Technical Assistance for a Study on Forest Biomass Energy Conversion

Second Progress Delivery Report Output D 2.1

A report with the collected information that explains how supply chains work and at what points the greatest amount of wood waste is generated

2nd Progress Report

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List of Abbreviations

ABO	Association Burundaise pour la Protection des Oiseaux
ACVE	Action Ceinture Verte pour l'Environnement
ADICN	Association pour le Développement Intégré et la Conservation de la Nature
AFD	African Development Bank
AFEB	Association of Women for the Environment in Burundi
ANCPA	National Association of Cashew Producers and Cooperatives
APEX	Promotion Agency of Exports of Burkina Faso
APFG	Association for the Promotion of Women of Gaoua
APFG	Association for the Promotion of Women of Gaoua
APFNL	Agency for the Promotion of Non-Timber Forest Products
CARITAS	Centre de Médecine Traditionnelle de Buta
CARPE	Central African Regional Programme for the Environment
CARPE	Central African Regional Programme for the Environment
CBO	Community Based Organisations
CERD	Centre d'Etude et de Recherche de Djibouti
CFA	Compagnie Forestière des Abeilles
CFA	Centre de Formation Artisanal
CFA	Centre de Formation Artisanal
CIFAT	Interprofessional Council of the Cashew Industry of Togo
CNT	Cashew Nut Tax
COMIFAC	African Forest Commission or Commission des Forêtsd'Afrique Centrale
CSO	Civil Society Organizations
CTCN	Climate Centre for Technology and Network
ECREEE	Center for Renewable Energy and Energy Efficiency
EDD	Électricité de Djibouti
FAO	Food and Agriculture Organization
FAO	Food and Agriculture Organization

FRA	Forest Resources Assessment
GDP	Gross Development Product
GDP	Gross Domestic Product
GIZ	German Technical Cooperation
INDC	Intended Nationally Determined Contributions
INECN	Institut National de l'Environnementet de la Conservation de la Nature
IUCN	International Union for Conservation of Nature
IUCN	International Union for Conservation of Nature
MEDD	Ministry of Environment and Sustainable Development
NGO	Non-Governmental Organisation
NIOTO	New Oilseed Industries of Togo
OBPE	*Office Burundais pour la Protection de l'Environnemen*
ODEB	Organisation de défense de l'environnement au Burundi
ODEF	Office for the Development and Exploitation of Timber
PMG	Participatory Management Group
ProDRA	Program for Rural Development and Agriculture
REDD+	Reducing emissions from deforestation and forest degradation
SDG	Sustainable Development GoalsG
SODEFOR	Forest Development Corporation
SORAD	Regional planning and development corporations
SPGS	Sawlog Production Grant Scheme
UGPPK	Union of Groups of Producers of Shea Products of Koundougou
UNAPROKA	National Union of Shea Producers
UNDP	United Nations Development Program
UNEC	United Nations Economic Commission
USAID	United States Agency for International Development

Definitions of commonly used terms

Term	Description
Deforestation	The conversion of forest to other land use independently whether human-induced or not.
Forest	Land covering an area of more than 0.5 hectares (5,000m^2) with trees growing to a height of more than 5 meters and a forest cover of more than 10%, or with trees capable of meeting these criteria (FAO). The definition excludes land whose predominant use is agricultural or urban.
Forest biomass	The term includes (i) primary forest residues generated during conventional forestry operations such as site preparation, salvage harvesting, thinning and final felling, (ii) secondary forest residues generated during industrial wood processing, (iii) tertiary residues from construction, renovation and demolition, and (iv) traditional fuelwood
Forest ownership	Generally refers to the legal right to freely and exclusively use, control, transfer, or otherwise benefit from a forest. Ownership can be acquired through transfers such as sales, donations, and inheritance.
Forest policy	A set of orientations and principles of actions adopted by public authorities in harmony with national socio-economic and environmental policies in a given country to guide future decisions in relation to the management, use and conservation of forest for the benefit of society.
Industrial roundwood	The wood removed for the production of goods and services other than energy production (woodfuel)
Other wooded land	Land not classified as "Forest", spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.
Plantation forest	Planted Forest that is intensively managed and meet all the following criteria at planting and stand maturity: one or two species, even age class, and regular spacing. • Specifically includes: short rotation plantation for wood, fibre and energy. • Specifically excludes: forest planted for protection or ecosystem restoration. • Specifically excludes: Forest established through planting or seeding which at stand maturity resembles or will resemble naturally regenerating forest
Planted forest	Forest predominantly composed of trees established through planting and/or deliberate seeding.
Production	Forest where the management objective is production of wood, fibre, bio-energy and/or non wood forest products.
Sustainable Forest Management	A dynamic and evolving concept, [that] is intended to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations.
Tree	A woody perennial with a single main stem, or in the case of coppice with several stems, having a more or less definite crown.
Woodfuel	The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use

1 INTRODUCTION

93% of rural households and 58 percent of urban households in Africa depend on wood biomass. Currently, the wood biomass conversion is highly inefficient and has very low recovery rates, yet there are various technologies that could be used to convert biomass to provide more convenient forms of bioenergy. Increasing use of traditional biomass, charcoal and firewood, is a direct cause of deforestation and forest degradation in many countries of West, Central and East Africa. Food and Agriculture Organization Global Forest Resources Assessment (FRA, 2005) has estimated that the demand for energy wood in the African Forest Commission or Commission des Forêtsd'Afrique Centrale (COMIFAC) countries in 2005 was 1,317,000 m^3 of wood in the rough, or 441,572 tonnes of firewood, and it took 611,995 tonnes of wood to produce 73,734 tonnes of wood charcoal. The use of firewood and wood charcoal will continue to be essential in the coming decades, both in cities and in rural settings. This growing demand is due to the combined effect of the following three underlying causes: (i) population growth, (ii) the absence of alternative energy sources appropriate for low-income populations, and (iii) inefficient production and use of wood charcoal. To address the wood biomass inefficiency challenge the Government of the Republic of the Congo, the Democratic Republic of the Congo, the Central African Republic, the Republic of Cameroon, the Gabonese Republic, the Republic of Equatorial Guinea, the Republic of Chad, the Republic of Burundi, the Republic of Senegal, the Republic of Côte d'Ivoire, the Republic of Mali, Burkina Faso, the Togolese Republic, the Republic of Benin and the Republic of Djibouti approached the Climate Centre for Technology and Network (CTCN) for a technical assistance (TA) aimed at identifying various options for economical industrial conversion of forest waste through projects with a significant positive climatic and social impact.

1.1 Objectives and Scope of the Study

The objective of the Study is to:

- Assess the bioenergy potential from sustainable biomass sources across 15 African countries, such as wood waste from forest harvesting operations and industry;
- Improve afforestation and forest sector residues energy conversion; and
- Identify market opportunities for the private sector that will bypass the exploitation of traditional biomass sources.

The CTCN technical assistance is intended to promote projects that establish a sustainable industrial chain for forest biomass energy conversion using planted forest as raw material and forestry biomass and sawmill waste. It is anticipated to bring about the following impacts and co-benefits and contribute to country obligations to the Paris agreement through the Intended Nationally Determined Contributions (INDCs) and Sustainable Development Goals (SDGs) (Table 1).

