this information should be available for most countries. However, implementing an assessment that analyses the diversity found in West African forests appears to be challenging, as only 6 of the 15 ECOWAS countries have reported this type of information. In addition, the lack of continuous monitoring highlighted earlier also has a negative impact on countries' abilities to report changes in biodiversity, which is crucial for understanding and managing forest health and sustainability.

1 For more information, see www.globallometree.org/about

In an attempt to contextualize the results from the gap assessment, two additional criteria were included, relating to participation in either the UN-REDD or FCPF programme, and the submission of a FREL to the UNFCCC. Participation in either programme does not necessarily guarantee the availability of suitable NFI data: Guinea and Togo are UN-REDD and FCPF countries, but both show significant data gaps, despite Togo submitting a reference level to the UNFCCC in 2020. It is however evident that countries that do not take part in either programme have significant data gaps and are less likely to submit a reference level to the UNFCCC, as is the case with Cabo Verde, the Gambia, Mali, and Niger. All these countries have significant data gaps and do not take part in either of the international initiatives designed to support the mitigation of climate change through a reduction in emissions from land-use change. Understanding their absence from these initiatives is beyond the scope of this assessment.

Specific recommendations emerging from this gap assessment include:

1. While most countries have information on forest extent and structure, the spatial and temporal differences make it difficult to combine these datasets at the regional scale. It is recommended that earth observation tools be employed to harmonize current field inventory data to produce a regional forest cover map including, if possible, additional information on structure and biomass. A harmonized forest cover map developed using country-level data will assist with the implementation of the Convergence Plan for the Sustainable Management and Utilization of Forest Ecosystems in West Africa, and will also assist countries such as Cabo Verde, the Gambia, Mali and Niger to understand their potential role in climate mitigation and potentially access climate finance. A harmonized approach to quantifying biomass will also help countries avoid the use of Tier 1 IPCC approaches to biomass estimation.

2. Following the recommendation above, the lack of continuous monitoring in the region will continue to hamper countries, especially those that have not undertaken a forest inventory in the last five to ten years, to access climate finance. Countries, which are data deficient (Guinea, Niger), would benefit from access to accurate timely forest cover and biomass maps developed and validated using regional inventory datasets. In addition, methods to undertake and update forest cover maps and regional biomass assessments will aid all countries in the region to support their own MRV activities.

3. The lack of comprehensive soil data for countries in the region is a cause for concern. As indicated, the soil carbon pool makes a significant contribution to carbon fluxes and should be included in all emissions-related reporting. This gap should be addressed through a regional soil inventory programme targeting the development of inventory capacities as well as establishing a network of soil laboratories facilitated through the FAO-led Global Soil Partnership.

4. Many of the ECOWAS countries included in this assessment have data from at least one forest inventory and as such have the opportunity to derive relevant biodiversity metrics, provided they have access to the analysis tools and methodologies. The same can be said for the use of species-specific allometric equations and wood density estimates. It is recommended that a capacity development programme be established to support countries to update the analysis of their inventory data using improved tools and methods. The additional information will be invaluable for forest management planning purposes and will also present new climate finance opportunities to participating countries.

5. Significant data gaps were identified in the DW and litter pools, both of which have the potential to improve a countries access to climate finance. Unfortunately, many countries are not in a position to implement a new inventory and as such should seek to use the IPCC defaults available for their reporting purposes. Once again, a capacity development programme targeting countries with significant data gaps should be established to support countries to make use of these default values and to help plan future inventories including these key categories.

4. Capacity needs assessment

Focus area 1 of the Sida-funded project also included capacity development activities aimed at improving participants' knowledge of and capacity to make use of relevant NFI tools. The forest data assessment discussed above provided a base on which to plan the overall structure of the capacity development interventions. The capacity development needs were further identified through an additional Google Forms survey targeted to the stakeholders in the region that sought to clarify:

1. the availability of field enumeration equipment and the ability to use the equipment;
2. the knowledge and capacity to undertake field inventory activities; and
3. the knowledge and capacity to use available geospatial tools to support forest inventory activities.

The survey results informed the content of the training webinars and were useful to establish a pre-evaluation of capacities. The same survey was readministered following the completion of the webinars and the results provided a reasonably objective assessment of impact.

The initial plan was to undertake face-to-face technical training workshops; however, with the COVID-19 pandemic lockdowns and travel bans, the project opted for an online approach. Between October and November 2020, the project hosted a series of 19 webinars in both English and French. Table 3 provides an overview of the sessions held, as well as the gender demographics of attendees.

Table 3. Webinar events

Session	Language	Date	Male (%)	Female (%)	Total
Introduction to the Global Transformation Project & Focus Area 1 (CBIT E-Learning)	English	15 October 2020	88 (75%)	29 (25%)	117
	French	15 October 2020	109 (89%)	13 (11%)	122
Analysis of the status of existing forest inventory data in West Africa	English	19 October 2020	97 (87%)	15 (13%)	112
	French	20 October 2020	51 (66%)	26 (34%)	77
Forest carbon assessment techniques – carbon pools	English	22–23 October 2020	124 (89%)	16 (11%)	140
	French	26–27 October 2020	48 (69%)	22 (31%)	70
Allometric equations and NFI data analysis	English	2 November 2020	95 (87%)	14 (13%)	109
	French	3 November 2020	51 (67%)	25 (33%)	76
FAO Land Cover Classification System (LCCS/LCML)	English	9 November 2020	90 (83%)	19 (17%)	109
	French	10 November 2020	47 (66%)	24 (34%)	71
Open Foris Collect Earth & NICFI Planet data	English	16 November 2020	90 (86%)	15 (14%)	105
	French	17 November 2020	42 (65%)	23 (35%)	65
Introduction to SEPAL (Day 1)	English	23 November 2020	77 (81%)	18 (19%)	95
	French	24 November 2020	79 (81%)	19 (19%)	98
Introduction to SEPAL (Day 2)	English	26 November 2020	32 (70%)	14 (30%)	46
	French	27 November 2020	33 (66%)	17 (34%)	50
Field Data Collection Tools (Collect, Collect Mobile, Calc & Arena)	English, French	30 November 2020	91 (81%)	22 (19%)	113

Notes: Table created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration using data from online surveys and webinars.

National forest inventory equipment

The first section of the online survey covered the availability of NFI field equipment to support field inventory activities. Table 4 provides an overview of the availability of NFI equipment; more than 400 technical staff in the region responded to the survey. Results indicate that while basic equipment such the Global Positioning System (GPS), diameter tape, and compasses are available to more than half of the respondents, more advanced equipment, such as a Vertex Hypsometer, Rangefinder and digital clinometer, are only available to a few (less than 20 percent). Overall, there is a lack of availability of digital equipment in the region, which is surprising, as 9 of the 15 countries assessed have undertaken an inventory in the past ten years. It would appear that most of these inventories made use of analogue instruments for data collection, which does not mean that the data are of poor quality; rather, it speaks to the efficiency of the inventories undertaken. Upgrading field measurement tools to digital equipment, paired with digital data collection devices, such as tablets, would enhance the efficiency of data collection activities.

Table 4. Availability of national forest inventory equipment

Equipment	Not available	Available
Vertex	90%	10%
Criterion RD1000	89%	11%
True pulse rangefinder	88%	12%
Bitterlich relascope	88%	12%
Blume leiss	87%	13%
Densitometer	85%	15%
Vernier caliper	84%	16%
Increment borer	83%	17%
Haglof digital clinometer	79%	21%
Soil sampling gauges	77%	23%
Suunto clinometer	65%	35%
Forest calipers	55%	45%
Compass	42%	58%
Diameter tapes	36%	64%
GPS navigation	16%	84%

Notes: Table created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration using data from online surveys and webinars.

National forest inventory field equipment: pre-training and post-training evaluation

Session 2 and Session 3 of the capacity development activities covered the equipment required for undertaking forest inventories as well as the general use of this equipment. Typically, equipment training is undertaken with participants actually testing the equipment in a controlled environment. Unfortunately, due to the COVID-19 pandemic the training on this equipment was undertaken virtually. The pre-training and post-training survey undertaken by the project sought to develop a baseline of competence, which informed the content of the training activities. The same survey completed after the capacity development activities provided insights into the effectiveness of the training. Table 5 presents the results for the NFI field equipment component of the training. Mirroring the results seen in the availability of NFI equipment, there is a discrepancy between digital and analogue equipment with the latter being more accessible to participants. Knowledge on the use of the equipment prior to the training indicated that participants were familiar with and have experience using diameter tapes, calipers and analogue clinometers. The knowledge and experience using more advanced and expensive equipment was much less.

Table 5. Pre-training and post-training evaluation of equipment capacities

	Pre-training evaluation				Post-training evaluation			
Equipment	**Novice**	**Beginner**	**Intermediate**	**Expert**	**No improvement**	**Some improvement**	**Moderate improvement**	**Significant improvement**
Diameter tapes	15%	13%	34%	38%	14%	2%	36%	48%
Caliper	21%	18%	30%	31%	16%	2%	37%	45%
Suunto clinometer	40%	16%	28%	16%	16%	9%	37%	37%
Haglof digital clinometer	63%	15%	17%	6%	6%	11%	46%	21%
TruePulse rangefinder	63%	17%	13%	7%	7%	12%	48%	18%
Criterion RD1000	71%	15%	9%	5%	5%	11%	48%	13%
Vertex	69%	18%	10%	3%	3%	13%	51%	10%
Increment borer	58%	16%	17%	9%	9%	12%	43%	19%
Soil sampling gauges	49%	22%	21%	8%	8%	13%	48%	23%

Notes: Table created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration using data from online surveys and webinars.

Following the completion of the online training associated with the use of NFI equipment, there was a significant improvement in participants' knowledge of and understanding of each of the tools discussed. There was once again a discrepancy between the analogue and digital tools, with the improvement associated with the analogue tools significantly higher compared to the digital tools. This finding is expected as the training events were held in a virtual format where the practical application of the tools may have been challenging, especially when it comes to tools that are rarely used in the region. Participants who demonstrated "expert knowledge" are mostly those that had at least attended a face-to-face field training on the use of these digital instruments, or have participated in inventories involving the use of this equipment.

National forest inventory field enumeration: pre-training and post-training evaluation

The enumeration of forest resources and the methods used for the enumeration are by far the most important information collected by field teams. The online survey focused on the tree-level enumeration activities and did not cover any of the navigation skills, species identification and forest assessment activities typically included in an integrated forest survey. For national forest carbon inventories, the important measurements include: tree DBH, tree height measurements, measurement of standing and lying DW, use of the "machete test" for DW categorization, measurement of tree stumps, litter, soil sampling, and increment core extraction for wood density determination. Table 6 provides a summary of the pre-training and post-training evaluation; results indicate that more than two-thirds of respondents rated themselves as intermediate or expert for basic enumeration activities. Responses associated with non-traditional methods such as the measurement of standing and lying DW, tree stumps, the "machete test" for DW categorization, and other non-traditional enumeration techniques were dominated by "no experience", "beginner" or "intermediate" level. These responses reflect the novelty of forest carbon assessment, which most foresters are yet to acquire skills on, and confirms findings in the NFI data review summarized in the previous section.

Table 6. Pre-training and post-training evaluation of field inventory expertise

	Pre-training evaluation				Post-training evaluation			
Enumeration techniques	**No experience**	**Beginner**	**Intermediate**	**Expert**	**No improvement**	**Some improvement**	**Moderate improvement**	**Significant improvement**
Tree diameter measurements	8.6%	16.1%	26.9%	48.4%	1.1%	11.0%	27.5%	60.4%
Tree height measurements	11.4%	18.3%	31.6%	38.7%	1.1%	11.1%	31.1%	56.7%
Standing DW	30.9%	20.4%	25.2%	23.5%	5.6%	12.2%	34.4%	47.8%
Lying DW	30.6%	20.4%	26.6%	22.5%	6.7%	12.2%	36.7%	44.4%
Machete test	56.6%	17.4%	15.7%	10.2%	10.3%	16.1%	40.2%	33.3%
Stump measurement	36.3%	23.0%	21.4%	19.3%	4.5%	20.2%	43.8%	31.5%
Litter	44.4%	24.0%	19.9%	11.7%	5.6%	16.9%	49.4%	28.1%
SOM	34.7%	31.1%	22.8%	11.4%	3.4%	18.0%	53.9%	24.7%
Timber core extraction	47.3%	23.3%	19.0%	10.4%	4.5%	18.2%	51.1%	26.1%

Notes: Table created by by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration using data from online surveys and webinars.

Following the completion of Session 3 of the webinar series, participants showed a significant improvement in their self-assessed knowledge and capacity to undertake in-field measurements of forest resources. While demonstrating positive impacts in the virtual training, there is still a need for improvement through face-to-face training, given that less than 50 percent of respondents fall in the "expert knowledge" category.

Open-source geospatial tools: pre-training and post-training evaluation

Geospatial tools play an important role in the life cycle of an NFI. From selecting statistically suitable locations for the establishment of PSPs, to locating those sampling locations in the field and onto creating maps of relevant metrics collected in the field, geospatial tools are as important to an inventory as a diameter tape or a clinometer. Over the years, FAO has recognized the important role these tools play in the enumeration of forest resources and in the management of the data collected as part of NFIs. In response to the specific needs of countries, FAO has developed a suite of geospatial tools under the Open Foris programme. All tools are free to use and have been made available as open-source applications. Over the years, a number of training events have taken place throughout the developing world and this project took the opportunity to revisit some of the basics and introduce participants to new developments and applications.

Prior to session, five to eight of the participants (less than 20 percent) rated themselves at the intermediate or expert level. Following the end of the geospatial tools webinars, which covered a number of relevant topics, such as the Land Cover Classification System Version 3 and Land Cover Metadata Language (LCCSv3/LCML), Google Earth Engine (GEE), Open Foris Collect Earth, and Collect Earth Online (CEO), participants self-reported an increase in their knowledge and capacity on the subject. The seminars also included a detailed introduction to SEPAL, a cloud-based image processing and analysis platform, which seeks to democratize access to and analysis of earth observation data. The webinar sessions covered the majority of the tools available to participants; in general, they self-reported an increased understanding and application of the tools.

Table 7. Pre-training and post-training evaluation of geospatial tools

	Pre-training evaluation				Post-training evaluation		
Geospatial tools	**No experience**	**Beginner**	**Intermediate**	**Expert**	**Beginner**	**Intermediate**	**Expert**
LCCS.v3/LCML	70%	16%	12%	2%	52%	41%	7%
Google Earth Engine	15%	30%	39%	17%	40%	47%	12%
Collect Earth	57%	19%	19%	5%	41%	38%	21%
Collect Earth Online	70%	16%	12%	2%	45%	42%	14%
SEPAL	78%	13%	8%	1%	52%	39%	10%
SEPAL – Mosaic Production	58%	21%	13%	8%	44%	39%	20%
SEPAL – Land Cover Classification	46%	25%	19%	10%	45%	38%	17%
SEPAL – Change Detection	52%	23%	17%	8%	50%	35%	15%
SEPAL – Stratified Area Estimation	54%	25%	15%	6%	49%	39%	12%
SEPAL – Accuracy Assessment	60%	21%	14%	6%	53%	36%	12%
SEPAL – RStudio	47%	34%	16%	3%	61%	32%	7%
SEPAL – SAR Toolkit	n.a.	n.a.	n.a.	n.a.	68%	30%	3%
SEPAL – BFAST	n.a.	n.a.	n.a.	n.a.	69%	26%	5%
Open Foris Collect	n.a.	n.a.	n.a.	n.a.	46%	43%	11%
Open Foris Collect Mobile	n.a.	n.a.	n.a.	n.a.	54%	38%	9%
Open Foris Calc	n.a.	n.a.	n.a.	n.a.	65%	28%	8%
Saiku	n.a.	n.a.	n.a.	n.a.	66%	29%	6%

Notes: Table created by Global transformation of forests for people and climate: a focus on West Africa. "n.a." refers to "not applicable".

Source: Authors' elaboration using data from online surveys and webinars.

Recommendations

The capacity development webinar series reported in this document presents a number of interesting outcomes and recommendations. Overall, the series can be considered a success as participation in the webinars was consistent throughout the two-month activity with little drop-off in the English and French cohorts. Surprisingly, despite West Africa having more French-speaking countries, anglophone attendance was higher compared to the francophone events. The results from the assessments should also be seen within the context of the global COVID-19 pandemic. The training component of the project was planned to be a regular, in-person training event with ample opportunity for explanation and physical access to the tools, but the public health situation relegated the training events to an online modality, which is less than ideal. As such, many of the recommendations following the training reflected the type of training undertaken.

1. Equipment

Approaches to NFI have not changed much in the past 20 years; however, the tools used to facilitate these inventories continue to evolve. The move to digital data collection tools is ongoing, and results from the training evaluations indicate that West African countries are perhaps lagging behind in both the availability and use of state-of-the-art enumeration tools. Future inventories supported by regional and international donors should prioritize digital tools over analogue instruments.

2. National forest inventory training

Updated tools require updated methods and training. The capacity development interventions, as well as the NFI assessment reported above, highlight the lack of capacity relating to inventory tools and methods. While this project has sought to capacitate country participants, the modality severely limited the significant impact planned. While this is unfortunately unavoidable, the project has identified key areas that require additional training in the future and which should be implemented as part of an ongoing forest inventory activity. The country NFI assessment has identified those countries that lack a suitable dataset to use for reporting purposes and also presents a record of which countries will require updated assessments in the near future. National and regional capacity development activities in the near future should target capacity development events that address the lack of knowledge and capacity concerning carbon-focused inventories.