Table 1: Project impacts, co-benefits, and contribution to INDCs and SDGs

Project Impacts	Co-benefits	Contribution to INDCs
• Sustainable industrial chain for forest biomass energy conversion using planted forest as raw material and forestry biomass and sawmill waste. • Reduction of pressure on native forests. • Increase the final bio-energy use options such as cogeneration plants that use pyrolysis gases and waste. • Significant reduction of greenhouse gas emissions thanks to more efficient charcoal production, waste conversion, increased forest cover, and decreased deforestation rates.	• Reduced greenhouse gas emissions, creation of employment through sustainable bio-energy projects. • Sustainable and efficient use of wood biomass, reduced discarded forest residues in wood processing value chains. • Contribution to the development of the COMIFAC Convergence Plan and national REDD+ processes. • Gender mainstreaming in the forestry sector.	• Reduced GHG emissions from deforestation and forest degradation • Improved forest site conditions for regeneration and planting thereby increasing carbon sequestration. • Production of electricity from sustainable sources such as forest biomass energy conversion and/or cogeneration. • Creation of a system of forest eco-industrialization in the sector

Contribution to SDGs

SDG 5 : Gender equality

- End of all forms of discrimination against all women and girls in selected countries.

SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all

- Industrial scale wood fuel will lower costs of production and improve its access; an d
- Industrial scale wood fuel and organization of artisanal producers will provide viable andsustainable wages for rural populations.

SDG 13: Take urgent action to combat climate change and its impact

- The information generated could be the base of new policies that promote the modern bio-energy sources from wood as a substitute to traditional biomass;
- Planted forests as source of raw material will strengthen the adaptation option and land restoration; and
- Industrial scale wood fuel will reduce the GHG emissions from current inefficient wood fuel production.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

- Industrial scale wood fuel will reduce the pressure on natural forests and thus help to forest recovery; and
- Reduced deforestation and degradation will lower GHG emissions by each of the 15 countries supported.

15 How Supply chain works and at what points the greatest amounts of wood waste is generated.

1.2 Technical Approach and Methodology

The TA covers six outputs, each with a set of activities:

1. Output 1: Development of implementation planning and communication documents
2. Output 2: Identification of the source of forest residues in the forest supply chain. Identification of hot spots of wastes in the supply chain in order to map the sites where the greatest amount of waste is generated
3. Output 3: Determine the requirements for and availability of technologies for converting the identified biomass resources. Bioenergy technologies to be selected must be specific for feasible solutions according to the specific context of each country
4. Output 4: Sustainability Assessment. Many factors may influence the final performance of the bioenergy end solutions proposed. The analysis must focus on risk and benefits vis a vis environmental, socio-economic, policies, business model, and funding sources factors
5. Output 5: Selection and the implementation of pilot projects (one per country)
6. Output 6: A final (1 day) workshop will be organized to present the activities of the technical assistance.

A detailed approach and methodology for each output and associated activities is provided in the proposal to CTCN. Here below we outline an abridged version of the approach and methodology. It involves three main aspects:

1. **Literature and document reviews:** This is being carried out through a review of policies, country development priority reports, past and ongoing project reports in the 15 countries focusing on the following sectors--Agriculture, Forestry, Energy, Environment, Gender and climate change processes. The aim of this exercise is to ensure that we understand countries priorities and policies regarding use of biomass energy, how the utilization of biomass in these countries affects related sectors such as agriculture, environment and socio-economic implication including gender.
2. **Consultation with main Stakeholders:** This is being carried out through intense consultations with the countries National Designated Entities (NDEs), project proponents and other key stakeholders. In this regards we have divided the 15 countries into three main areas and identified coordinators of these regions, for ease of implementation:
    - Central Africa Countries - Government of the Republic of the Congo, the Democratic Republic of the Congo, the Central African Republic, the Republic of Cameroon, the Gabonese Republic, the Republic of Equatorial Guinea and the Republic of Chad
    - West Africa Countries -the Republic of Senegal, the Republic of Côte d'Ivoire, the Republic of Mali, Burkina Faso, the Togolese Republic, the Republic of Benin and
    - East and Horn of Africa - the Republic of Burundi and the Republic of Djibouti
3. **Collection of primary data where applicable and field visits:** We have identified country contacts who are assisting in the collection of the required field data. However, due to Covid-19 pandemic very limited visits are being carried out in the initial period, with more focus on available secondary data.

This report covers Output 2: Identification of the source of forest residues in the forest supply chain. As per the terms of reference, it involved the following activities:

- Mapping actors involved in the supply chain and flows of wood and their wastes.
- Identification and description of flow of wood and wood waste (from harvesting - transport - to processing - to a lesser extent consumption);
- Georeferencing of the links where wood waste is generated in the supply chain.
- Quantification of the waste generated in each site of the supply chain; and
- Assessment of feasibility of forest biomass residues pilot projects.

In order to map out forest biomass residue sources and users and to quantify forest biomass residues in different forest areas in each of the 15 countries, three types of forms (presented in Annex 1a, 1b and 1c) were used to collect information. Using these forms, the following information was collected and analysed: sources and generators of forest residue biomass, forest biomass residue availability and quantities in target countries and estimated costs of generating different bioenergy products and biproducts.

2 OVERVIEW OF THE FOREST AND ENERGY SECTOR IN AFRICA

2.1 An overview of the Forest Sector in Africa

2.1.1 Economic importance of Africa's forest and role in climate change mitigation

"The African Union recognizes forests and woodlands as important resources for uplifting the continent from poverty, especially with regard to energy, food, timber, a wide range of non-timber forest products and environmental services that underpin ecosystem functions in support of agricultural productivity and

Africa is rich in forests and woodlands, as well as trees outside forests. According to FAO (2020) Africa has 637 million hectares (ha) under forests, which comprise 16% of the world's forest cover (FAO, 2020). Table 2 shows the forest area changes in Africa by sub-region, 1990–2020, compared to other regions.

Table 2: Forest area, by region and sub-region, 1990-2020

Region/subregion	Forest area (1 000 ha)			
	1990	2000	2010	2020
Eastern and Southern Africa	346 034	332 580	314 849	295 778
Northern Africa	39 926	38 104	36 833	35 151
Western and Central Africa	356 842	339 365	324 333	305 710
Total Africa	**742 801**	**710 049**	**676 015**	**636 639**
East Asia	209 906	229 071	252 390	271 403
South and Southeast Asia	326 511	308 077	305 461	296 047
Western and Central Asia	48 976	50 262	53 109	55 237
Total Asia	**585 393**	**587 410**	**610 960**	**622 687**
Europe excl. Russian Federation	185 369	193 000	198 847	202 150
Total Europe	**994 319**	**1 002 268**	**1 013 982**	**1 017 461**
Caribbean	5 961	6 808	7 497	7 889
Central America	28 002	25 819	23 706	22 404
North America	721 317	719 721	722 987	722 417
Total North and Central America	**755 279**	**752 349**	**754 190**	**752 710**
Total Oceania	**184 974**	**183 328**	**181 015**	**185 248**
Total South America	**973 666**	**922 645**	**870 154**	**844 186**
WORLD	**4 236 433**	**4 158 050**	**4 106 317**	**4 058 931**

Source: FAO, 2020

The forestry sector throughout sub-Saharan Africa is of great importance, due to its significance in subsistence production in rural communities which gives forestry a high share of the Gross Domestic Product (GDP) of these countries. Forests, woodlands, and trees play a key role in African economies, providing a substantial source of employment and economic growth as well as contributing to risk reduction and resilience strategies. The sector provides major sources of income and subsistence benefits, generates informal work opportunities and constitutes reservoirs of economic value that help ameliorate shocks to household incomes, particularly in rural areas (FAO, 2016). The value added in the forest sector amounts to just US$17 billion and accounts for about 0.9% of the Africa economy

(FAO, 2014). Enterprises producing solid wood products are the largest employers at the global level and in all regions except Africa, with total employment at about 5.4 million people (FAO, 2014).

Forests are important sources of energy for many countries. They generate considerable biomass that supports an overwhelming majority of Africans with their energy needs, mostly as wood-fuel. Forests and woodlands are the main source of household energy in Africa, with 82% of households relying on fuel-wood and charcoal for cooking and heating. Demand is expected to increase by 20% over the 2010–2030 period (Bromhead, 2012). Forests are also good sanctuaries for wildlife, offer opportunities for beekeeping, support many important ecosystem services and goods, and are home to many genetic resources. They are catchments to many rivers that are essential to the economic development of the continent.

Forests and trees in Africa account for 23% of global carbon stored in forests, and deforestation and forest degradation account for 30% of Africa's Greenhouse Gas (GHG) emissions. Forests and trees have the potential to become a significant carbon sink and contribute to climate regulation. Between 1990 and 2010, Africa contributed 21% of the global total of carbon in forest biomass, with Central Africa containing the largest amount of carbon in forest biomass. Côte d'Ivoire reported the highest level of carbon stock per hectare in the region (177 tonnes per hectare) followed by the Republic of the Congo.

2.1.2 Deforestation and forest degradation in Africa

Despite their importance, Africa continues to lose its forest cover. The global forest area declined by about 178 million ha (an area approximately the size of Libya) in the 30 years from 1990 to 2020 according to the FAO 2020 Global Forests Resource Assessment (FAO, 2020). The rate of net forest loss decreased substantially over the period 1990–2020 due to a reduction in deforestation in some countries, plus increases in forest area in others through afforestation and the natural expansion of forests.

Africa had the highest net loss of forest area in the decade to 2020, with Eastern and Southern Africa and Western and Central Africa accounting for most of the losses (Table 3). There has been an increase in the average annual rate of net forest loss in Africa since 1990, from 3.28 million ha in 1990–2000, to 3.40 million ha in 2000–2010, to 3.94 million ha in the most recent decade (Figure 1). The main causes of deforestation are increases in the area planted for subsistence agriculture to meet food security needs and increasing demands for wood energy.

Table 3: Deforestation rate, by region and subregion, for four periods spanning 1990-2020

Region/subregion	Deforestation (1 000 ha/yr)			
	1990–2000	2000–2010	2010–2015	2015–2020
Eastern and Southern Africa	1 781	2 240	2 116	2 199
Northern Africa	461	442	330	316
Western and Central Africa	1 854	1 631	1 998	1 899
Total Africa	**4 096**	**4 314**	**4 444**	**4 414**
East Asia	399	353	369	170
South and Southeast Asia	3 689	2 232	2 460	1 958
Western and Central Asia	82	99	96	107
Total Asia	**4 170**	**2 684**	**2 925**	**2 235**
Total Europe	**88**	**92**	**201**	**69**
Caribbean	3	2	23	5
Central America	228	222	142	168
North America	740	475	253	263
Total North and Central America	**972**	**699**	**418**	**436**
Total Oceania	**655**	**662**	**458**	**42**
Total South America	**5 837**	**6 667**	**3 354**	**2 953**
WORLD	**15 818**	**15 117**	**11 801**	**10 150**

Source: FAO, 2020

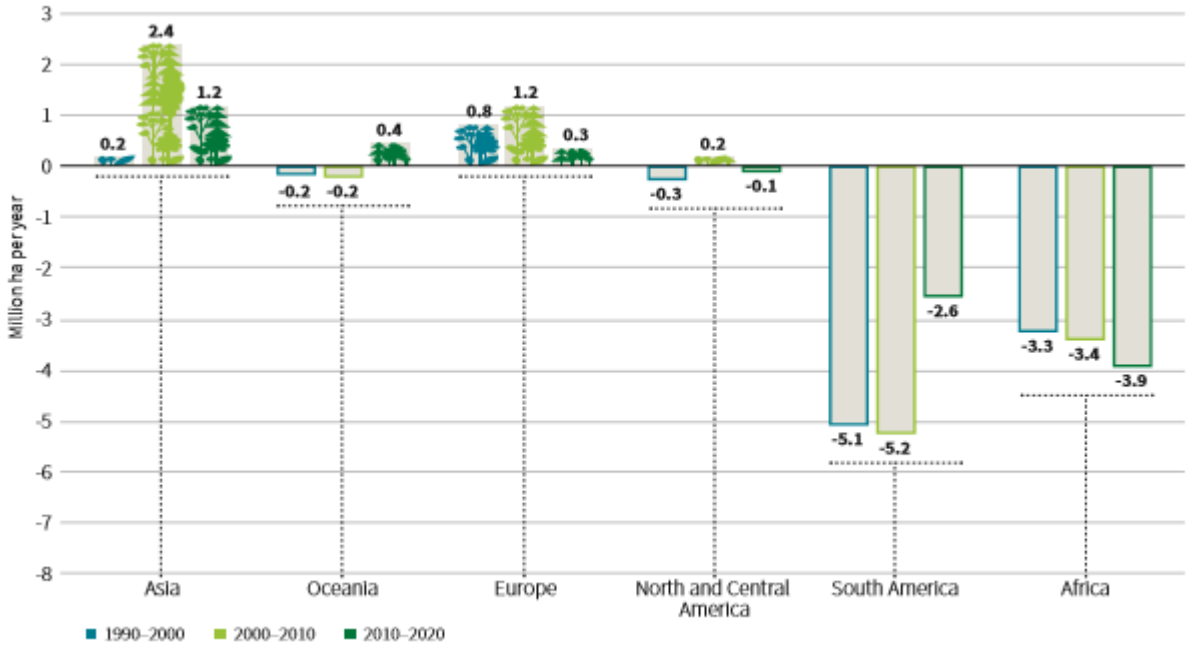


Figure 1: Annual forest area net change, by decade and region, 1990-2020 Source: FAO, 2020

2.1.3 Rate of Plantation Establishment in Africa

In terms of plantation establishment, globally, the area of planted forests increased by 123 million ha between 1990 and 2020. In Africa, this grew by 2.9 million in the same period from 8.5 in 1990 to 11.4 in 2020(Table 4).