3. Geospatial tools

Geospatial tools are the cornerstone of any NFI. From planning and data collection to the cleaning and analysis of inventory data, maps and geospatial analyses guide the process and ease the collection of accurate and replicable results. The project sought to introduce participants to the suite of geospatial tools developed by FAO and its partners. While some participants had experience with some of these tools, most were unfamiliar with the advanced earth observation analysis tools and data types. A key recommendation from the activity is to maintain the development activities at a regional level. Countries who choose to pursue a national inventory activity in the near future could prioritize geospatial tools and analyses in their capacity development as part of the preparations for the inventory.

5. Conclusion: data needs and capacities

The data needs and capacity assessment were undertaken using a desktop literature review along with online consultations, surveys and a series of webinar training events. The approach had to be altered as the global public health situation made travel to regional and local events impossible. All events and activities undertaken in support of the needs and capacity assessment were virtual. Participation in the virtual events was consistent throughout the two-month period for both the English and French webinars.

Concerning data needs and recommendations, most countries in the region have undertaken an inventory in the past ten years, with only a handful of countries not having access to national forest statistics. These countries have been identified in the report, and should a regional or international donor be available to support data collection activities, they should be prioritized. None of the countries assessed during the study have undertaken more than one NFI in the past 20 years. This is a concern and is typically the result of a lack of funds within the country to support such an activity. Climate finance through the REDD+ programme or some other mitigation funding mechanism represents a realistic opportunity to fund new and ongoing data collection activities in the ECOWAS region. Those countries whose inventory activities were supported through the UN-REDD Programme or FCPF are best placed to receive additional funds through results-based payment mechanisms or forward purchase agreements for emissions reductions.

These funds should be used to facilitate ongoing forest monitoring as well as additional forest-related livelihood activities focused on poverty alleviation and development. Countries that have not undertaken an inventory in the past 20 years must be prioritized for training and support with an emphasis on digital data collection tools and methods focused on carbon assessments. Within the context of the Convergence Plan for the Sustainable Management and Utilization of Forest Ecosystems in West Africa, it might be useful for the region to establish regional cooperation agreements whereby countries with advanced NFIs and NFMS in place mentor and lead other countries that are yet to benefit from the collection of national level forest statistics. The needs assessment identified a strong relationship between NFI data availability and participation in an international emissions mitigation programme such as UN-REDD or the FCPF. Both of these programmes are at advanced stages and will probably not be accepting new partners; as such, it is important for countries who are not part of these programmes to learn as much as possible from the experiences of other countries and to source funding from other climate finance initiatives such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF).

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Annex 1:
National forest inventory fact sheets

Benin

Figure A1.1 Satellite image of Benin

Source: FAO. 2022. SEPAL: Benin. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 11 476 000 ha

Forest cover: 3 135 150 ha (FAO, 2020)

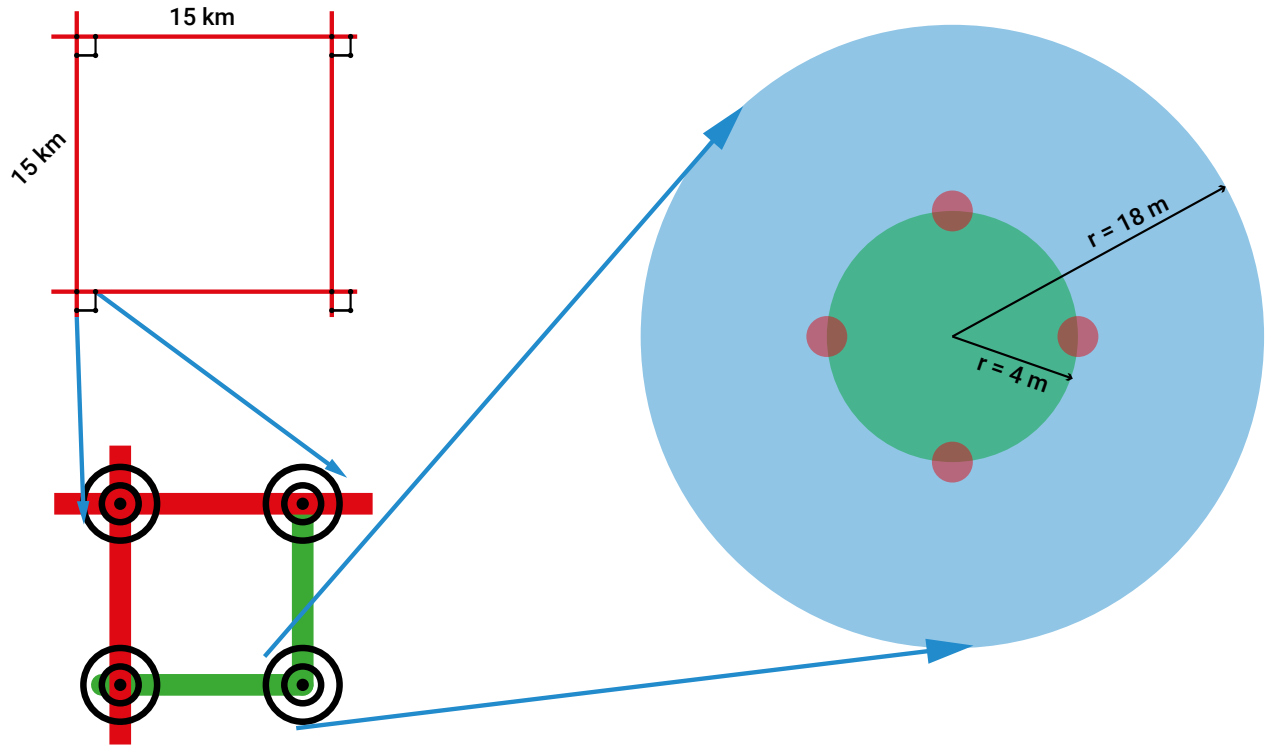
Country overview

The forests in Benin are managed by the Department of Water, Forests and Hunting (DGFC), which operates under the Ministry for the Environment and Sustainable Development (MCVDD). The DGFC receives support from the Forestry Study, Research and Training Centre. Benin can be divided into three main phytogeographic/ecological zones: the Guineo-Congolan zone in the south, the Sudano-Guinean zone in the centre and the Sudanian zone in the north. The different types of land cover and land uses in Benin include dense forests, open forests, savannah woodlands, mangroves, gallery forests, woodlands, wooded savannahs, shrub savannahs, plantation forests and fruit trees. In the past 20 years, Benin has conducted several inventories. In 2007, a national inventory was carried out as part of the Fuelwood Project Phase II (2006–2007), followed by a regional inventory in 2008, which also supported a fuelwood assessment. In 2010, a reassessment of permanent sample plots (PSPs) in protected forest areas also took place. The last inventory estimated various parameters, including the number of trees per hectare, diameter at breast height (DBH), mean tree height, basal area, tree volume and biomass, fuelwood volume, roundwood volume, volume yields, non-timber forest products (NTFPs) and biodiversity indicators.

Sample design, scale and intensity

Sampling design consisted of a 15 km × 15 km grid with four observation units (nested circular plots) at each grid intersection. There was a total number of 1 540 observation units. At each observation unit, three types of circular plots were established: a main plot of 18 m radius (1 000 m^2) to measure all trees of DBH > 10 cm; a nested plot of 4 m radius to measure all trees with diameters between 3 cm and 10 cm (3 cm < DBH < 10 cm); and four circular plots of 1 m radius along the radius of the 4 m nested plot to measure regeneration or seedlings with DBH < 3 cm and height < 1.3 m.

Figure A1.2 Sampling design, Benin



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.1 Gap assessment variables, Benin

Variable	Gap assessment score
Year of inventory	2
The country undertook a reassessment of PSPs in 2010. Since then there have been no new inventory activities.	
Type of inventory	2
The last inventory undertaken by the country was a full national scale inventory where PSPs were reassessed.	
Method of estimation of above ground biomass (AGB)	1
Default Intergovernmental Panel on Climate Change (IPCC) values were used based on Biomass Conversion and Expansion Factors (BCEFs).	
Method of estimation of dead wood (DW)	1
Default IPCC values were used for DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	1
Default IPCC values were used for litter biomass.	
Soil organic matter (SOM) assessment	1
Estimates of SOM were provided, but are based on an independent study (subnational).	
Allometric equations	1
Species-specific allometric equations are in place; however, the country still made use of pantropical equations for biomass estimation. During the national forest inventory (NFI) (2006–2008), allometric equations for volume estimation for 15 species were developed, including: *Afzelia africana*, *Albizia zygia*, *Antiaris toxicana*, *Burkea africana*, *Ceiba pentandar*, *Crossopterix febrifuga*, *Detarium microcarpum*, *Diosperos mespiliformis*, *Isoberlinia* spp., *Kaya sengalensis*, *Lophira lanceolata*, *Pseudocedrela kotschyi*, *Terminalia* spp., *Uapaca todoensis* and *Vitellaria paradoxum*.[i]	
Wood density estimates	1
Species-specific wood density estimates are available for some major species and were used in the most recent inventory.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species, including: *Vitellaria paradoxa, Isoberlinia doka, Anogeissus leiocarpus, Burkea africana, Pterocarpus erinaceus, Daniellia oliveri, Terminalia sericea, Lannea coromandelica, Crossopteryx febrifuga* and *Parkia biglobosa*.[ii]	
Non-timber forest products (NTFPs)	1
The following information was provided on NTFPs: *Adansonia digitata, Annona senegalensis, Azadirachta indica, Blighia sapida, Bombax costatum, Borassus aethyopum, Detarium microcarpum, Diospyros mespiliformis, Gardenia erubenscens, Grewia venusta, Parkia biglobosa, Pilostigma thonningii, Raphia sudanica, Sida acuta, Strychnos spinosa, Terminalia avicennoides, Vitellaria paradoxa, Vitex doniana* and *Zanthoxylum zanthoxyloides*.[iii]	
Biodiversity indices (based on FRA 2020)	1
Information was provided on biodiversity indices from the NFI in 2007. Importance indices were developed for the following species: *Vitellaria paradoxa, Terminalia* spp., *Lannea* spp., *Burkea africana, Crossopteryx febrifuga, Pterocarpus erinaceus, Detarium microcarpum, Anogeissus leiocarpus, Isoberlinia doka, Piliostigma* spp., *Daniellia oloveri, Combretum* spp., *Combretum collinum* and *Entanda* spp.[iv]	
Total score	**13/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	No

Contact(s)

K. Séverin Nsia: foretsbenin@yahoo.fr
Sylvain Akindele: akisylva@gmail.com
Rémi Hefoume (Focal point, Convergence Plan) : rhefoume@yahoo.fr
Adjinda Adjakou (Alternate focal point, Convergence Plan): adjindak@yahoo.fr
Charles Chaffra Yabi (Focal point, NFI): yabicc@yahoo.fr; yabicc@gmail.com

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

[i] Honoré, B.S.S., Balagueman, R.O., Ogoudjè, A.I., M'Mouyohoun, K. & Kuyéma, N.A. 2021. *Allometric equations for biomass estimation of fuelwood in semi-arid natural forests of North Benin.* Porto-Novo, Ministry of the Environment and Nature Protection.

[ii] Duhem, C.S. 2007. *Fuelwood project phase II - IFN: Wood energy supply basins of Cotonou, Porto-Novo, Lokossa, Abomey, Bohicon, Djougou, Natitingou and Parakou.* Porto-Novo, Ministry of the Environment and Nature Protection.

[iii] Goussanou, C., Tente, B., Djego, J., Agbani, P. & Sinsin, B. 2010. Characterisation and management methods for some non-timber forest products in the Donga watershed. *Annals of Agronomic Sciences, 14(1), 75–100.* https://www.researchgate.net/publication/309618878_INVENTAIRE_CARACTERISATION_ET_MODE_DE_GESTION_DE_QUELQUE S_PRODUITS_FORESTIERS_NON_LIGNEUX_DU_BASSIN_VERSANT_DE_LA_DONGA

[iv] FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Burkina Faso

Figure A1.3 Satellite image of Burkina Faso

Source: FAO. 2022. SEPAL: Burkina Faso. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 27 420 000 ha

Forest cover: 6 216 400 ha (FAO, 2020)

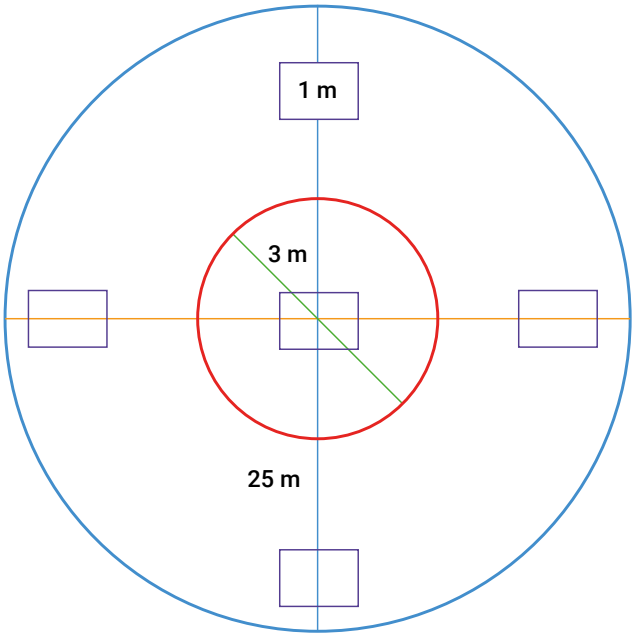
Country overview

The Directorate General of Water and Forests oversees the National Forestry Information System Service (SNSIF), which is responsible for conducting forest inventories in Burkina Faso. The country is characterized by various phytogeographic and ecological zones, including different land-use classes such as open/clear forests, gallery forests, settlements, forest plantations, irrigated croplands, rainfed and agroforests, bare rocks, woody savannahs, shrub and herbaceous savannahs, eroded and denuded areas, soil hardpans (cuirasses), woody steppes, shrub and herbaceous steppes, water bodies and humid zones. In the 2020 submission to the United Nations Framework Convention on Climate Change (UNFCCC), Burkina Faso included the following classes: open (clear) forests, forest plantations, woody savannahs, woody steppes, agroforestry parks, shrubby savannahs and herbaceous savannahs. The country has conducted two major inventories: the first National Forest Inventory (NFI, IFN1) took place between 1980 and 1983, while the second (IFN 2) was conducted between 2013 and 2015. These inventories measured various parameters, including site characteristics such as tree diameters, total and bole heights, stump occurrence, regeneration, live wood and dry weight, health status of species, standing tree potentials (stock volume), above ground biomass (AGB), carbon stocks, herbaceous biomass and ecological and biodiversity indices. To estimate tree biomass (biomass), volume allometric equations were developed based on measurements from felled (destructively sampled) trees. The tree volume (Vt) was then multiplied by biomass conversion and expansion factors (BCEFs).

Sample design, scale and intensity

The second NFI used nested circular plots of 25 m radius (main plot: for trees > 5 cm diameter) and 3 m nested plots (for trees < 5 cm diameter). Five 1 m square plots were used to assess herbaceous biomass. A total of 5 850 plots were established, including 1 147 permanent sample plot (PSPs) and 4 703 temporary sample plots (TSPs).

Figure A1.4 Sampling design, Burkina Faso



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.2 Gap assessment variables, Burkina Faso

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken after 2010 and are rated as most recent. The inventories have mainly been supported either through: Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) projects; Forest Carbon Partnership Facility (FCPF) projects; or through bilateral support.	
Type of inventory	2
The last inventory undertaken by the country was a full national-scale inventory where permanent sample points were assessed.	
Method of estimation of above ground biomass (AGB)	1
The default Intergovernmental Panel on Climate Change (IPCC) method was used, based on BCEFs. $Biomass = Vt \times BCEF$	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	1
Default IPCC values were used for litter biomass.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	1
Several species-specific and multispecies volume equations were developed based on 3 893 felled trees from 13 regions. Discs were extracted at different sections of the main stem and secondary stem for wood density estimation and carbon content determination. Leaves were harvested and weighed, and subsequently used for leaf biomass estimation.*	
Wood density estimates	1
Country-specific wood density values exist for tree species (produced by scientists in the country).	
Main timber species (based on FRA 2020)	1
Lamien (2009) and FRA 2020 provide a list of main tree species in the country, including: *Afzelia africana, Anogeissus leiocarpa, Ceiba pentandra, Daniellia oliveri, Diospyros mespiliformis, Eucalyptus camaldulensis, Gmelina arborea, Isoberlinia doka, Isoberlinia tomentosa, Khaya senegalensis, Pterocarpus erinaceus, Milicia excelsa, Senna siamea* and *Tectona grandis*.	
Ten main species include: *Vitellaria paradoxa, Anogeissus leiocarpa, Detarium microcarpum, Combretum glutinosum, Balanites aegyptiaca, Lannea microcarpa, Lannea acida, Pilostigma thonningii, Terminalia avicennioides, Combretum micranthum, Parkia biglobosa, Acacia dudgeoni, Terminalia laxiflora, Crossopteryx febrifuga, Pterocarpus erinaceus* and *Burkea africana*.**	
Non-timber forest products (NTFPs)	1
The main NTFPs in the country include: *Acacia macrostachya, Acacia senegal, Adansonia digitata* (Baobab tree), *Balanites aegyptiaca, Bombax costatum, Parkia biglobosa, Saba senegalensis, Sclerocarya birrea, Tamarindus indica, Vitellaria paradoxa* and *Ziziphus mauritiana*.	
Biodiversity indices (based on FRA 2020)	1
Studies referenced below include detailed information on ecological indices, including parameters such as basal area (BA), relative dominance, relative density and importance value index (IVI) for both species and families. Additionally, comprehensive data on biodiversity indices consists of species richness, Shannon diversity indices (H), Simpson indices (1/D) and Simpson evenness indices (E).***	
Total score	**14/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	Forest Carbon Partnership Facility (FCPF)
Forest Reference Emissions Level (FREL) submission	Yes (2020)
Data publicly available	No
Contact(s)	
Sia Coulibaly (Focual point, NFI): coulibaly_s@hotmail.com Zanre Adama (Focal point, Convergence Plan): adzanre@gmail.com Korogo Bertin (Focal point, Geospatial Database): korogo3@gmail.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* Picard, N., Saint-André, L. & Henry, M. 2012. *Manual for building tree volume and biomass allometric equations: from field measurement to prediction.* Rome, FAO and Montpellier, France, Centre for International Cooperation in Agricultural Research for Development. https://www.fao.org/3/i3058e/i3058e.pdf

** Lamien, N., Lingani-Coulibaly, P., & Traore-Gue, J. 2009. Importance of local fruits consumption in diet balance in Burkina | Faso, West Africa. *ActaHorticulturae*, 806: 203–208. http://hdl.handle.net/10625/41647

*** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Cabo Verde

Figure A1.5 Satellite image of Cabo Verde

Source: FAO. 2022. SEPAL: Cabo Verde. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 403 000 ha

Forest cover: 45 720 ha (FAO, 2020)

Country overview

The Ministry of Agriculture and Environment is the responsible institution mandated with conducting forest inventories in Cabo Verde. The country is characterized by several main phytogeographic and ecological zones, namely humid, semi-humid, semi-arid and arid zones. There are four primary land-use/land-cover types, which include closed forests, open forests, agroforestry areas and shrublands. Cabo Verde carried out a national forest inventory (NFI) between 2008 and 2012, and a recent inventory was conducted in 2020. Additionally, over the past 20 years, the country has undergone several inventories between 2006 and 2010. In 2007, a national inventory was undertaken as part of the Fuelwood Project Phase II (2006–2007). In 2008, a regional inventory was conducted, also supporting the assessment of fuelwood resources. The parameters measured and estimated in the most recent inventory encompass various aspects, including the number of trees per hectare, diameter at breast height (DBH), mean tree height, basal area, tree volume and biomass, fuelwood volume, round wood volume, volume yields, non-timber forest products (NTFPs) and biodiversity indicators.

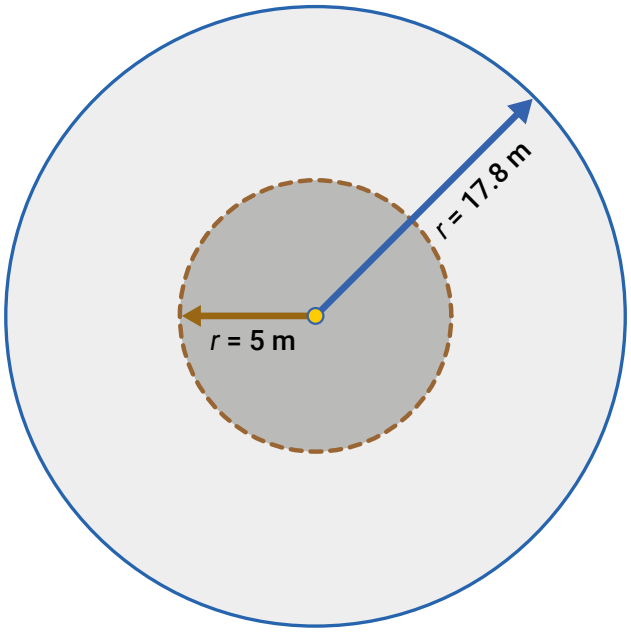
Sample design, scale and intensity

The inventory used a stratified sampling design, with the first-phase sample based on a regular systematic grid of equidistant points of 150 m × 150 m (on Santiago Island), 450 m × 450 m (on the islands of Santo Antão, São Nicolau, São Vicente, Boavista, Maio and Fogo) and 300 m × 300 m (on the islands of Brava and Sal). It is not clearly specified if the sample plots are all permanent, temporary, or both. Variable-sized, circular (non-nested) plots were used on Santiago Island, depending on land-use class: 1 000 m² for the agroforestry and open forest land-use class, and circular plots of 500 m² for the forestry and shrubland land-use class. In the other islands, 1 000 m² were used, regardless of land-use class. Data collection and management was done within the Field-Map Inventory Analyst software (FMIA).[2]

The 2020 inventory used nested circular plots of 17.8 m and 5 m. Within the 17.8 m plot, all trees with diameter > 2 cm and height > 1 m were identified and measured for diameter and height, with the extent of damage noted. Within the 5 m radius subplot, all trees with diameter ≤ 2 cm and/or with height ≤ 1 m were identified and counted, including herbs and dead trees. Data analysis used Chave *et al.* (2014) for forest biomass estimation.

Parameters estimated in the most recent inventory included: DBH, tree heights, areas, volume, biomass, carbon stocks, tree damage and regeneration. Tree biomass was estimated as a product of tree merchantable volume, BCEF and biomass conversion factor: $Biomass = Vt \times BCEF \times 0.47$

Figure A1.6 Sampling design, Cabo Verde



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

2 For more information, see www.field-map.com

Gap assessment variables

Table A1.3 Gap assessment variables, Cabo Verde

Variable	Gap assessment score
Year of inventory	3
An inventory was undertaken after 2010 and is rated as most recent. Past inventories have mainly been supported either through REDD+ projects or bilateral support.	
Type of inventory	2
The last inventory undertaken by the country was a full national-scale inventory where permanent sample points were reassessed.	
Method of estimation of above ground biomass (AGB)	1
The default Intergovernmental Panel on Climate Change (IPCC) method was used, based on biomass conversion and expansion factors. $Biomass = Vt \times BCEF$	
Method of estimation of dead wood (DW)	0
No information was provided on DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	0
No estimate of litter was presented.	
Soil organic matter (SOM) assessment	1
Estimates of SOM were provided, but are based on an independent study.	
Allometric equations	0
Stem profile models were used to determine volumes. Biomass conversion and expansion factors were used to convert volumes to biomass. Total AGB for tree-like growing species were estimated using BCEFs. The country's capacity to develop allometric equations is not stated, but may possibly be low, given that no country-specific equations exist. The 2020 inventory used a pantropical allometric equation to estimate forest biomass from field measurements.*	
Wood density estimates	0
No country-specific wood density values were available.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report). Natural forest species have largely disappeared in the country due to deforestation. These species include: *Adansonia digitata* (baobo), *Ficus* spp., *Tamarindus indica* and *Faidherbia albida* (Acacia albida). Existing vegetation is mostly composed of exotic species obtained from plantation forestry. Exotic species include: *Cupressus* spp., *Eucalyptus* spp., *Gravillea robusta* and *Pinus canariensis*. FRA 2015 cites *Proposis juliflora* (as most extensive), *Acacia holosericea*, *Parkinsonia aculeata*, *Prosopis juliflora* (most extensive), *Acacia* spp., *Eucalyptus* spp., *Grevillea* spp., other broadleaves and *Pinus* spp.**	
Non-timber forest products (NTFPs)	0
No information was provided on NTFPs.	
Biodiversity indices (based on FRA 2020)	0
No information was provided on biodiversity indices.	
Total score	**8/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	No
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	Yes Link: www.caboverdeifn.ifer.cz
Contact(s)	
Soares Maria da Cruz Gomes (MDR-DGADR, Rural Engineering and Forestry Services Department): Maria.da.Cruz@mdr.gov.cv Alexandre Ribeiro Centeio (Focal point, NFI): alexcenteio84@gmail.com; alexandre.Centeio@maa.gov.cv	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

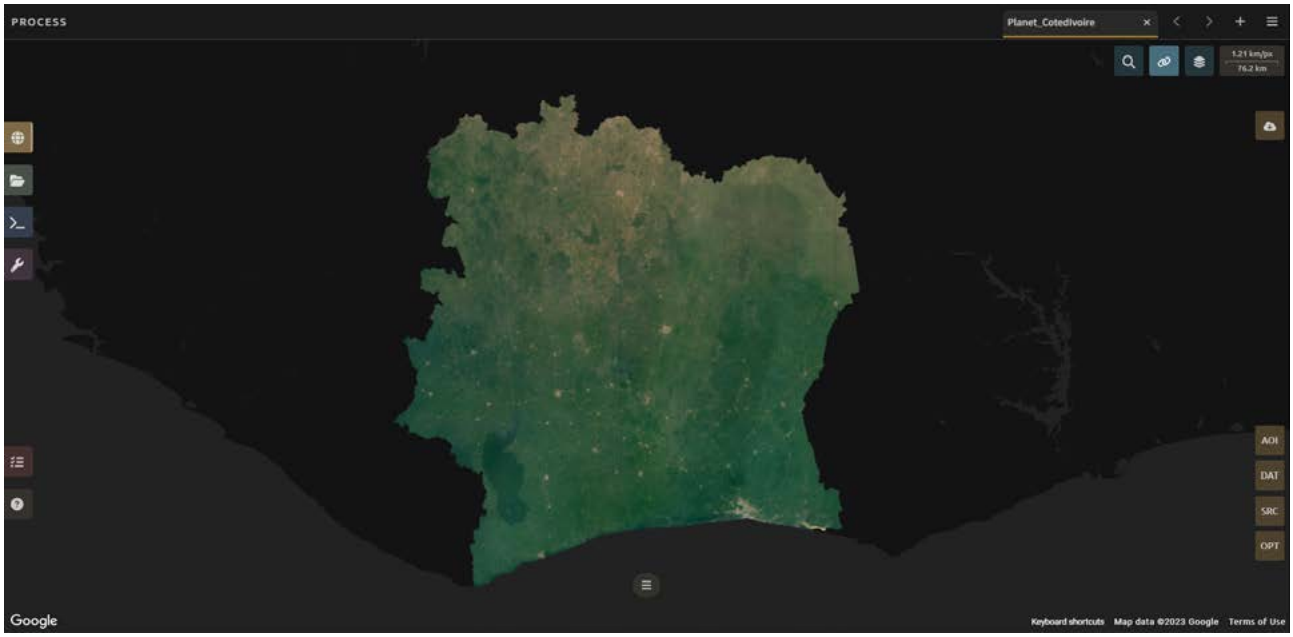
* Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M.S., Delitti, W.B.C., Duque, A. *et al*. 2014. Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, 20(10): 3177–3190. https://doi.org/10.1111/gcb.12629

** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Côte d'Ivoire

Figure A1.7 Satellite image of Côte d'Ivoire



Source: FAO. 2022. SEPAL: Côte d'Ivoire. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 32 246 300 ha

Forest cover: 2 972 830 ha (IFFN 2021: National Forest and Wildlife Inventory – Côte d'Ivoire)

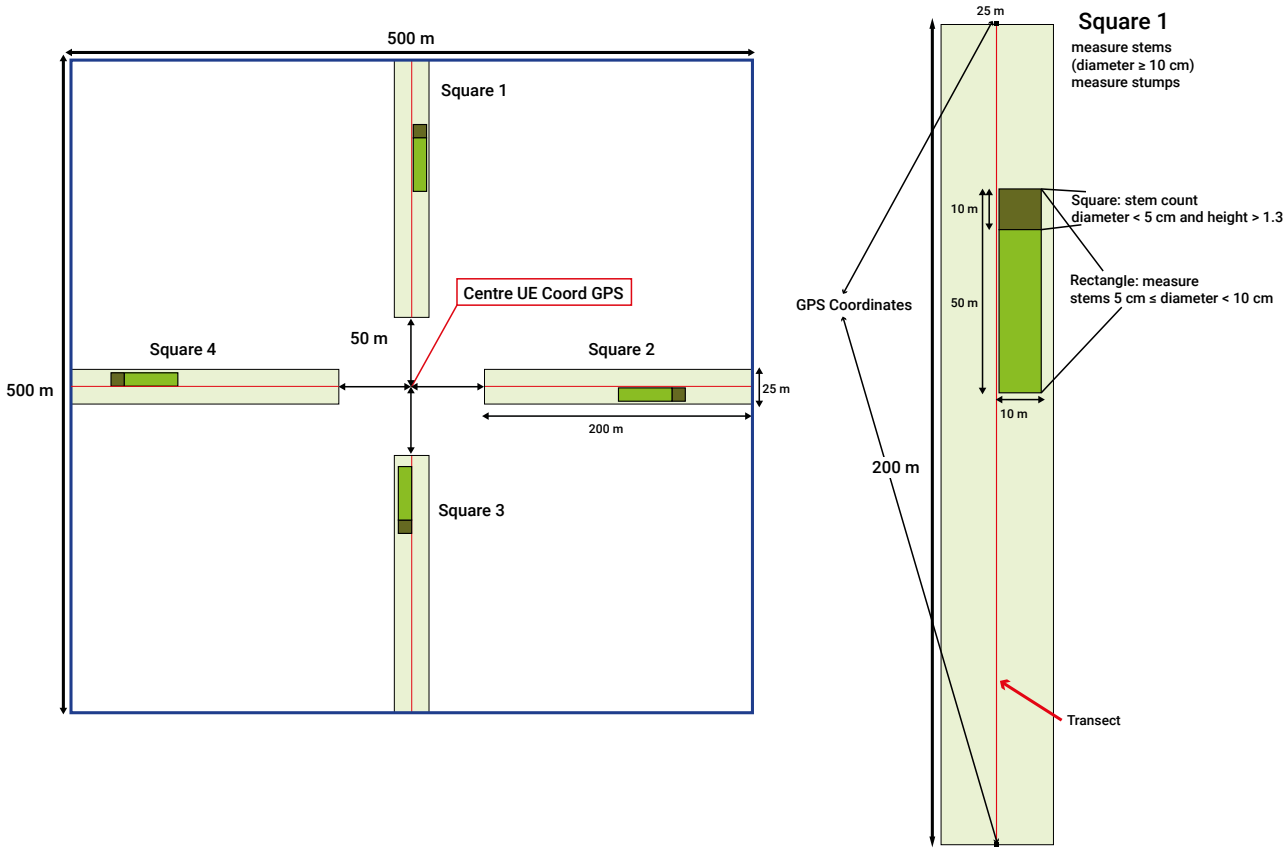
Country overview

The Ministry of Water and Forestry (MEF) is the mandated lead institution in charge of forest inventories in Côte d'Ivoire. Another institution is the Forest Development Company (SODEFOR). The main phytogeographic/ecological zones include: humid dense forest, semi-deciduous forest, humid evergreen forest, transitional forest–savannah zone, transitional savannah zone and savannah zone. The most recent inventory was undertaken in 2020 and 2021; results included fact sheets and leaflets. Full reports and annexes are available. Parameters/variables measured and/or estimated/observed include: site/stand characteristics, tree diameters, total and bole heights, stumps, regeneration, live wood and dead wood, health status of species, standing tree potentials (volume stocks), AGB and carbon stocks. Even though manual data sheets are used, data collection was done directly with Open Foris Collect Mobile. Data analysis was undertaken using pantropical allometric equations to provide AGB and carbon stocks, dead wood biomass and stump biomass.

Sample design, scale and intensity

The sampling unit was a cluster of 500 m × 500 m (25 ha) composed of rectangular-shaped sample plots (RPs) of 25 m × 200 m in a cross-like arrangement, oriented in the north, east, south and west directions, and laid at 50 m from the centre of the sampling unit. All standing live and dead trees with diameters greater than 10 cm (DBH ≥ 10 cm) and all lying dead trees crossing the main transect were measured for diameter. Within each RP was a nested subrectangular plot (SRP) of 10 m × 50 m, within which small trees of diameters between 5 cm and 10 cm (5 cm ≤ DBH < 10 cm) were measured. Furthermore, square subplots (SSPs) of 5 m × 5 m were nested within the RP at 50 m, 100 m, 150 m and 200 m from the cluster centre for RP1 (north-oriented RP), RP2 (east-oriented RP), RP3 (south-oriented RP) and RP4 (west-oriented RP), respectively. Biodiversity assessment (all trees, shrubs, regeneration with DBH < 5 cm and height > 3 m) is assessed within the SSPs. Stumps are measured within the RP and SRP according to the diameter limits for live trees. Tree heights for a subsample of trees were measured (with Vertex), and were used to establish a height–diameter relationship.