Table 4: Area of planted forest, by region and subregion, 1990-2020

Region/subregion	Area of planted forest (1 000 ha)			
	1990	2000	2010	2020
Eastern and Southern Africa	6 161	6 214	6 758	7 139
Northern Africa	1 383	1 477	1 849	1 983
Western and Central Africa	956	1 230	2 017	2 269
Total Africa	**8 500**	**8 921**	**10 624**	**11 390**
East Asia	57 483	68 298	86 882	98 139
South and Southeast Asia	12 949	21 503	27 781	31 469
Western and Central Asia	3 757	4 206	4 976	5 621
Total Asia	**74 188**	**94 007**	**119 640**	**135 230**
Europe excl. Russian Federation	41 743	46 572	52 080	55 004
Total Europe	**54 394**	**61 932**	**71 693**	**73 884**
Caribbean	479	501	731	851
Central America	74	133	267	391
North America	22 596	31 986	39 646	45 785
Total North and Central America	**23 149**	**32 621**	**40 645**	**47 027**
Total Oceania	**2 784**	**3 775**	**4 491**	**4 812**
Total South America	**7 046**	**9 406**	**14 866**	**20 245**
WORLD	**170 061**	**210 662**	**261 958**	**292 587**

Source: FAO, 2020

Globally, the average annual rate of increase was higher in 2000–2010, at 5.13 million ha, than in 1990–2000, at 4.06 million ha, but it dropped to 3.06 million ha in 2010–2020. In Africa, the average annual rate of increase doubled from 0.4million ha to 0.8 million ha (Table 5).

Table 5: Annual change in the area of planted forest, by region and sub-region, 1990-2020

Region/subregion	Planted forest annual change					
	1990–2000		2000–2010		2010–2020	
	1 000 ha/yr	%	1 000 ha/yr	%	1 000 ha/yr	%
Eastern and Southern Africa	5	0.09	54	0.84	38	0.55
Northern Africa	9	0.66	37	2.27	13	0.70
Western and Central Africa	27	2.54	79	5.07	25	1.18
Total Africa	**42**	**0.48**	**170**	**1.76**	**77**	**0.70**
East Asia	1 082	1.74	1 858	2.44	1 126	1.23
South and Southeast Asia	855	5.20	628	2.59	369	1.25
Western and Central Asia	45	1.14	77	1.70	65	1.23
Total Asia	**1 982**	**2.40**	**2 563**	**2.44**	**1 559**	**1.23**
Europe excl. Russian Federation	483	1.10	551	1.12	292	0.55
Total Europe	**754**	**1.31**	**976**	**1.47**	**219**	**0.30**
Caribbean	2	0.45	23	3.84	12	1.54
Central America	6	6.07	13	7.21	12	3.86
North America	939	3.54	766	2.17	614	1.45
Total North and Central America	**947**	**3.49**	**802**	**2.22**	**638**	**1.47**
Total Oceania	**99**	**3.09**	**72**	**1.75**	**32**	**0.69**
Total South America	**236**	**2.93**	**546**	**4.68**	**538**	**3.14**
WORLD	**4 060**	**2.16**	**5 130**	**2.20**	**3 063**	**1.11**

Note: The rate of change (%) is calculated as the compound annual change rate.

Source: FAO, 2020

2.2 An overview of the Energy Sector in Africa

In Africa, energy is a key economic component value of forests. Total primary energy supply (TPES) is the measure of total energy use in a country and is usually measured in energy statistics in million tonnes of oil equivalent (MTOE). Wood energy makes the greatest contribution to TPES in Latin America and the Caribbean and in Africa (13% and 27% respectively). In both of these regions, woodfuel from forests accounts for the majority of all wood energy used, the highest contribution being in Africa where about one-quarter of all energy used in this region comes from forests and trees (FAO, 2014). The TPES for Africa is predominantly determined by biomass demand (Figure 2), with almost half of the energy demand (47.9%) being covered by biomass and waste.

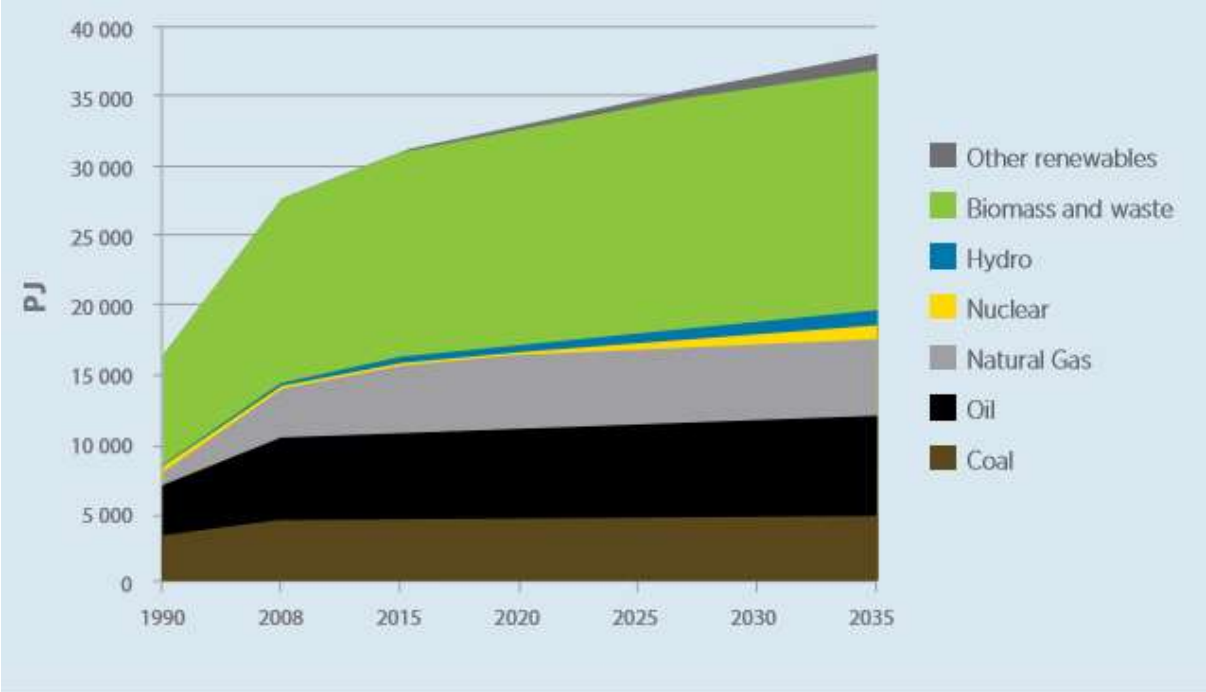


Figure 2: Total primary energy demand for energy sources in Africa Source: (IEA, 2010)

The International Energy Agency (IEA) estimates that the total final consumption biomass/waste share will lie between 51% and 57% by 2035 depending on which scenarios are assumed (IEA, 2010). However, there are enormous regional differences within Africa. Particularly those countries characterised by high poverty, the proportion of biomass is much higher. In some countries, such as Burundi and the Central African Republic covered in this study, the energy provision from biomass is 90% or greater (S., 2011)The Biomass Potential in Africa Study notes that despite an increase in energy use, many poor households in Africa have no access to modern energy sources, with majority (a total of 657 million people (80% of the population) relying on traditional biomass use (mostly firewood and charcoal) (IEA, 2010). It is important given this scale of biomass use that modern bioenergy systems are developed to provide an important contribution to future energy systems and to the development of sustainable energy supplies in Africa.