Figure A1.8 Sampling design, Côte d'Ivoire



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.4 Gap assessment variables, Côte d'Ivoire

Variable	Gap assessment score
Year of inventory	3
An inventory was undertaken after 2010 and is rated as most recent. Past inventories have mainly been supported either through REDD+ projects, Forest Carbon Partnership Facility (FCPF), or bilateral support.	
Type of inventory	2
The last inventory undertaken by the country was a full national-scale inventory.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations (mostly pantropical equations).	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	1
Stump biomass estimates were derived from recent inventories conducted with the objective of estimating forest biomass for determining emission factors.	
Method of estimation of litter	2
Tier 2 method was used, based on country data from inventory.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	0
No country-specific allometric equations were used in biomass estimation.	
Wood density estimates	0
No country-specific wood density values were available.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report): *Ceiba pentandra* (Kapok tree), *Terminalia ivorensis* (Ivory Coast almond), *Terminalia superba* (Africa limba wood), *Triplochiton scleroxylon* (African whitewood), *Pycnanthus angolensis* (African nutmeg), *Pterigoto macrocarpa*, *Heretia utilis* and *Hallea ciliata*.*	
Non-timber forest products (NTFPs)	0
No information was provided on NTFPs.	
Biodiversity indices (based on FRA 2020)	1
Information was provided on biodiversity indices.	
Total score	**14/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme), Forest Carbon Partnership Facility (FCPF)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	No
Contact(s)	
Conservator General, General Elvire Joëlle Mailly Zouzou (Focal point, Convergence Plan): elvzouz@yahoo.fr Lt-Col Loukou Koffi Maxime (Focal point, NFI): lmaxkof@gmail.com By email: onfci@onfinternational.org By telephone: (+225) 22 468301	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

The Gambia

Figure A1.9 Satellite image of the Gambia

Source: FAO. 2022. SEPAL: The Gambia. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 1 130 000 ha

Forest cover: 242 670 ha (FAO, 2020)

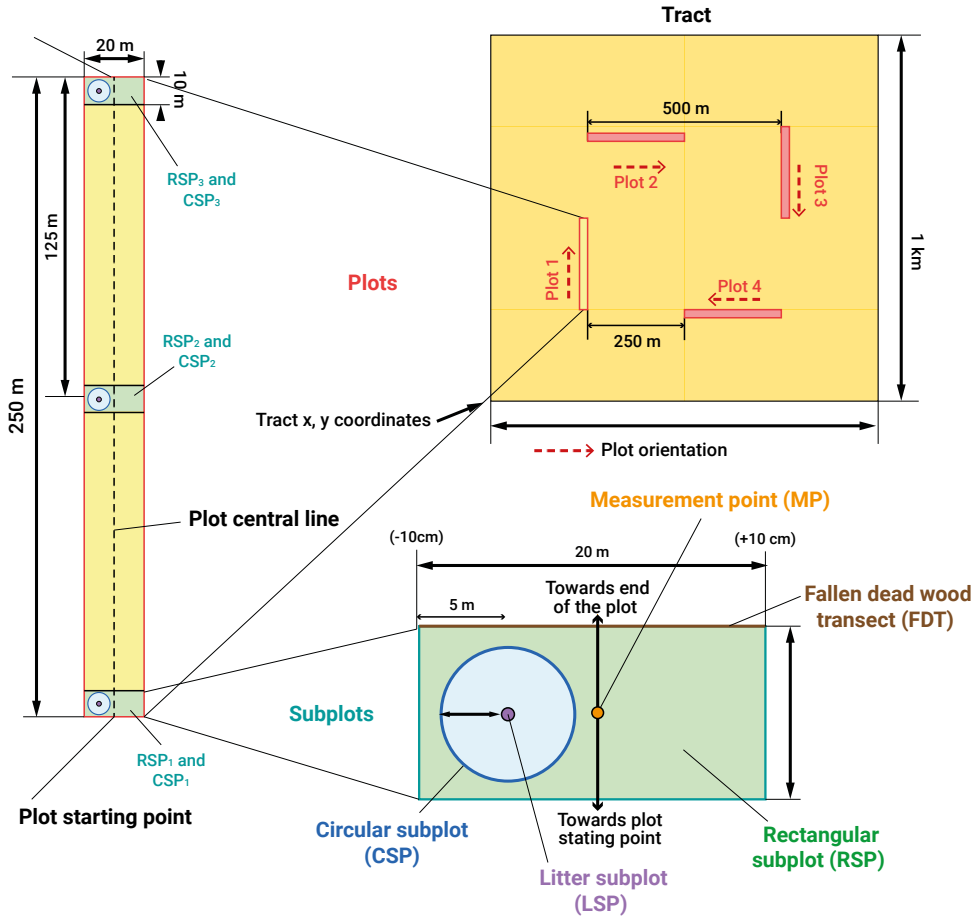
Country overview

The Forestry Department is responsible for conducting national forest inventories (NFIs) in the Gambia. The main land-use and land-cover types in the country include woodland, savannah woodland, tree and shrub savannah, agroforestry (agriculture with trees), agriculture, fallow areas and mangroves. The Gambia has carried out three NFIs. The first two, conducted in 1982 and 1988, utilized nested circular plots. The third NFI, known as the National Forest Assessment (NFA), was conducted in 2010 using nested square and random points sampling. The most recent inventory, the NFA, dates back to 2009/2010 according to the National Forest Assessment (2010) report. Various parameters and variables were measured, observed, or estimated in the inventories. These included site and stand characteristics, tree diameters, total and bole heights, regeneration, live and dry weight, health status of species, standing tree potentials (volume stocks), above ground biomass (AGB) and carbon stocks, herbaceous biomass, as well as ecological and biodiversity indices. Volume allometric equations were developed based on measurements from felled (destructively sampled) trees. Tree biomass was estimated by multiplying tree volume with biomass conversion and biomass expansion factors (BCEFs): $Biomass = Vt \times BCEF \times 0.47$

Sample design, scale and intensity

The sampling unit was a cluster of 500 m × 500 m (25 ha) composed of rectangular-shaped sample plots (RPs) of 25 m × 200 m in a cross-like arrangement, oriented in the north, east, south and west directions, and laid at 50 m from the centre of the sampling unit. All standing live and dead trees with diameters greater than 10 cm (diameter at breast height [DBH] ≥ 10 cm), as well as all lying dead trees crossing the main transect, were measured for diameter. Within each RP an additional subrectangular plot (SRP) of 10 m × 50 m was nested, within which small trees of diameters between 5 cm and 10 cm (5 ≤ DBH < 10 cm) were measured. Furthermore, square subplots (SSPs) of 5 m × 5 m were nested within the RP at 50 m, 100 m, 150 m and 200 m from the cluster centre for RP1 (north-oriented plot), RP2 (east-oriented RP), RP3 (south-oriented RP) and RP4 (west-oriented RP), respectively. Biodiversity assessment (all trees, shrubs, regeneration with DBH < 5 cm and height > 3 m) was assessed within the SSPs. Stumps were measured within the RP and SRP according to the diameter limits for live trees. Tree heights for a subsample of trees was measured (with Vertex), and was used to establish a height–diameter relationship.

Figure A1.10 Sampling design, the Gambia



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.5 Gap assessment variables, the Gambia

Variable	Gap assessment score
Year of inventory	2
Inventories were undertaken in 1981/82, 1997/98 and 2009/10.	
Type of inventory	2
The last inventory undertaken by the country was a full national-scale inventory.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations (mostly pantropical equations).	
Method of estimation of dead wood (DW)	0
No information was provided on DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	0
No inventory information on litter.	
Soil organic matter (SOM) assessment	0
No information on soil organic carbon was provided.	
Allometric equations	1
Have allometric equations even though they still rely on pantropical equations for biomass estimation.	
Wood density estimates	0
Information on sawntimber density and fuelwood density available.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report): *Avicennia nitida, Adansonia digitata, Cordyla pinnata, Combretum glutinosum, Terminalia macroptera, Khaya senegalensis, Pterocarpus erinaceus, Elais guineense, Daniellia oliveri* and *Mitragyna inermis*.*	
Non-timber forest products (NTFPs)	1
Information was provided on NTFPs.	
Biodiversity indices (based on FRA 2020)	1
Information was provided on biodiversity indices.	
Total score	**10/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	No
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	No
Contact(s)	
Sanyang Babanding (Focal Point, FRA 2020): sanyangbaba@yahoo.com Malang Jatta (Database expert, NFI): mjatta04@gmail.com Muhammed Jaiteh (Focal point, Convergence Plan): modikaba2002@yahoo.com	

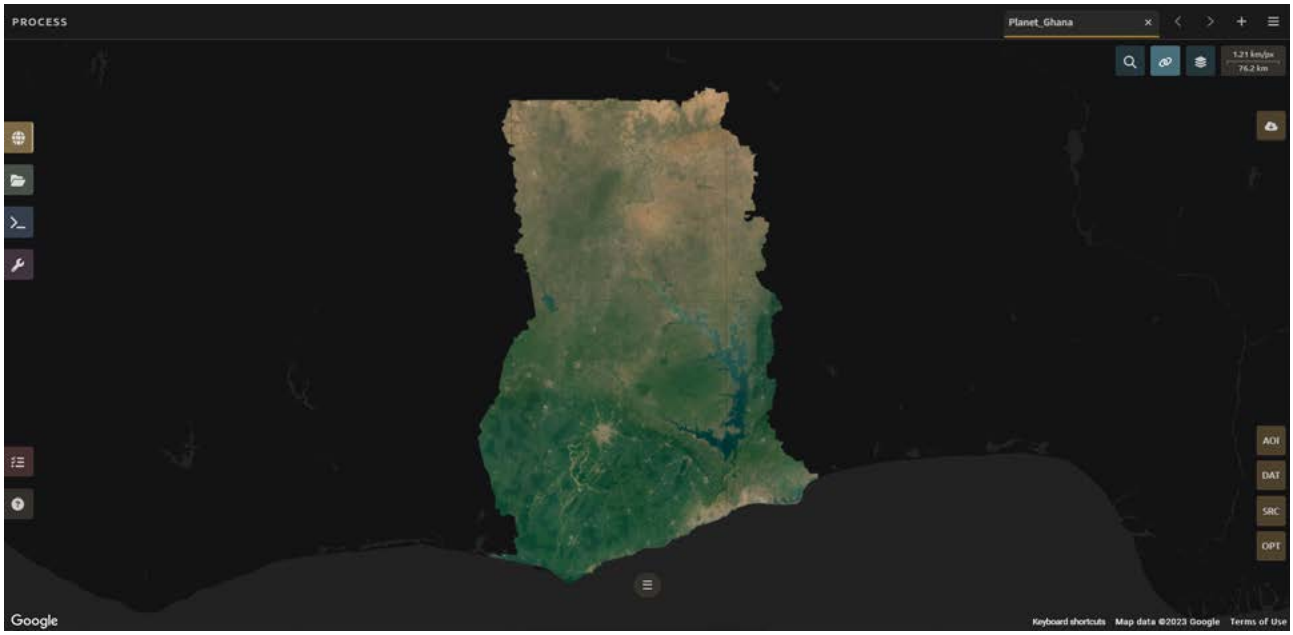
Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Ghana

Figure A1.11 Satellite image of Ghana



Source: FAO. 2022. SEPAL: Ghana. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 23 853 000 ha

Forest cover: 7 985 710 ha (FAO, 2020)

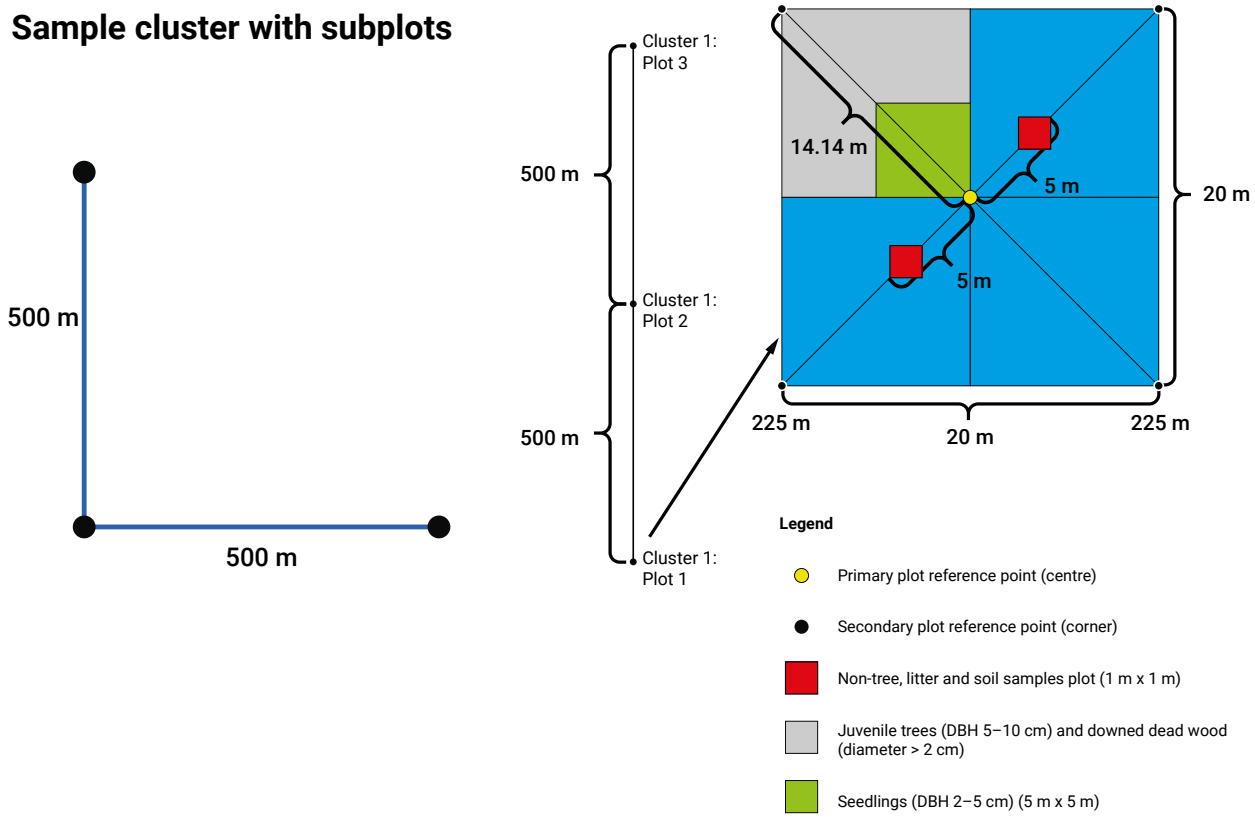
Country overview

National forest inventory (NFI) activities in Ghana are led by the Resource Management Support Centre (RMSC) of the Forestry Commission, mandated by Act 571 (1999), which works in collaboration with the Forest Services Division (FSD) of the Forestry Commission. The country has six main ecological zones: Sudan savannah, Guinea savannah, forest–savannah transition, semi-deciduous rainforest, high rainforest and coastal savannah. Over the past 20 years, the country has undertaken a number of forest inventories: the Ghana Forest Inventory Project (1985–1989), using both temporary sample plots (TSPs) and permanent sample plots (PSPs); the Forest Inventory and Management Project (1989–1995), using both TSPs and PSPs; the multiresource inventory (2000–2001), using both TSPs and PSPs; and the Forest Preservation Programme (FPP) (2012–2014), using temporary plots. Parameters measured/estimated by the last inventory (during the Forest Preservation Programme study) included: diameter at breast height (DBH), tree height, stem volume, stem biomass, branch, twig and leaf biomass, dead wood (DW) (standing or lying), litter, root biomass, wood density, biomass expansion factors (BEFs) and biomass conversion and expansion factor (BCEFs), and root–shoot ratio.

Sample design, scale and intensity

The Forest Preservation Programme used 20 m^2 × 20 m2 (400 m^2) square plots. Sampling units were clusters of three square nested plots. An alternate method consisted of three square nested plots arranged in an L-shaped fashion: with one plot in the north at 500 m from the elbow plot and another in the eastward direction at 500 m from the elbow plot. Standing live and dead trees (DBH ≥ 10 cm) were measured over the entire plot. Within each square plot, a nested subplot of 10 m × 10 m was established, within which juvenile trees (5 cm ≥ DBH < 10 cm) and lying dead wood (DBH ≥ 2 cm) were enumerated. Regeneration enumeration within the plots was conducted using 5 m × 5 m subplots that were established at a distance of 5 m from the plot centre, positioned at a 45-degree angle. Litter, non-tree and soil samples were collected from two 1 m^2 subplots located on the southwest and northeast diagonal line, 5 m apart from the plot centre.

Figure A1.12 Sampling design, Ghana



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.6 Gap assessment variables, Ghana

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken after 2010 and are rated as most recent. The inventories have mainly been supported either through: Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) projects, or Forest Carbon Partnership Facility (FCPF) projects of bilateral support in the countries.	
Type of inventory	2
The last inventory undertaken by the country was a full national-scale inventory where permanent sample points were reassessed.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and the application of allometric equations (mostly pantropical equations).	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	1
Stump biomass estimates were derived from recent inventories conducted with the objective of estimating forest biomass for determining emission factors.	
Method of estimation of litter	2
Tier 2 method was used based on country data from inventory.	
Soil organic matter (SOM) assessment	0
No information on soil organic carbon was provided.	
Allometric equations	1
Have allometric equations even though they still rely on pantropical equations for biomass estimation. The Forestry Research Institute of Ghana (FORIG) has undertaken preliminary development of country and ecozone-specific allometric equations for AGB and below ground biomass (BGB), based on some studies, including those within the Forest Preservation Programme (FPP).	
Wood density estimates	1
Country-specific wood density estimates are available for some major species (a partial country-specific wood density database based on data collected during the FPP through destructive sampling, and analysed at the Wood Density Laboratory at FORIG). Few experts exist to undertake wood density analysis; the laboratory has inadequate facilities and lacks modern equipment for wood density analysis.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report): *Triplochiton scelroxylon, Celtis mildbraedii, Piptadeniastrum africanum, Ceiba pentandra, Terminalia superba, Celtis zenkeri, Petersianthus macrocarpus, Nesogordonia papaverifera, Psycanthus angolensis* and *Antiaris toxicaria*.*	
Non-timber forest products (NTFPs)	0
Not available.	
Biodiversity indices (based on FRA 2020)	0
Not available.	
Total score	**15/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	Forest Carbon Partnership Facility (FCPF), United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	Yes Link: https://nfmsgh.bigdataghana.com
Contact(s)	
Joseph Osiakwan (Focal point, Convergence Plan): josephosiakwan@yahoo.com Kofi Affum Baffoe (Focal point, NFI): kab64baf@gmail.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Guinea

Figure A1.13 Satellite image of Guinea

Source: FAO. 2022. SEPAL: Guinea. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 24 586 000 ha

Forest cover: 6 189 000 ha (FAO, 2020)

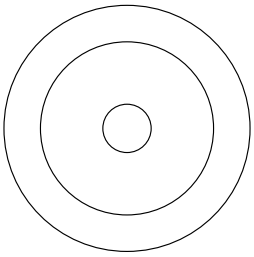
Country overview

The National Directorate of Forest and Fauna (DNEF) within the Ministry of Environment, Water and Forests is the mandated institution responsible for national forest inventories (NFIs). The main ecological zones in the country include: humid dense forest, dense dry and open forest, mangroves and savannah woodlands. In 2004, Winrock International conducted a biomass assessment in selected protected areas. Additionally, forest reserves such as Bakoun (240 temporary sample plots [TSPs]), Balayan Souroumba (260 TSPs), Nialama (66 TSPs) and Soutiyanfou (194 TSPs) underwent assessments between 2002 and 2003. Parameters measured included: diameter at breast height (DBH), tree height, stem volume and stem biomass. No national inventory has been undertaken in the past 20 years.

Sample design, scale and intensity

The Winrock methodology involved using circular nested plots with radii of 20 m (main plot), 14 m (nested subplot 1) and 4 m (nested subplot 2). On the 20 m radius plot, all standing live (and dead trees) with DBH greater than 50 cm (DBH > 50 cm) were measured for diameter; trees with diameters between 20 cm to 50 cm (20 cm ≤ DBH ≤ 50 cm) were measured within the 14 m radius subplot, while trees between 5 cm and 20 cm (5 cm ≤ DBH < 20 cm) were measured in the 4 m radius subplot. The methodology described was employed to assess and estimate the CO^2 sequestration potentials in ten classified forests in Guinea. These forests include Nialama, Sinceri Oursa, Balayan Souroumba, Nono, Baro, Souti Yanfou, Diécké, Ziama, Pic de Fon and Mont Nimba.

Figure A1.14 Winrock plot design, Guinea

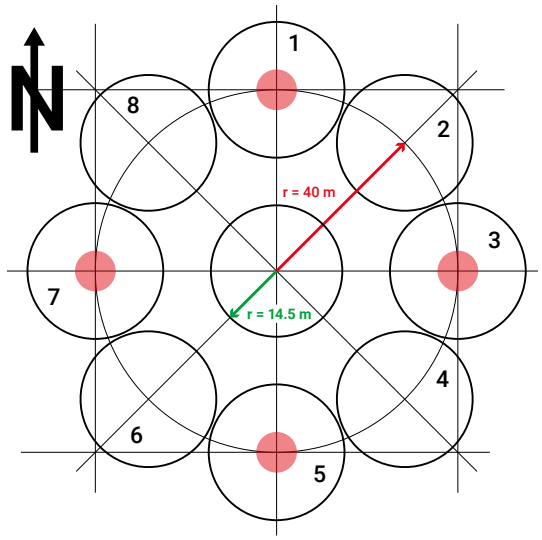


Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting (Winrock study).

The GFA Consulting methodology involved the detailed forest assessment inventory, which used a cluster of nine circular plots of 14.5 m radius (660.185 m²), with four of them having 2 m radius (12.56 m²) nested plots for tallying of trees less than 20 cm. The nested plots were located in the north, east, south and west directions of the cardinal points. A central plot contained the coordinates of the cluster from which the centres of the eight others were determined at 40 m radius (corrected for horizontal distance). Sample trees were felled and sectional measurements undertaken at 2 m intervals to determine stem volumes from which volume equations were developed. Forest biomass was determined by applying wood density values for the species (source of wood density values not indicated) to the volume estimates. Tree measurements were undertaken either with a forest compass or diameter tape. A total of 1 120 clusters (10 080 circular plots) were planned for Diécké Forest. Six tree quality classes were used: 1 (excellent), 2 (low branches), 3 (broken top), 4 (inclined), 5 (fallen) and 6 (no remarks). However, this inventory only measured economic species. Another forest is Ziama.

Figure A1.15 GFA plot design, Guinea



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting (Winrock study).

Gap assessment variables

Table A1.7 Gap assessment variables, Guinea

Variable	Gap assessment score
Year of inventory	1
Inventories are old and obsolete; they were undertaken before 2000.	
Type of inventory	1
Inventory has been undertaken only at subnational level.	
Method of estimation of above ground biomass (AGB)	1
The default Intergovernmental Panel on Climate Change (IPCC) method was used, based on biomass conversion and expansion factors. $$Biomass = Vt \times BCEF$$	
Method of estimation of dead wood (DW)	0
No information was provided on DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	0
No estimate of litter biomass is provided.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	0
No country-specific allometric equations were used in biomass estimation.	
Wood density estimates	0
No country-specific wood density values were available.	
Main timber species (based on FRA 2020)	0
No information was provided on the ten most important timber species (based on the FAO FRA 2020 report).*	
Non-timber forest products (NTFPs)	1
Anona senegalensis, Alchornea cordifolia, Carapa procera, Combretum glutmosum, Combretum, Cassia siberiania, Cola cordifolia, Crossopteris februfuga, Detarium microcarpum, Dialium guineensis, Ficus gnafalocarpa, Hymenocardia acida, Lannea acida, Lophira lanceolata, Parinari excelsa, Pterocarpus erinaceus, Parkia biglobosa, Piliostigma thonningui, Prosopis, Pteroccarpus santalinoïdes, Spondia mombin, Sygizum guineensis, Terminalia glaucecens, Vitex doniana, Vitellaria paradoxa and *Uapaca somon*.**	
Biodiversity indices (based on FRA 2020)	0
Not available	
Total score	**4/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	No
Contact(s)	
Nantenin Diallo (Focal point, FRA 2020): nantenendiallo8@gmail.com Layaly Camara (Focal point, Convergence Plan): camf0111@yahoo.fr Abdoul Gadiri Diallo (Focal point, NFI): abdoulgad45@gmail.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

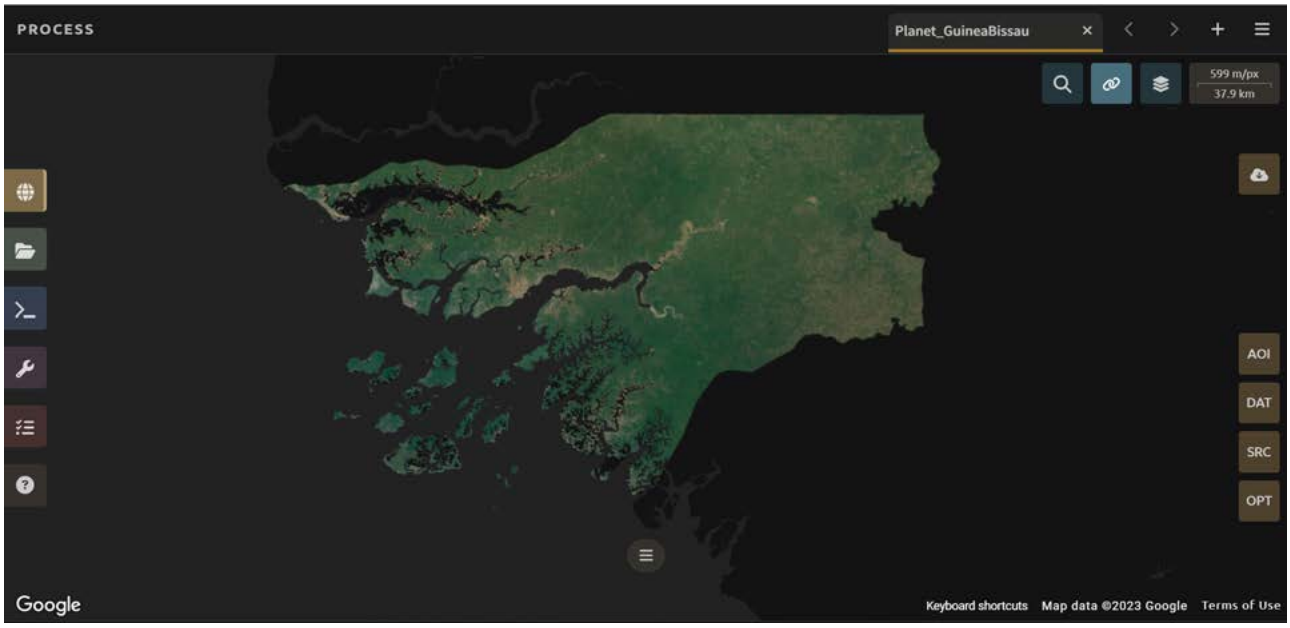
* FAO. 2020. *Global Forest Resources Assessment 2020: Main report. Rome.* https://doi.org/10.4060/ca9825en

** Brown, S. & Pearson, T. 2005. *Exploring the carbon sequestration potential of classified forests in the Republic of Guinea.* Washington DC, Winrock International. http://www.sciepub.com/reference/263415

Source: Authors' elaboration using data and capacity needs assessment.

Guinea-Bissau

Figure A1.16 Satellite image of Guinea-Bissau



Source: FAO. 2022. SEPAL: Guinea-Bissau. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 3 613 000 ha

Forest cover: 1 980 000 ha (FAO, 2020)

Country overview

The Directorate General for Forests and Fauna (DGFF) of the Ministry of Agriculture and Rural Development (MARD) is the legitimate institution for national forest inventories (NFIs) and management, but collaborates with the Institute for Biodiversity and Protected Areas (IBAP) in monitoring biodiversity in marine and terrestrial protected areas. The DGFF and IBAP are attached to the Secretariat of State for Environment (SEE), and are both responsible for NFIs in the country. The main phytogeographic zones in Guinea-Bissau include: closed forest, open forest, savannah and mangroves. Three main inventories undertaken include those by: SCET International, through French cooperation, in 1978; Atlanta Consult, through German cooperation, in 1985; and CARBOVEG, through Portuguese cooperation, in 2011. Parameters measured included: diameter at breast height (DBH), total height, tree location, plot centre location, and standing and lying dead trees.

Sample design, scale and intensity

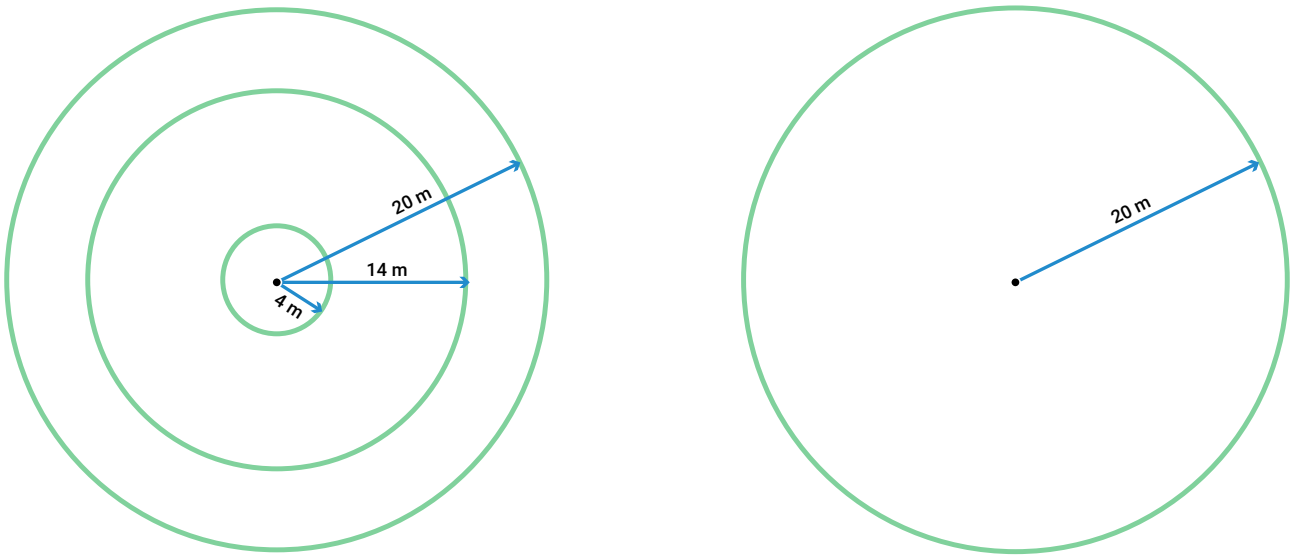
Sampling design used circular nested plots of radii 20 m (main/large plot), 14 m (nested subplot: medium) and 4 m (small nested plot). The general procedure for all four strata (closed forest, open forest, savannah and mangroves) was to: measure all trees greater than 5 cm DBH ≥ 5 cm) within the 4 m nested plot; all trees greater than 20 cm (DBH > 20 cm) within the 14 m plot; and all trees greater than 50 cm (DBH ≥ 20 cm) within the 20 m plot. However, some modifications were used in some inventories in the mangroves during the inventories in 2010 (CBADP1) and 2012 (CBADP2) (see Table A1.8).

Table A1.8 Sample plot characteristics, Guinea-Bissau

Plot radius	General procedure for four strata	CBADP1: mangroves (2010)	CBADP2: mangroves (2012)
Within the 5 m radius	All trees with DBH ≥ 5 cm were measured.		
Between 5 m and 14 m radius	Only trees with DBH ≥ 20 cm were measured.	Only trees with DBH ≥ 10 cm were measured.	
Between 14 m and 20 m radius	Only trees with DBH ≥ 50 cm were measured.	Only trees with DBH ≥ 15 cm were measured.	Only trees with DBH ≥ 20 cm were measured.

Source: *Authors' elaboration from NFI reporting.*

Figure A1.17 Nested and mangrove plot design, Guinea-Bissau



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.9 Gap assessment variables, Guinea-Bissau

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken after 2010 and are rated as most recent. The inventories have mainly been supported either through Reducing Emissions from Deforestation and Forest Degradation (REDD) projects or Forest Carbon Partnership Facility (FCPF) projects of bilateral support in the countries.	
Type of inventory	2
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations, mostly pantropical equations.	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	1
Default Intergovernmental Panel on Climate Change (IPCC) values were used for litter biomass.	
Soil organic matter (SOM) assessment	1
Estimates of SOM were provided, but are based on an independent study.	
Allometric equations	0
No country-specific allometric equations were used in biomass estimation.	
Wood density estimates	1
Country-specific wood density estimates are available for SOM major species.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report).*	
Non-timber forest products (NTFPs)	0
Not available	
Biodiversity indices (based on FRA 2020)	0
Not available	
Total score	**13/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	Datasets for the SCET and Atlanta Consult inventories are not available; data for CARBOVEG is available on project website.
Contact(s)	
M. Seiti Cassama (Focal point, Convergence Plan): seiticas02@gmail.com M. Samiro Dias (Focal point, NFI): samirodias2011@hotmail.com; samirodias2011@gmail.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Liberia

Figure A1.18 Satellite image of Liberia

Source: FAO. 2022. SEPAL: Liberia. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 11 137 000 ha

Forest cover: 7 617 440 ha (FAO, 2020)

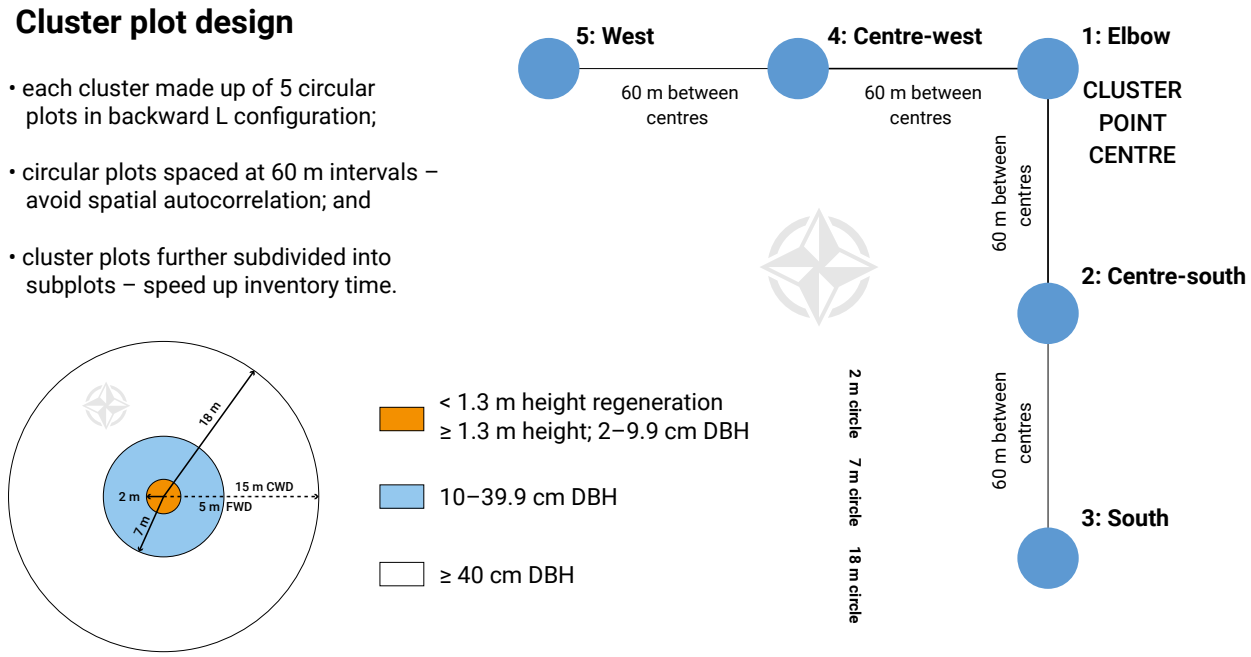
Country overview

The Forestry Development Authority (FDA) is the lead institution in charge of forest inventories, mandated by the FDA Act of 1976 and the 2006 National Forest Reform Law. The FDA undertakes inventory activities in collaboration with the Liberia Institute of Statistics and Geo-Information Services (LISGIS). Other institutions include: the Department of Forestry, University of Liberia and the Forestry Training Institute (FTI). The main phytogeographic/ecological zones in Liberia are: pure agricultural lands, mixed agricultural and forest areas, agriculture degraded forest, open dense forest, closed dense forests, savannah or bare soil, coastal ecosystem complex and agro-industrial plantation. A number of regional surveys have been undertaken in the past. Some permanent sample plots (PSPs) were established by the Liberia Forest Reassessment (LFR) Project in 2005 and another local inventory was undertaken in 1968. The most recent inventory, completed in 2019, was the first holistic national forest inventory (NFI). This led to the construction of the Forest Reference Emissions Level (FREL) of Liberia, as well as the NFI report. The design used nested circular sample plots. Biophysical variables other than tree-related metrics included: visual sighting of fauna (birds, mammals, reptiles and amphibians), topography, forest resources, understory type, land ownership, land use, forest types, crops (if present), disturbance, soil characteristics, canopy cover, dead wood, coarse and fine wood debris and regeneration. Tree measurements included diameter at breast height (DBH), tree height total and bole heights. Socioeconomic variables included: towns and villages selected within counties based on proximity to clusters, within which socioeconomy surveys were undertaken.