Energy is a major use of wood from forests and trees outside forests. About 50% of the roundwood extracted from forests worldwide annually (or around 1.86 billion cubic metres) is used as fuel, for cooking and heating in households, for small industrial activities (such as brick making and tea processing), and to a lesser extent for generating electricity. As shown in Figure 3, roundwood's share of energy use varies across regions, reaching 90% in Africa and over 60% in Asia. About 40% of the world's wood-fuel is consumed in Asia, 36% in Africa, 17% in America, and 8% in Europe (FAO, 2017). FAO has estimated that woodfuel accounts for about 6% of the world's total primary energy supply (based on 2011 data). In Africa, it accounts for 27% of primary energy supply; it is highest in Central Africa (70%), East Africa (65%) and West Africa (30%), and lower in Southern Africa (11 percent) and North Africa (9%). Overall, wood provides more than half of national primary energy supplies in 29 countries, of which 22 are in sub-Saharan Africa (FAO, 2014).

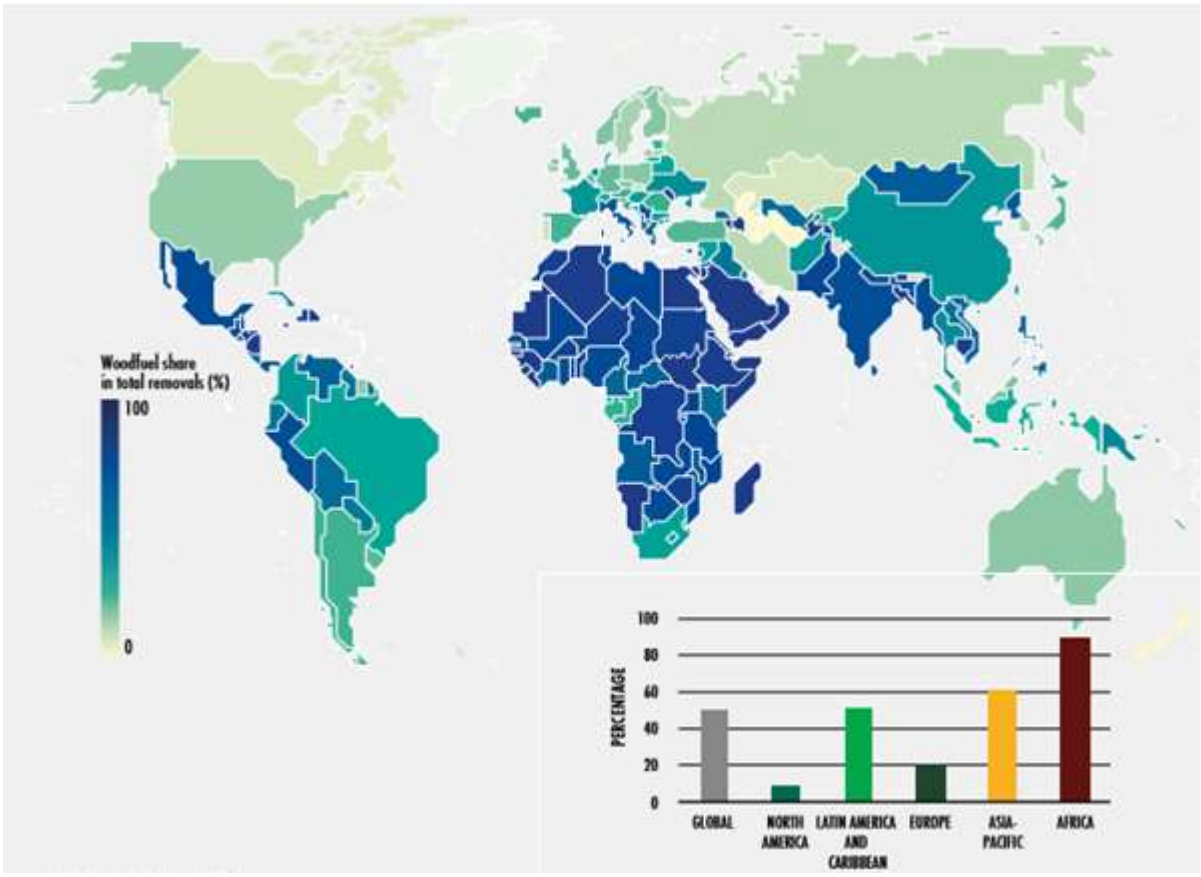


Figure 3: Proportion of roundwood used as fuel in different regions and across countries

Forests also make substantial contribution to renewable energy by generating electricity through hydropower. After biomass, hydropower generation is the second largest renewable energy source (FAO, 2018). Latest data from Tracking Sustainable Development Goal (SDG) 7, the 2020 Energy Progress Report (IEA, IRENA, UNSD, World Bank, WHO, 2020) show that the global population lacking access to electricity dropped to 789 million in 2018, from 1.2 billion in 2010 (IEA, IRENA, UNSD, World Bank, WHO, 2020). Between 2010 and 2018, electrification accelerated faster than demographic growth worldwide. For Sub-Saharan Africa, even though electrification outpaced population growth for the period, recent growth in access (2016 to 2018) fell below population growth. This resulted in a net annual increase of almost 0.3 million people without access to electricity in the region between 2016 and 2018, driven largely by a slowdown in two large access-deficit countries: DRC and Nigeria (Figure 4).

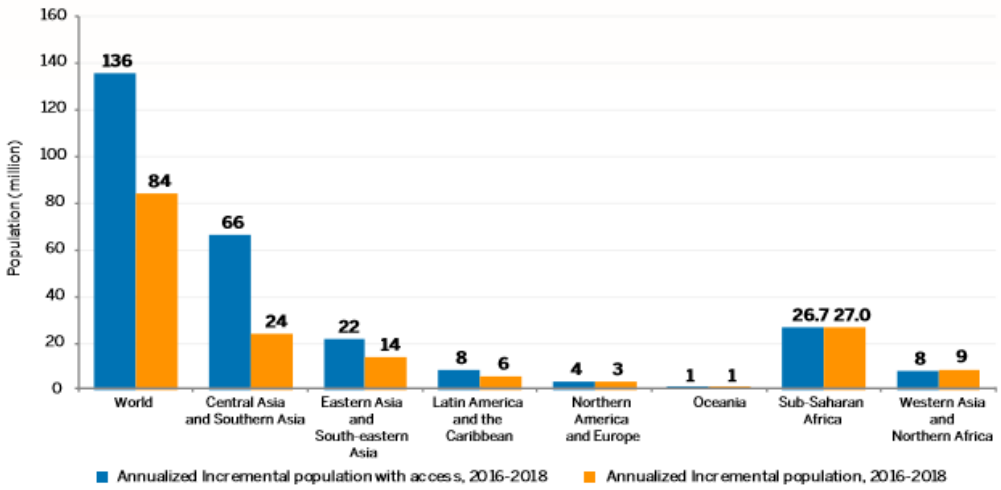


Figure 4: Annual incremental increases in electrification and population, 2016-2018, by region

SDG target 7.1 is universal access to affordable, reliable, sustainable, and modern