Sample design, scale and intensity

The inventory used a cluster design consisting of a set of five nested circular plots (of radii 18 m, 7 m and 2 m) arranged in a west-to-south direction at 60 m intervals (see Figure A1.19). On the 18 m radius plot (main plot), all live and dead standing trees with diameter equal to or greater than 40 cm (DBH ≥ 40 cm) were measured, while those between 10 cm and 39.9 cm were measured within the 7 m radius nested subplot; those with diameters between 2 cm and 9.9 cm (and height > 1.3 m) were tallied in the 2 m radius nested subplot. Coarse woody debris (CWD) were measured on a 18 m transect, while fine woody debris (FWD) were measured on a 5 m transect (first section of the transect). Other measurements included stumps. Field teams used digital data collection tools (Open Foris Collect Mobile).

Figure A1.19 Sample plot design, Liberia



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.10 Gap assessment variables, Liberia

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken in 2019 and are rated as most recent. The inventories have mainly been with technical support from the Food and Agriculture Organization of the United Nations (FAO) and financial support from the Forest Carbon Partnership Facility (FCPF) and the Government of Norway.*	
Type of inventory	2
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations, mostly pantropical equations.	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	1
Stump biomass estimates were derived from recent inventories conducted with the objective of estimating forest biomass for determining emission factors.	
Method of estimation of litter	2
Tier 2 method was used, based on country data from inventory.	
Soil organic matter (SOM) assessment	0
No information on soil organic carbon was provided.	
Allometric equations	0
No country-specific allometric equations were used in biomass estimation.	
Wood density estimates	1
Country-specific wood density estimates are available for some major species.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report): *Heritiera utilis* (niangon), *Entandrophragma utile* (sipo), *Canarium schweinfurthii* (aiele), *Lovoa trichiliodes* (dibetu), *Anigera robusta* (aningre), *Nauclea diderrichii* (kussa), *Triplochiton scleroxylon* (wawa), *Hellea ciliata* (abura), *Tieghemella heckelii* (makore) and *Terminalla ivorensis* (framire).*	
Non-timber forest products (NTFPs)	1
Calamus deeratus (bitter root/rattan), *Alchornea cordifolia* (christmas bush), *Xylopia staudtti* (country spice), *Baphia nitida* (cam wood), *Raphia palmapinus* (bamboo cane), *Ceiba pantandra* (cotton tree), *Hugaruna* (hugaruna), *Piptadeniastrum africanum*, *Mangabe* (monkey), *Panthere pardus* (leopard skin), *Apis mellifera* (honey), *Antelopes* (duikers) (deer meat) and *Phython sebae* (boa constrictor grease).**	
Biodiversity indices (based on FRA 2020)	1
Biodiversity information was obtained during the multi-resource inventories.	
Total score	**16/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme), Forest Carbon Partnership Facility (FCPF)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	No
Contact(s)	
Saah A. David, Jr (Focal point, REDD+ and ECOWAS Forest Conversion): fawasa@gmail.com Isaac Nyaneyon Kannah Teah (Expert, Climate MRV): inkteah@gmail.com J. Negatus Wright (Expert, Climate MRV): wright_jn@yahoo.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

** Forestry Development Authority. 2021. *Liberia: National forest inventory 2018/2019.* Monrovia, Government of Liberia. https://www.forestcarbonpartnership.org/system/files/documents/Liberia%20National%20Forest%20Inventory.pdf

Source: Authors' elaboration using data and capacity needs assessment.

Mali

Figure A1.20 Map of Mali

Source: FAO. 2022. SEPAL: Mali. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 1 241 238 km^2

Forest cover: 37 741 231 ha (2006 and 2014 Forest Inventory, National Forestry and Wildlife Directorate [DNEF], Ministry of the Environment, Sanitation and Sustainable Development [MEADD])

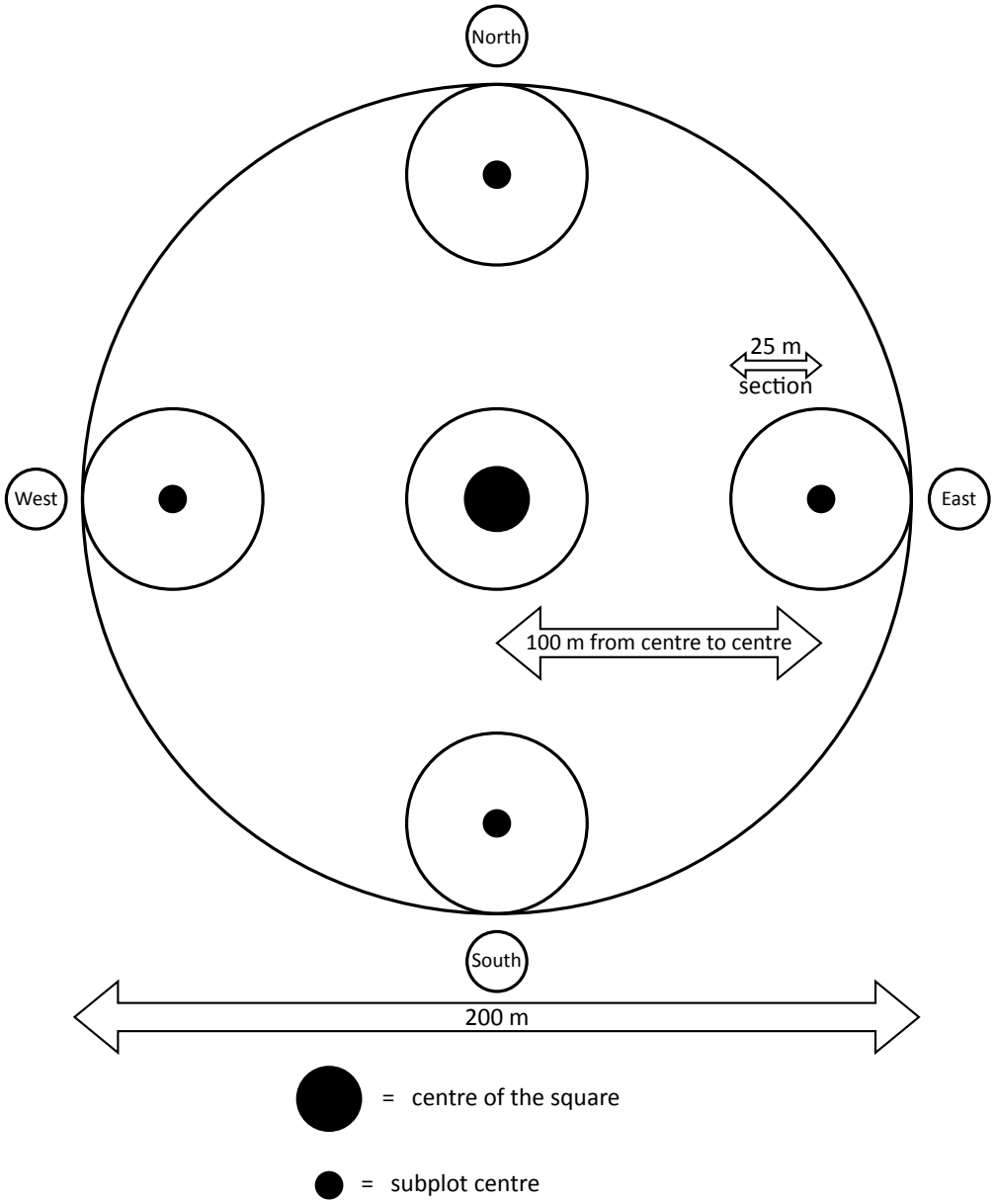
Country overview

The Forest Information System Management Unit (SIFOR) within the National Directorate of Water and Forests is the mandated lead institution in charge of forest inventories in Mali. Several inventories have been undertaken in the past, including the Integrated Wood Research Programme (PIRL) inventory in 1987 and the Agroecology and Sustainable Management of Rural Ecosystems (AGRER–GEEDER) mission in 2014. Other inventories include: the National Forest Inventory_1 (IFN_1), undertaken from 1986 to 1990; the National Forest Inventory_2 (IFN_2), covering northern Mali, undertaken from 2006 to 2009; and the National Forest Inventory_3 (IFN_3), covering southern Mali, undertaken from 2013 to 2014. Regarding measured variables, only the circumference of the trees at 1.3 m was measured, while the height of the trees was measured only for a sample of trees (the five tallest in each subplot, in order to estimate the dominant height/crown). Codification classes have been adopted for: dominant size (3: a, b, c); trees per ha (4: a, b, c, d); and basal area (4: a, b, c, d). A sample of trees was also measured for the development of tree volume equations. Measured carbon pools included: above ground (above ground biomass [AGB]), subsoil (below ground biomass [BGB]), dead wood and stumps, litter and soil organic matter (carbon).

Sample design, scale and intensity

The inventory was carried out between December 2013 and June 2014. In total, 682 clusters, made up of five circular plots and 3 409 subplots, were sampled. A two-stage stratified sampling design was adopted in each stratum. The primary sampling unit was a circle with a diameter of 250 m (a radius of 125 m) in which there are five circular subplots or a radius of 25 m: one central subplot and four others located in the four cardinal directions (north, south, east and west), 100 m from the central subplot.

Figure A1.21 Sample plot design, Mali



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.11 Gap assessment variables, Mali

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken in 2019 and are rated as most recent. The inventories have mainly been supported either through Reducing Emissions from Deforestation and Forest Degradation (REDD) projects or Forest Carbon Partnership Facility (FCPF) projects of bilateral support in the countries.	
Type of inventory	2
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations, mostly pantropical equations.	
Method of estimation of dead wood (DW)	0
No information was provided on DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	1
Default Intergovernmental Panel on Climate Change (IPCC) values were used for litter biomass.	
Soil organic matter (SOM) assessment	1
Estimates of SOM were provided, but are based on an independent study.	
Allometric equations	1
While Mali made use of pantropical equations, they developed country-specific allometric equations in 2014 where 543 trees were felled and measured for volume estimation in three bioclimatic zones. These included the Sudano-Guinean zone where equations for closed (1) and open forests (2) were generated; equations for open forests (3) in the country's Sahelian zone (3) were also generated. $V(1) = 7.455 \times C^{2.5145}$ $V(2) = 5.9 \times C^{2.5047}$ $V(3) = 18.402 \times C^{2.1822}$ Where: V : = tree volume in cm^3 C : circumference in cm	
Wood density estimates	0
No country-specific wood density values were available.	
Main timber species (based on FRA 2020)	1
Information was provided on the ten most important timber species (based on the FAO FRA 2020 report): *Guiera senegalensis* (sabara/sabara), *Combretum micrantum* (coubou/guéza), *Balanites aegyptiaca* (garbey/adoua), *Piliostigma reticulatum* (kossey/kalgo), *Combretum nigricans* (deligna/tchiriri), *Acacia nilotica* (banigna/bagaroua), *Acacia albida* (gao/gao), *Ziziphus mauritiana* (darey/magaria), *Hyphaene thebaica* (kangaou/gorouba) and *Acacia raddiana* (kandili).*	
Non-timber forest products (NTFPs)	1
Acacia senegal (gum arabic), *Apis melefica* (honey), *Ziziphus mauritiana* (jujubier fruit), *Balanites aegyptiaca* (balanites fruit), drupe de *Parinari macrophyla*, fruits and leaves of *Adansonia digitata*, fruits of *Parkia biglobosa*, leaves of *Hyphaene thabaica*, *Borassis aethiopium* (palm tree) and leaves of *Moringa oleifera*.**	
Biodiversity indices (based on FRA 2020)	0
Biodiversity information were not provided.	
Total score	**12/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	No
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	No

Contact(s)

Konongolo Coulibaly (Focal point, Convergence Plan): coulibalyk06@yahoo.fr

Cheick Oumar Karamoko Traoré (Focal point, FRA 2020): trakacho@gmail.com; contact@sifor-mali.net

Alassane Diallo (Focal point alternate, FRA 2020): cg.sifor@gmail.com; alassane201035@yahoo.fr; asalamaleykoum2013@gmail.com

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

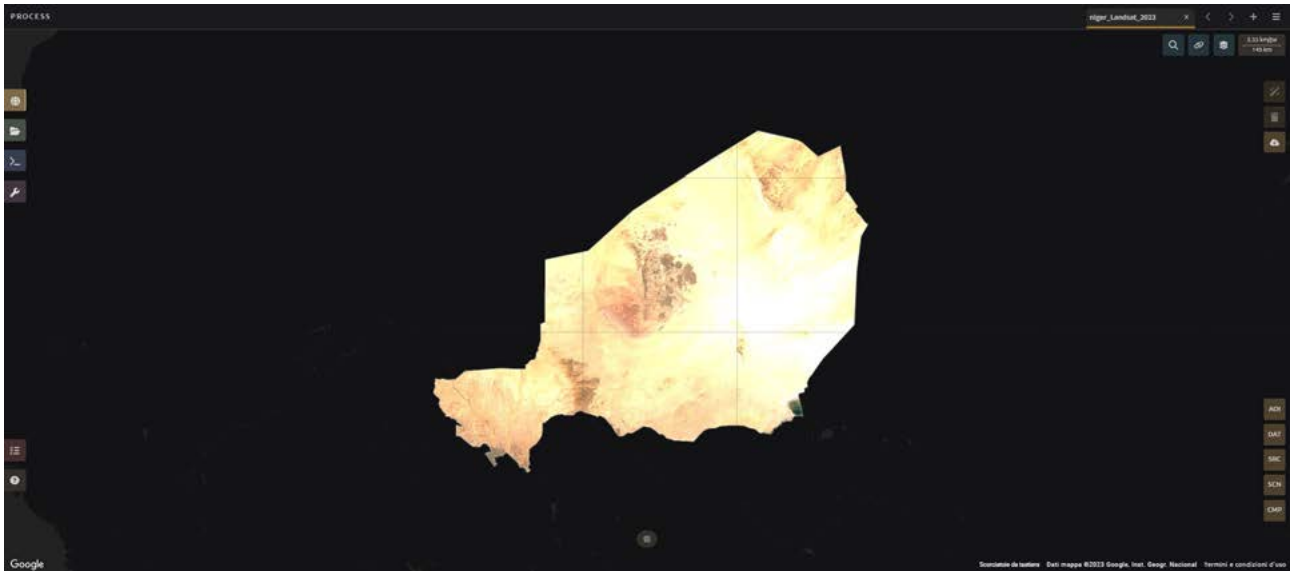
* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Niger

Figure A1.22 Map of Niger



Source: FAO. 2022. SEPAL: Niger. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 126 700 000 ha

Forest cover: 1 079 700 ha (FAO, 2020)

Country overview

The Mapping and Forest Inventory Division under the Ministry of Environment and Fight against Desertification is the primary institution responsible for forest inventories in Niger. Other institutions involved in this process include the National Centre for Ecological and Environmental Monitoring, research organizations such as the National Institute of Agronomic Research of Niger (INRAN), Agrhymet Regional Centre, Faculty of Science and Agronomy, as well as the National Forest Seed Center (CNSF). To date, no comprehensive national forest inventory (NFI) has been conducted in the country. However, some outdated reports referenced in the FRA 2020 include *Evaluation of the Forest Resources of Niger, Situation 1980–1985* and *Tropical Forest Action Programme (PAFI) for Niger* (1992) (FAO, 2020). The main ecological zones in Niger encompass: the Sudan-savannah (approximately 1 percent of the country) characterized by woody and shrub-savannah; the Sudano-Sahelian zone (approximately 10 percent of the country) dominated by wooded and shrub steppe; the Sahelian zone (approximately 12 percent of the country) consisting of herbaceous and shrub steppe with grassland dominance; and the Sahelo-Saharan and Saharan zones (approximately 77 percent of the country) covered with intermittent shrub/steppe vegetation, including species like *Acacia* spp., *Commiphora africana* and *Balanites aegyptiaca*. One recent inventory was conducted within the Sustainable Agroforestry for Food Security (SAFE) Project in the Diffa region. Additionally, researchers from the National Institute of Agronomic Research of Niger (INRAN) have been monitoring forest biomass plots measuring 12.4 hectares (620 m × 200 m) consisting of 124 contiguous random points (RPs) measuring either 20 m × 50 m or 30 m × 50 m. Some localized inventories have also been carried out on forest reserves known as "massifs forestiers" for the purpose of forest management. The SAFE study encompassed the measurement of tree diameter, tree height, stump diameter, stump height, tree health status and evidence of human interventions. The INRAN plots included measurements of diameters at 0.20 m above the ground and at 1.30 m, tree height, form coefficient, number of stems/sprouts per tree/stump, floristic composition, dry weight, age of sprouts, soil bulk density and soil organic carbon in the top 30 cm of the soil horizon.

Sample design, scale and intensity

The most recent forest inventory study is that of the Baban Rafi forest in 2013. The sampling method used was a systematic survey in which the basic statistical unit was the sample plot of 50 m × 20 m (1 000 m^2). The present sampling design had the advantage of facilitating field operations (rapid location and identification of plots) and allowed for a suitable distribution of sampling units (regularity in the distribution of plots over the entire population, which denotes good representativeness). A total of 1 338 plots were inventoried along 29 lanes, representing a sampling rate of 0.36 percent. The lines were oriented north/south, the plots were also oriented along their length, and the width was oriented west/east.

On the 1 338 plots, the inventory focused on the following main parameters:

- **distribution of stems by diameter class at 25 cm from the ground of the species** (*Combretum micranthum, Combretum nigricans, Combretum glutinosum, Guiera senegalensis* and other species):
  - **class 1**: 4 cm to 8 cm in diameter, or 12 cm to 25 cm in circumference (small wood);
  - **class 2**: 8 cm to 14 cm in diameter, or 25 cm to 44 cm in circumference (medium wood);
  - **class 3**: 14 cm to 20 cm in diameter, or 44 cm to 63 cm in circumference (large timber);
  - **class 4**: 20 cm to 30 cm in diameter, or 63 cm to 94 cm in circumference;
  - **class 5**: 30 cm to 40 cm in diameter, or 94 cm to 126 cm in circumference; and
  - **class 6**: > 40 cm in diameter, or circumference > 126 cm

- **at stand level:**
  - number of stems and frequency per species;
  - number per hectare, by class of diameter or circumference and by species; and
  - volume of wood per hectare according to the nature of the wood (dead, small living wood, medium and large living wood).

- **qualitative parameters:**
  - stem shape
  - quality of wood
  - phenological state
  - vigour
  - accessibility settings

Gap assessment variables

Table A1.12 Gap assessment variables, Niger

Variable	Gap assessment score
Year of inventory	1
The inventories conducted in the past are outdated and no longer up to date. However, under the Natural Forest Development Project (PAFN) in 2004–2005, a total of 358 000 hectares of forests in 38 communes were surveyed. Additional inventories were carried out in specific locations as part of various projects. For example, in 2015, an inventory was conducted in the city of Zinder and Maradi, followed by Niamey, Tillaberi and Dosso in 2017 under the FONABES project. Furthermore, in 2013, an inventory took place in the classified forests of Baban Rafi.	
Type of inventory	1
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	1
The default Intergovernmental Panel on Climate Change (IPCC) method was used, based on biomass conversion and expansion factors (BCEFs). $Biomass = Vt \times BCEF$	
Method of estimation of dead wood (DW)	1
The volumes of DW are taken into account and evaluated according to specific formulas. According to several documents, the formula usually used: $V = (0.0077 \times 77) + (0.0256 \times 0) + (0.0327 \times 0) + (0.048 \times 0) + (0.5858 \times 0)$ No information was provided on DW biomass.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	0
No estimate of litter biomass provided.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	1
17 allometric equations have been produced by researchers for: *Combretum glutinosum, Combretum micranthum, Combretum nigricans, Guiera senegalensis, Prosopis africana* and *Balanitex aegyptiaca.*	
Wood density estimates	1
Some wood density data has been produced from researchers in Niger for the following seven species: *Combretum glutinosum, Combretum micranthum, Combretum nigricans, Guiera senegalensis, Prosopis Africana, Faidherbia albida* and *Balanites aegyptiaca.* However, all species are taken into account and the density is calculated on this basis. The seven species listed are mostly used for fuelwood.	
Main timber species (based on FRA 2020)	1
Guera senegalensis (sabara/sabra), *Combretuim micranthuim* (guieza/goubou), *Balanites égyptiaque* (adoua/garbey), *Piliostigma reticulatuim* (kalgo/kossay), *Combretuim nigricans* (tchiriri/deligna), *Acacia nilotica* (baggaroua/banigna), *Acacia albida* (gao/gao), *Ziziphus mauritiana* (maggaria/darey), *Hyphaena thebaica* (goriba/kangaou) and *Acacia raddiana* (kandili). **Introduced species:** *Azardirachta indica* (dogan yaro), *Gmalena arborea* (baniroua inbaka ounwa), *Terminalia mentaly* (terminalia), *Terminalia catappa*, *Eucalyptus* and *Prosopis esp.**	
Non-timber forest products (NTFPs)	1
Gum Arabic, Apis melefica (honey), *Ziziphus mauritiana, Balanites aegyptiaca, Neocarya macrophyla, Adansonia digitata, Parkia biglobosa* (African locust bean), *Hyphaene thabaica* (leaves and fruits), *Borassis aethiopium, Moringa oleifera, Tamarindus indica, Vitellaria paradoxa, Boscia senegalensis, Faidherbia albida* (gao), *Sclerocarya birrea (fruit), Acacia nilotica (fruit) and Diospyros mespiliformis (fruit).***	

Biodiversity indices (based on FRA 2020)	1
Biodiversity information provided.	
Total score	**9/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	–
Forest Reference Emissions Level (FREL) submission	No
Data publicly available	Yes

Contact(s)

Souleymane Bokoye (FRA 2020): bokoyesouleymane@yahoo.fr
Yacouba Seybou (Focal point, Convergence Plan): yacoubseybou@yahoo.fr
Mamane Amina Tidjani (Focal point, NFI): tidalou@gmail.com

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Nigeria

Figure A1.23 Map of Nigeria

Source: FAO. 2022. SEPAL: Nigeria. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 92 377 000 ha

Forest cover: 12 625 950 ha (FAO, 2020)

Country overview

The Federal Department of Forestry is the mandated lead institution in charge of forest inventories in Nigeria. Another institution includes the Forest Research Institute Nigeria. The main ecological zones include: the mangrove forest and coastal vegetation, freshwater swamp forest, lowland rainforest, derived savannah, Guinea-savannah, Jos-plateau, Montane-forest, Sudan-savannah, and Sahel-savannah. Variables measured include: tree diameter, tree heights, dead wood diameters, lengths and heights, stump diameters and heights, and dead wood categories. Carbon pools estimated include: above ground biomass (AGB), below ground biomass (BGB), dead wood and stumps, litter, and soil organic matter (carbon).

Sample design, scale and intensity

The sampling design used was a stratified random cluster sampling, using the main ecological zones as strata. The sampling plan used a grid size of 10 km × 10 km in the various ecological zones, except the mangrove, where a grid size of 5 km × 5 km was used. The sampling unit was a cluster composed of a set of three square nested plots (or recording units) of 35 m × 35 m (main plots), two of which are positioned at right angles to the apex of a central plot in an L-shape transect arrangement, 100 m apart (see Figure A1.24). Within the main plots were the following nested plots: a 25 m × 25 m subplot (intermediate plot), a 7 m × 7 m subplot, and a 2 m × 2 m subplot (not shown in Figure A1.24).

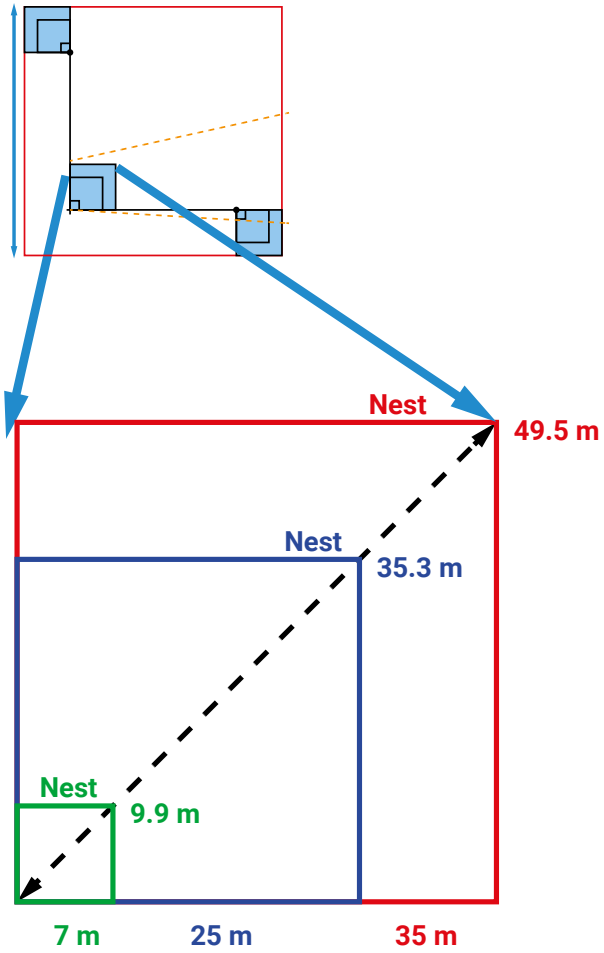
Table A1.13 Variable of interest, Nigeria

Unit	Size (area)	Tree diameter at breast height (DBH) limits
Sampling unit or tract	170 m × 170 m (28 900 m^2)	N/A
Nest 1 (large plot)	35 m × 35 m (1 225 m^2)	DBH > 40 cm
Nest 2	25 m × 25 m (625 m^2)	DBH 20 cm to 40 cm
Nest 3	7 m × 7 m (49 m^2)	DBH 5 cm to 20 cm
Nest 4	2 m × 2 m (4 m^2)	Saplings with DBH < 5 cm and height > 1.30 m

Note: Table created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Figure A1.24 Sample plot design, Nigeria



Note: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

An initial attempt to sample mangroves and freshwater swamps using this design failed due to the peculiarities of the ecosystems. Hence, a design similar to the one used for subregional inventory in Cross River State, as described in Ajonia (2008), was used. The design used three 10 m × 20 m rectangular-shaped sample plots (RPs) laid along a transect at intervals of 10 m, with 5 m × 5 m subplots nested within them, in an alternate manner (see Figure A1.25). All trees with diameter > 10 cm were measured in the entire plot; for trees with stilt/roots, measure diameter at 0.3 m (30 cm) above stilt. On the 5 m × 5 m subplot, all trees with diameter < 10 cm and height > 1.3 m were measured in the 5 m × 5 m subplot. Stilts were sampled in a 1 m × 1 m randomly located quadrat; soil samples were collected for soil organic carbon estimation.

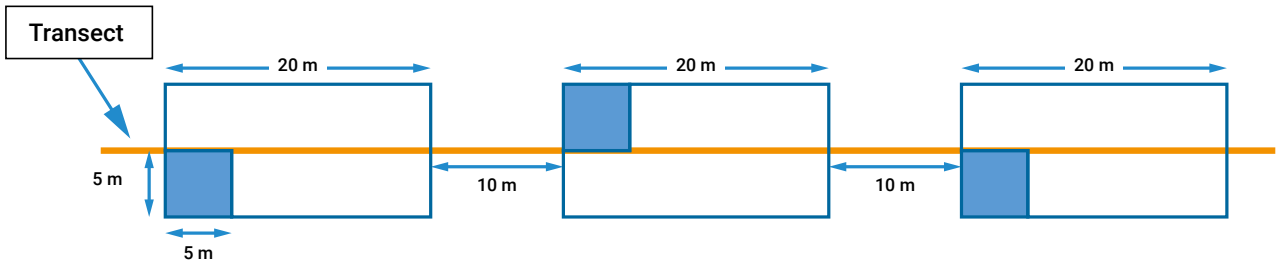
Table A1.14 Variable of interest, mangrove, Nigeria

Unit	Size (area)	Tree diameter at breast height (DBH) limits
Sampling unit or tract	10 m × 20 m (200 m^2)	DBH > 10 cm, trees with stilt/roots, measured at diameter at 0.3 m
Nest 2	5 m × 5 m (25 m^2)	DBH < 10 cm and height > 1.3 m
Nest 2	1 m × 1 m (1 m^2)	Randomly located quadrat to sample stilts

Note: Table created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Figure A1.25 Sample plot design, mangrove, Nigeria



Note: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.15 Gap assessment variables, Nigeria

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken after 2010 and are rated as most recent. The inventories have mainly been supported either through Reducing Emissions from Deforestation and Forest Degradation (REDD) projects or Forest Carbon Partnership Facility (FCPF) projects of bilateral support in the countries.	
Type of inventory	2
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations, mostly pantropical equations.	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	1
Stump biomass estimates were derived from recent inventories conducted with the objective of estimating forest biomass for determining emission factors.	
Method of estimation of litter	2
Tier 2 method was used, based on country data from inventory.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	1
Have allometric equations even though they still rely on pantropical equations for biomass estimation. Volume allometric equations and a few biomass allometric species for individual species in plantations.*	
Wood density estimates	1
Country-specific wood density estimates are available for some major species.	
Main timber species (based on FRA 2020)	1
From Global Forest Resource Assessment (FRA 2020): **Native species**: *Albizia zygia* (albizia), *Entandrophragma candollei* (entandrophragma), *Parkia biglobosa* (locust bean), *Vitellaria paradoxa* (shea butter), *Milicia excelsa* (iroko), *Khaya senegalensis* (dry zone mahogany), *Mansonia altisima* (mansonia), *Chrsophyllum albidum* (cherry), *Afzelia africana* (African mahogany) and *Garcinia kola* (bitter kola). **Exotic species**: *Tectona grandis* (teak), *Gmelina arborea* (gmelina), *Eucalyptus regia* (eucalyptus), *Acacia nilotica* (gum arabic) *and Pinus radiata* (pine).**	
Non-timber forest products (NTFPs)	1
Chrysophillum albidum, cane/rattan, honey, Adzadiracta indica, Parkia biglobosa (locust beans), dyes, Acacia nilotica, mushrooms, Thryonomys swinderanus (bushmeat) and *Garcinia kola (bitter cola).***	
Biodiversity indices (based on FRA 2020)	1
Information was provided on biodiversity indices.	
Total score	**17/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	Forest Carbon Partnership Facility (FCPF), United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	Yes (national FREL)
Contact(s)	
FRA 2020: Rasak Kolawole Adekola (Focal point, Convergence Plan): koladekola@yahoo.com Henry Karshima (Focal point, NFI): henrykarshima@yahoo.com	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* Ajonia G.N. 2008. Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic Coast of Cameroon. Breisgau, Germany, Albert-Ludwig-Universsitat Freiburg. PhD thesis. https://doi.org/10.13140/rg.2.2.12879.79526

** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

*** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Senegal

Figure A1.26 Satellite image of Senegal

Source: FAO. 2022. SEPAL: Senegal. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 19 671 200 ha

Forest cover: 8 068 160 ha (FAO, 2020)

Country overview

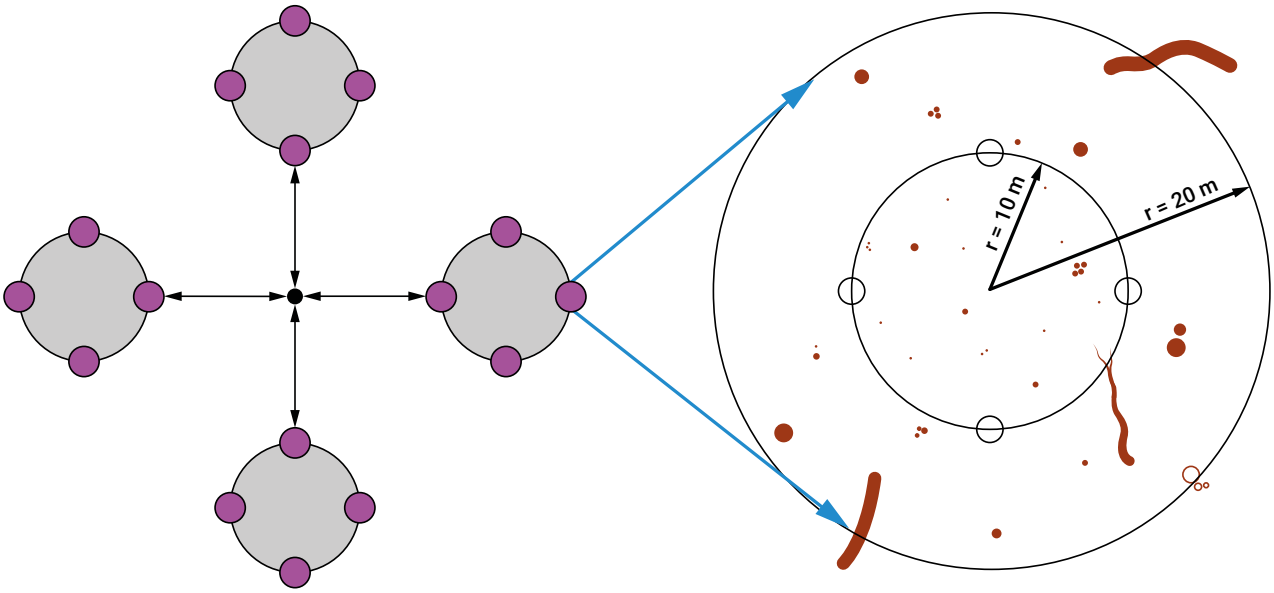
The Directorate of Water, Forests, Wildlife and Soil Conservation (DEFCCS) is the mandated lead institution in charge of forest inventories in Senegal. Another institution is the Ecological Monitoring Centre (CSE). Land cover types include: dense and clear/open forest in the south, gallery forests, woody and shrub savannah, filao plantations and *Casuarina equisetifolia* plantations for dune stabilization, and mangrove forests. Various types of inventories were undertaken within the Project for the Sustainable and Participatory Management of Traditional and Alternative Energies (PROGEDE1 and PROGEDE2), including inventories of community forests, national forests, and biodiversity inventories. Both permanent sample plots (PSPs) and temporary sample plots (TSPs) were established. The objective of PSPs is to monitor natural forest stand dynamics and yields. It should be noted that CSE and the National Forest Research Centre (CNRF) have specific permanent plot systems with well-defined objectives mainly focused on research. In addition to that, the Institute of Environmental Sciences (ISE) has its own sample plot system designed. The plot systems associated with the CSE, ISE and CNRF are not at all related to those employed by the DEFCCS, which has a national scope.