In 2018, 63% of the global population had access to clean cooking fuels and technologies, comprising electric, liquefied petroleum gas (LPG), natural gas, biogas, solar, and alcohol-fuel stoves. According to the Tracking SDG 7 Report, the rate of increase in access to clean cooking has decelerated since 2012, falling behind population growth in some countries. Deficient access rates dominate in the developing countries of Sub-Saharan Africa and Asia (Figure 6). When considering the average access-deficit for the five-year period between 2014 and 2018, the 20 countries with the largest populations lacking access to clean fuels and technologies are concentrated in these regions (Figure 5)

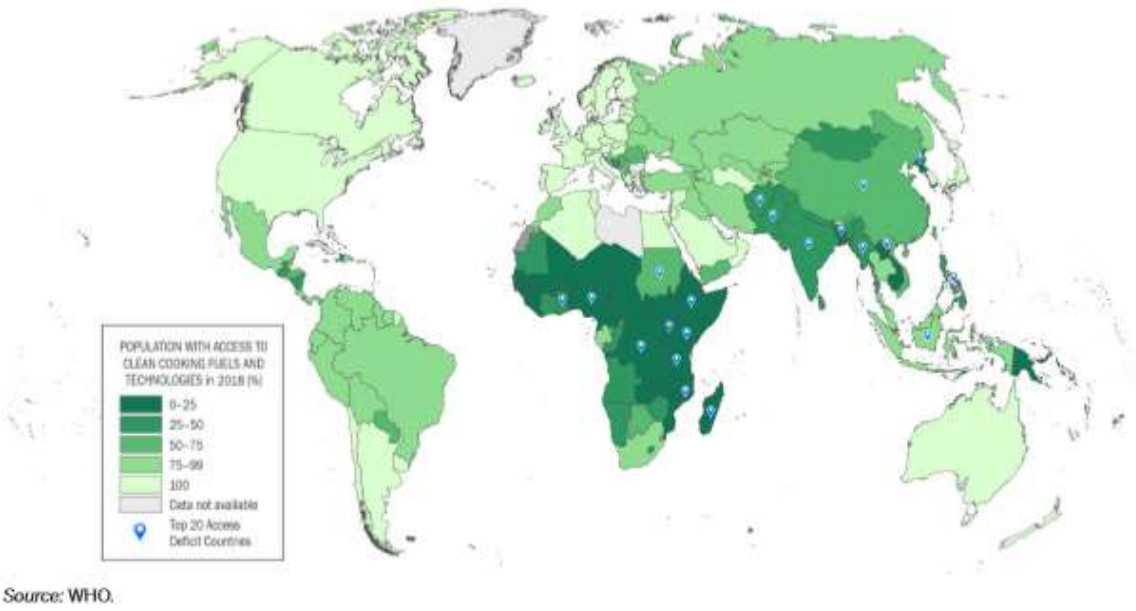


Figure 5: Regional populations, by rate of access to clean cooking fuels and technologies, 2018

Source: WHO

Figure 6: Top 20 access deficit countries, 2014-2018

2.2.1 Forests – Energy – Climate Nexus

Energy is essential to development, and without modern energy services, Sub Sahara African (SSA) countries have struggled to raise agricultural productivity and alleviate poverty. In contrast to North Africa and South Africa with quite universal modern energy access, still over 70-90% of the populations in most parts of SSA depend on traditional woodfuels, such as fuelwood and charcoal, as primary energy for cooking and heating. Nearly all rural households use wood for cooking and over 90% of urban households use charcoal. While few updated reliable statistics are available, Africa has the highest per capita woodfuel consumption (0.89 m^3/year) compared to other continents (e.g. Asia: 0.3 m^3/ cap/year) by the late 1990s (WAF, n.d.). The majority still rely on inefficient and rudimentary technologies in terms of energy consumption to harvest, produce and consume traditional woodfuels. Woodfuel supply becomes unsustainable if harvest is beyond the carrying capacity of the ecosystems and faster than natural or planted renewal rates. Among potential implications of unsustainable woodfuel harvest, environmental and socio-economic impacts at the household level come first. Unsustainable woodfuel harvest can be among key drivers of the loss of tree cover and deforestation, then land degradation and soil erosion, thus the loss of the ecosystem services (soil, water, and biodiversity) which result in declining farm productivity.

Overall, forests supply about 40% of global renewable energy in the form of woodfuel – as much as solar, hydroelectric and wind power combined. The total forest carbon stock (i.e. including all carbon pools) is estimated at 662 Gt (163 tonnes per ha) according to the latest data by FAO (i.e. the 2020 Forest Resource Assessment Report) and Africa only contributes about 12% (Table 6). The global forest carbon stock decreased between 1990 and 2020, due to an overall decrease in forest area. There were considerable regional and sub-regional differences in the trend, however: for example, the carbon stock in forest biomass decreased considerably in South America and Western and Central Africa (Figure 7).

Table 6: Forest carbon stock in carbon pools, by region and sub-region, 2020

Region/subregion	Carbon in living biomass		Carbon in dead wood and litter		Carbon in soil		Total carbon	
	Million tonnes	tonnes/ha	Million tonnes	tonnes/ha	Million tonnes	tonnes/ha	Million tonnes	tonnes/ha
Eastern and Southern Africa	13 248	44.8	1 302	4.4	11 700	39.6	26 250	88.7
Northern Africa	1 090	31.0	103	2.9	897	25.5	2 090	59.5
Western and Central Africa	36 229	118.5	1 522	5.0	14 795	48.4	52 546	171.9
Total Africa	**50 567**	**79.4**	**2 927**	**4.6**	**27 392**	**43.0**	**80 886**	**127.1**
East Asia	11 767	43.4	5 051	18.6	21 089	77.7	37 907	139.7
South and Southeast Asia	23 393	79.0	976	3.3	17 100	57.8	41 468	140.1
Western and Central Asia	2 388	43.2	399	7.2	2 571	46.5	5 358	97.0
Total Asia	**37 547**	**60.3**	**6 426**	**10.3**	**40 760**	**65.5**	**84 733**	**136.1**
Europe excl. Russian Federation	13 833	68.4	3 725	18.4	21 635	107.0	39 192	193.9
Total Europe	**54 574**	**53.6**	**17 191**	**16.9**	**100 677**	**98.9**	**172 442**	**169.5**
Caribbean	493	62.5	82	10.4	1 522	193.0	2 098	265.9
Central America	1 840	82.1	166	7.4	2 063	92.1	4 069	181.6
North America	39 301	54.4	30 953	42.8	69 697	96.5	139 951	193.7
Total North and Central America	**41 634**	**55.3**	**31 201**	**41.5**	**73 282**	**97.4**	**146 118**	**194.1**
Total Oceania	**13 881**	**74.9**	**3 247**	**17.5**	**15 935**	**86.0**	**33 063**	**178.5**
Total South America	**96 331**	**114.1**	**7 057**	**8.4**	**41 457**	**49.1**	**144 846**	**171.6**
WORLD	**294 535**	**72.6**	**68 049**	**16.8**	**299 504**	**73.8**	**662 088**	**163.1**