Variables measured/observed (in both TSPs and PSPs) include: geomorphological features, relief/altitude, slope and aspect, edaphic factors (soil depth) and ecological indicators, incidences of erosion, fires, type of regeneration, number of trees, reference diameter for standing live and dead trees, total height, length and width of crown, and length and quality of tree logs. Ecological and biodiversity variables included: floristic composition, tree frequency, relative dominance, regeneration status, tree harvesting, and damages. Dendrometric variables included: trees per hectare, basal area per hectare, quadratic diameter, mean height, stem quality, reference diameter for stumps, and standing dead trees. For standing dead wood, diameter and height measurements were taken to estimate the volume. All lying dead wood, regardless of the diameter of the stems, were weighed to determine the weight of the lying dead wood. These were combined to calculate volume and biomass.

Sample design, scale and intensity

Sampling design consisted of clusters of four nested circular plots, established at four cardinal directions (see Figure A1.27), and at 1 km from plot centre, and at 200 m from plot centre, within casuarina plantations and gallery forest stands. There were also circular nested plots with radii of 20 m, 10 m and 1 m. Within the 20 radius plot, all standing live and dead trees and stumps with diameter reference (DRE) equal to, or greater than 10 cm (DRE ≥ 10 cm) were measured, while those between 3 cm and 10 cm (3 cm ≥ DRE < 10 cm) were measured within the 10 m radius subplot. Regeneration was tallied in four 1 m radius subplots.

Figure A1.27 Sample plot design, Senegal



Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.

Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.16 Gap assessment variables, Senegal

Variable	Gap assessment score
Year of inventory	2
Inventories were undertaken between 2000 and 2010 (rated as recent).	
Type of inventory	2
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	2
Tier 2 method was used to estimate AGB. Data was collected during a recent inventory in the country.	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	1
Default Intergovernmental Panel on Climate Change (IPCC) values were used for litter biomass.	
Soil organic matter (SOM) assessment	0
No information on SOM was provided.	
Allometric equations	1
Allometric equations have been developed by scientists for some major species in Senegal. One of the studies used 600 sample trees from 12 species (covering over 80 percent of the national territory) from 102 sample locations. Methodology: Selected trees were measured while standing, then felled and cut into sections and measured for sectional lengths and diameters (for sectional diameter ≥ 10 cm) and for volume by water displacement for those with sectional measurements between 3 cm and 10 cm (3 cm ≤ diameter 10 cm). Wood density was determined based on oven-dried sample disks extracted from tree sections. Allometric equations to 3 cm top diameter were then developed based on the sample data.*	
Wood density estimates	1
Some wood density data collected during allometric equations data collection.	
Main timber species (based on FRA 2020)	1
FRA 2020: *Sterculia setigera* (gum karaya), *Combretum glutinosum* (mudcloth), *Cordyla pinnata* (bush mango), *Pterocarpus erinaceus* (African kino tree), *Daniella oliveri* (African copaiba balsam tree), *Terminalia macroptera, Lannea acida, Khaya senegalensis* (African mahogany), *Erythrophleum guineense* (ordeal tree) and *Combretum nigricans*.	
Non-timber forest products (NTFPs)	1
FRA 2020: *Detarium senegalensis* (sweet detar), *Ziziphus mauritiana* (Indian jujube), *Parkia biglobosa* (African locust bean), *Saba senegalensis* (weda tree), *Adansonia digitata* (African baobab), *Sterculia setigera* (gum karaya), *Acacia senegal* (gum acacia), *Elaeis guineensis* (African oil palm) and *Borassus aethiopium* (palm tree).**	
Biodiversity indices (based on FRA 2020)	0
No information was provided on biodiversity indices.	
Total score	**13/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	Forest Carbon Partnership Facility (FCPF), United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	No
Contact(s)	
FRA 2020: Mamadou Badji: abeune69@yahoo.fr Mamadou Kora (Focal point, Convergence Plan): mamadou.kora@environnement.gouv.sn; mamadoukora@yahoo.fr Olimata Faye (Focal Point NFI): fayeolimata@yahoo.fr	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* Diop, M., Sambou, B., Goudiaby, A., Guiro, I. & Niang-Diop, F. 2011. Plant resources and social preferences in rural Senegal. *Tropical woods and forests, 310(4): 57–68.* https://doi.org/10.19182/bft2011.310.a20459

** FAO. 2020. *Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

Sierra Leone

Figure A1.28 Satellite image of Sierra Leone

Source: FAO. 2022. SEPAL: Sierra Leone. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

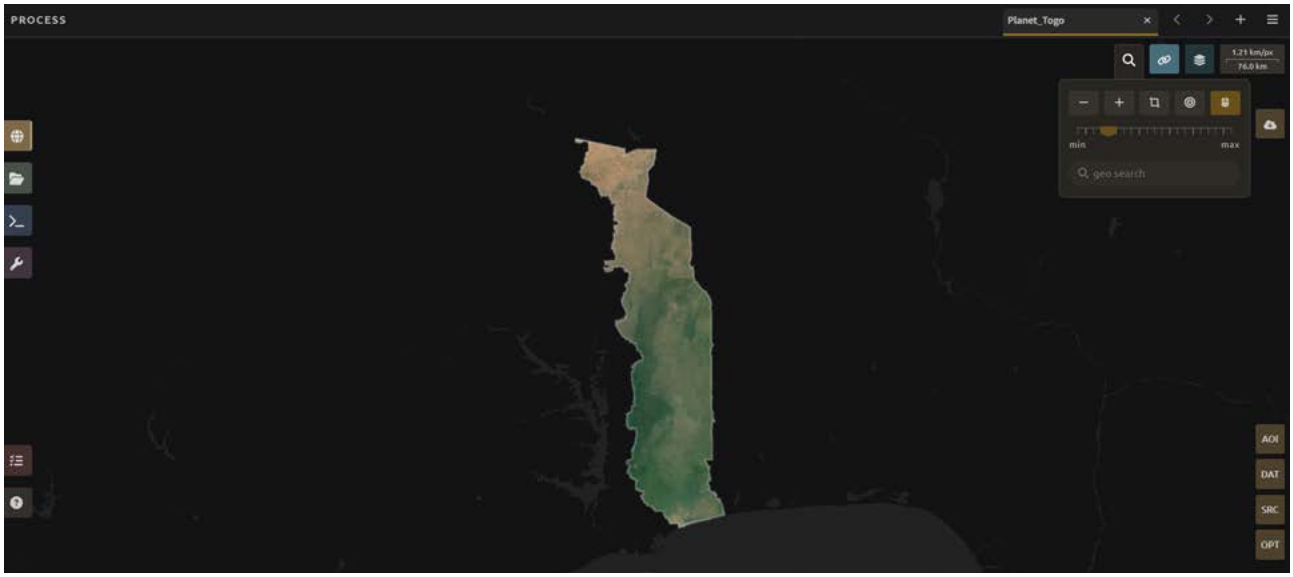
Country area: 7 230 000 ha

Forest cover: 2 534 880 ha (FAO, 2020)

Data not available at the time of publication.

Togo

Figure A1.29 Satellite image of Togo



Source: FAO. 2022. SEPAL: Togo. In: *SEPAL*. Rome. Cited 18 May 2023. https://sepal.io

Country area: 5 679 000 ha

Forest cover: 1 209 270 ha (FAO, 2020)

Country overview

The Ministry of Environment and Forest Resources (MERF) is responsible for conducting forest inventories in Togo. In 2015, the country carried out a national forest inventory (NFI) as part of the ProREDD NFI Project. Currently, Togo is conducting a second inventory by remeasuring the permanent sample plots (PSPs) established in 2015. The plot centres of all sample plots have been geolocated to facilitate future remeasurements. The ProREDD NFI, supported by the German Society for International Cooperation (GIZ), has been underway since September 2015, using a stratified random sampling approach with 1 000 PSPs. The land cover types in Togo include dense semi-deciduous and deciduous forests, gallery forests, open/clear forests, woody savannah, shrub and herbaceous savannah, cultivated and fallow land, and swamp forests. The information collected in the most recent inventory includes data on regeneration, bole height, total height, and diameter at breast height (DBH) for both live and dead trees. However, there is no available data on wood density or allometric equations. The ProREDD NFI measured and assessed various parameters such as DBH, tree height, volume of the main stem, stem biomass, branch biomass, twigs and leaves, wood biomass (for dry weight), non-timber forest products (NTFPs) and data necessary for calculating biodiversity indices.

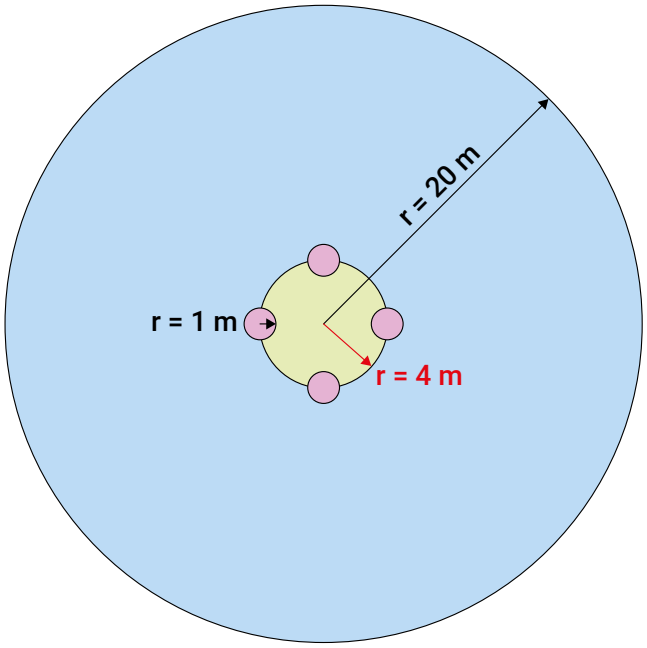
Sample design, scale and intensity

The sampling design consisted of a 16 000 2 km × 2 km grid/polygons covering the entire country from which 4 000 were randomly selected. Within the selected polygon, a grid of 200 m × 200 m was selected and nested circular plots were established within each grid. The nested plots were composed of a 20 m radius plot (main plot) within which one 4 m radius circular subplot and four 1 m radius circular subplots were nested (see Figure A1.30).

On the 20 m radius plot, all standing live and dead trees with diameter equal to or greater than 10 cm (DBH ≥ 10 cm) were measured for diameter and height, while those between 5 cm and 10 cm (5 cm ≤ DBH < 10 cm) were measured on the 4 m radius plot. The four 1 m radius circular subplots were used for sampling regeneration (that is, all saplings with DBH < 5 cm and height > 1.3 m). One 20 cm metallic peg was buried at the centre of each plot for relocation in the future.

Figure A1.30 Sample plot design, Togo

Notes: Figure created by Global transformation of forests for people and climate: a focus on West Africa.



Source: Authors' elaboration from NFI reporting.

Gap assessment variables

Table A1.17 Gap assessment variables, Togo

Variable	Gap assessment score
Year of inventory	3
Inventories were undertaken in 2015/2016 and 2021, and are rated as most recent. The inventories have mainly been supported either through Reducing Emissions from Deforestation and Forest Degradation (REDD) projects (ProREDD, 2015/2016) or Forest Carbon Partnership Facility (FCPF) projects of bilateral support in the countries (REDD+, 2021).	
Type of inventory	1
Inventory has been undertaken at national level.	
Method of estimation of above ground biomass (AGB)	1
Tier 2 method was used to estimate above ground live biomass, based on country inventory data and application of allometric equations, mostly pantropical equations.	
Method of estimation of dead wood (DW)	2
Tier 2 method was used to estimate DW biomass. Data was collected during a recent inventory in the country.	
Stump biomass assessment	0
Stump biomass estimates were not provided.	
Method of estimation of litter	0
No estimate of litter biomass provided.	
Soil organic matter (SOM) assessment	0
No country-specific soil data collected during NFI.	
Allometric equations	0
No country-specific allometric equations.	
Wood density estimates	0
No country-specific wood density values for species.	
Main timber species (based on FRA 2020)	1
FRA 2020: *Anogeissus leiocarpus, Ceiba pentandra, Isoberlinia doka, Cola gigantea, Daniellia oliveri, Pterocarpus erinaceus, Diospyros mespiliformis, Manilkara multinervis, Vitellaria paradoxa* and *Isoberlinia tomentosa.*[*] Exotic Species: *Tectona grandis, Cassia siamea, Mangifera indica, Acacia auriculaeformis* and *Persea Americana.* A total of 345 species (324 indigenous species and 21 exotic species) were surveyed from the 918 plots. The ten most important species, based on importance value index, include: *Vitellaria paradoxa, Pterocarpus erinaceus, Lannea acida, Anogeissus leiocarpus, Cussonia kirkii, Daniellia oliveri, Isoberlinia doka, Crossopteryx febrifuga, Ficus sur* and *Terminalia nglaucescens.*[**]	
Non-timber forest products (NTFPs)	1
FRA 2020: **All NTPFs**: *Adansonia digitata* (baobab), *Apis mellifera* (honey bee), *Blighia sapida, Borassus aethiopum* (palm), *Cola nitida* (cola tree), *Detarium senegalense* (sweet detar), *Dialium guineense*, *Garcinia kola* (small cola tree), *Hyphaene thebaica, Irvingia gabonensis* (wild mango tree), *Lannea microcarpum, Monodora myristica, Moringa oleifera* (moringa tree), Parkia biglobosa (African locust bean), *Pentadesma butyracea, Piper guineense*, Plantes médicinales, *Spondias mombin, Tamarindus indica, Vitellaria paradoxa* (shea butter tree), *Vitex doniana, Xylopia aethiopica* (Ethiopian pepper) and *Z. Zanthoxyloides*. **The ten most important NTFPs include**: *Parkia biglobosa* (African locust bean), *Vitellaria paradoxa* (shea butter tree), *Abeille* (honey and beeswax), *Tamarindus indica* (tamarind tree), *Moringa oleifera* (moringa tree), *Detarium senegalense* (sweet detar), *Pentadesma butyracea* (African butter tree), *Xylopia aethiopica* (Ethiopian pepper), *Borassus aethiopum* (palm tree) and *Garcinia kola* (small cola tree).[***]	
Biodiversity indices (based on FRA 2020)	0
–	
Total score	**9/18**

Reducing Emissions from Deforestation and Forest Degradation (REDD) programme	Forest Carbon Partnership Facility (FCPF), United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)
Forest Reference Emissions Level (FREL) submission	Yes
Data publicly available	No
Contact(s)	
Dr. Amah Atutonou (Focal point, Convergence Plan): lydia_atutonu@yahoo.fr Moussa Samarou (Focal Point NFI): msamarou76@gmail.com Gnama Wiyaou (Alternate Focal Point CBDR/IFN): princegnama@yahoo.fr	

Notes: Contents of this factsheet have been reviewed and approved by the relevant country authority.

* *Dangbo, F., Gardi, O., Adjonou, K., Hlovor, A., Blaser, J. & Kokou, K.* 2020. *An analytical assessment of forest cover changes over the last 30 Years in the semi-deciduous forest zone of Togo. Journal of Horticulture and Forestry, 12(2): 70–83.* https://academicjournals.org/journal/JHF/article-full-text-pdf/F65C57E64057

** *Dangbo, F., Gardi, O., Kokou, K. & Blaser, J.* 2019. *Estimating biomass and biomass change in semi-deciduous forests zone of Togo.* Lomé, University of Lomé. http://article.sapub.org/10.5923.j.ijaf.20201004.01.html

*** *FAO. 2020. Global Forest Resources Assessment 2020: Main report.* Rome. https://doi.org/10.4060/ca9825en

Source: Authors' elaboration using data and capacity needs assessment.

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For more information, please contact:

Forestry Division - Natural Resources and Sustainable Production

E-mail: NFO-Publications@fao.org

Web address: www.fao.org/forestry/en

Food and Agriculture Organization of the United Nations

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