Source: FAO, 2020

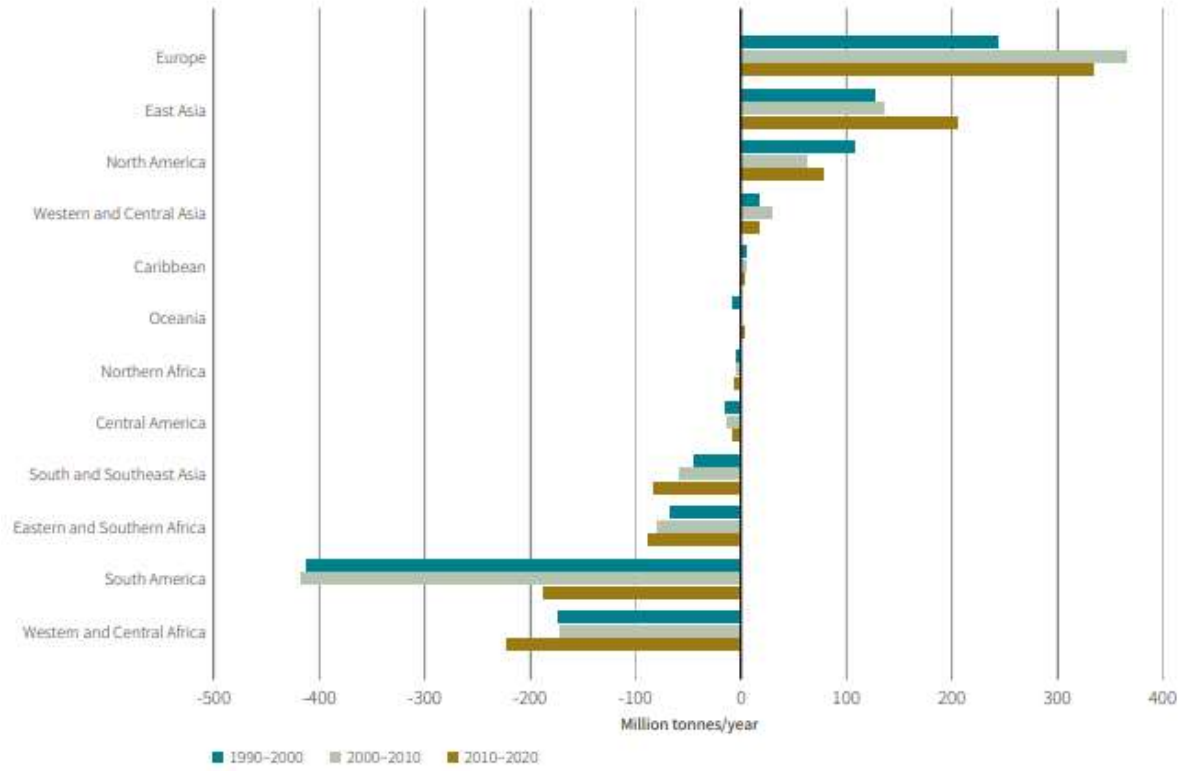


Figure 7: Change in forest biomass carbon stock, by region and sub-region, 1990-2020 Source: FAO, 2020

African forests and landscapes, however, are under pressure, and account for a substantial proportion of global GHG emissions from land-use change, agriculture, deforestation, and forest degradation. Since these factors together account for 30% of GHG, African forests, if well managed, have potentially a contribution to make to global climate mitigation. Opportunities for solution in the forest – energy – climate nexus include building policies for sustainable biomass production that could enable new business opportunities for smallholders and forest based enterprises to grow, biomass value chain development to enhance better utilization of scarce raw material (e.g. forest biomass residuals) and parallel change for using other renewable energy sources (e.g. solar) as well as utilization of improved cooking stoves. Table 7 below provides a summary of the FAO, Forest Resource Assessment Statistical fact sheet for Africa in relation to forest coverage (natural and planted forests), forest management and ownership.

Table 7: Statistical Factsheet for Africa, 2020

AFRICA 58 countries and territories					
VARIABLE (UNIT)	1990	2000	2010	2020[a]	DATA AVAILABILITY (%)[b]
Forest area (million ha)	743	710	676	637	100
Forest area (% of land area)	24.9	23.8	22.6	21.3	100
Growing stock (billion m^3)	88	84	81	76	100[c]
Growing stock (m^3/ha)	118.0	118.8	119.8	120.0	100[c]
Carbon stock in biomass (Gt)	59	56	54	51	100[c]
Carbon stock in biomass (t/ha)	79.1	79.3	79.5	79.4	100[c]
Total carbon stock (Gt)	94	90	86	81	100[c]
Total carbon stock (t/ha)	126.9	126.9	127.1	127.1	100[c]
Naturally regenerating forest (million ha)	734	701	665	625	100
Planted forest (million ha)	8.5	8.9	10.6	11.4	100
… of which plantation forest (million ha)	6.0	6.2	7.1	7.7	100
Primary forest (million ha)	143	137	131	123	51
Mangroves (million ha)	3.40	3.33	3.26	3.24	95
Forest in protected areas (million ha)	124	125	129	131	72
Forest area with management plans (million ha)	–	79	91	118	64
Designated management objective					
Production (million ha)	109	104	91	91	79
Protection of soil and water (million ha)	43	41	38	36	52
Conservation (million ha)	95	97	104	107	69
Social services (million ha)	2.0	1.8	1.7	3.0	28
Multiple use (million ha)	95	88	82	73	37
Other (million ha)	0	0	0	0	23
VARIABLE (UNIT)	1990	2000	2010	2015	DATA AVAILABILITY (%)[b]
Private ownership (million ha)	46	39	37	36	93
Public ownership (million ha)	526	508	481	463	93
Other/unknown ownership (million ha)	166	158	154	157	100

Note:
[a] Data for 2020 comprise countries that reported complete time series of data, and values may differ from those presented in the report based on the analysis of exclusively 2020 data.
[b] Data availability refers to the proportion of total forest area represented by reporting countries.
[c] Missing values have been filled with FAO estimates.

Source: FAO, 2020

2.2.2 Importance of the Bio-energy Sub Sector in Africa

Bio-energy is currently the primary energy resource for about 2.7 billion people worldwide (Wicke, Smeets, & Faaij, 2011), playing a traditional role in Africa. Bio-energy is energy derived from the conversion of biomass feedstocks, where biomass may be used directly as fuel, or processed into liquids and gases. Biomass feedstocks among other things includes plants and animals, wood, waste, gas, and alcohol fuels. In Africa,82% of households rely on fuel-wood or charcoal for cooking and heating, and the demand for fuel-wood and charcoal is projected to increase by 20% between 2010 and 2030. While much fuel-wood in rural areas is locally collected and used, charcoal is the fuel of choice in most urban areas because of its flexibility and the ease with which it can be transported. Woodfuel is not only used for cooking and sterilizing water but also has a wider role as a source of energy, including heating homes and the industrials scale use of woodfuel for electricity generation or co-generation of heat and power (FA, 2018). Figure 8 shows the percentage of households that rely on woodfuel for cooking.

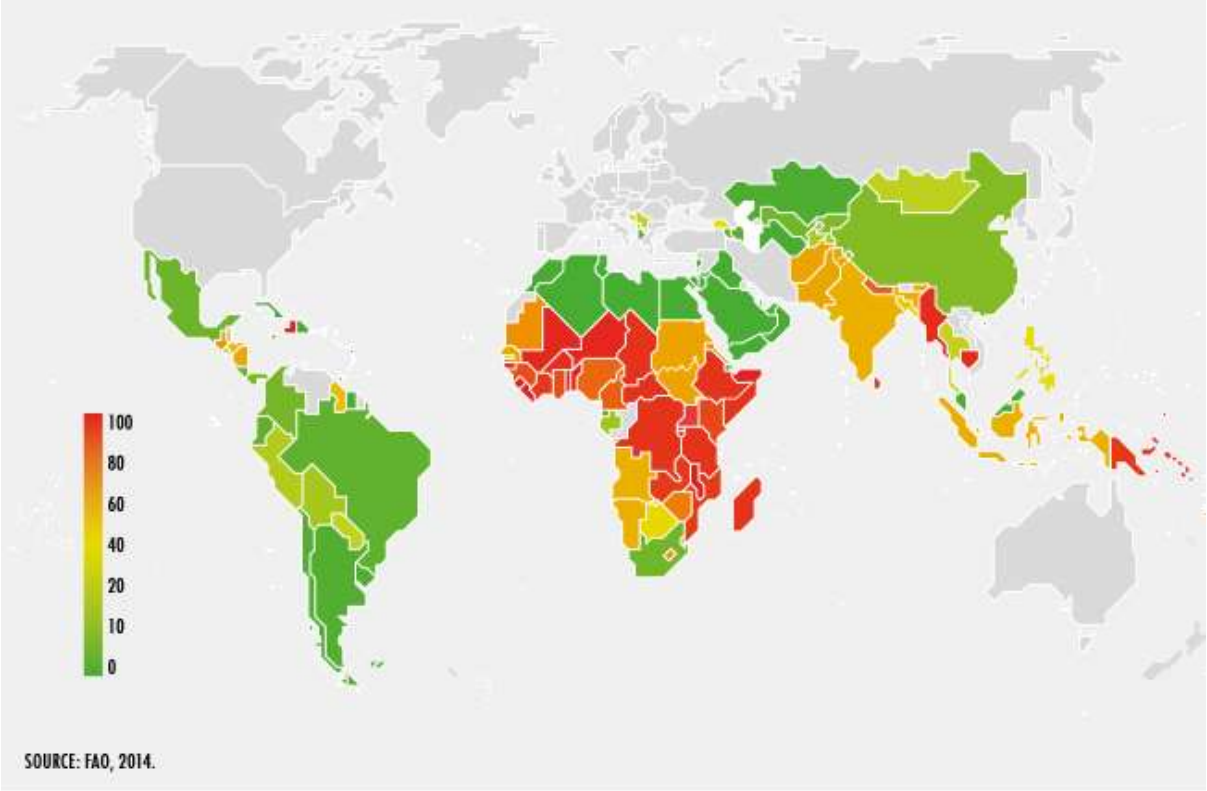


Figure 8: Percentage of households that rely on woodfuel for cooking globally

Fuel-wood and charcoal account for 90% of timber removals in Africa or 615 million m^3 annually, but this sub-sector's economic contribution is not reflected in GDP figures. For example, wood energy accounts for 90% or more of all energy used in 13 African countries. In addition to much of western and central Africa, wood energy also accounts for a high proportion of TPES in a number of countries in Central America, Southeast Asia and the Pacific (FAO, 2014).

In terms of employment, 195 million people are engaged in woodfuel and charcoal production in Africa (FAO, 2014). Women only account for 10 percent of this employment since production of charcoal and woodfuel for urban markets as full-time employment is dominated by men. For part-time (unpaid) collection of woodfuel for rural uses, women account for almost 80% of all labour and a significantly higher proportion than this is in Africa and Latin America and the Caribbean. Thus, based on the information available, women appear to bear the greatest cost of woodfuel collection (in terms of opportunity costs) by a very large margin, while they receive very few benefits from the possibilities of earning income from production (FAO, 2014).

2.2.3 Bio-energy needs and potential

Bio-energy in Africa represents almost 50% of the TPES for the African continent (International Energy Agency (IEA), 2009), and more than 60% of the Sub-Saharan TPES. Bio-energy is therefore a strategic asset for Africa's energy future and needs to be further developed and harnessed (Figure 9). The biomasss potential in Africa study (Stecher, Brosowski, & Thrän, 2013), although not conclusive and

definite regarding the availability and potential of biomass in Africa due to the large range in results presented by the reviewed studies, it showed an enormous range of potential:

- The calculated area potential for energy crops ranged between 1.5 million hectares (ha) and 150 million ha.
- The various assessments indicated a potential for energy crops from 0 PJ/yr to 13,900 PJ/yr, between 0 PJ/yr and 5,400 PJ/yr for forestry biomass and 10 PJ/yr to 5,254 PJ/yr for residues and waste in Africa by 2020.
- All the biomass calculations to the year 2100 showed a considerable range in potential. For the year 2050, a potential range between 2,360PJ/yr and 337,000 PJ/yr is revealed for Africa (energy crops: 0 PJ/yr to 317,000 PJ/yr; forestry biomass: 14,820 PJ/yr to 18,810 PJ/yr; residues and waste: 2,190 PJ/yr to 20,000 PJ/yr).

The report highlights the need for developing recommendations and standard methods to provide accurate estimates of bio-energy potentials.

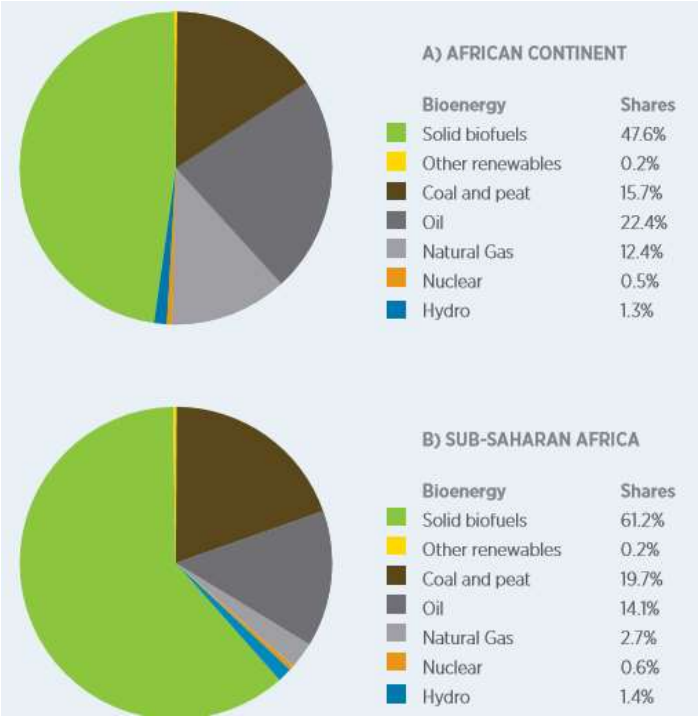


*Figure 9: The charts show the shares of bioenergy in the TPES **

*Based on IEA data for 2009. The charts show the shares of bioenergy in the TPES. (A) African continent. TPES: 673 Mtoe (28, 177 PJ), (B) Sub-saharan Africa

2.2.4 Bio- energy development: drivers and barriers

Bio-energy is the largest single source of renewable energy with a share of over 10% of global primary energy use (REN21, 2011). The proportion of bio-energy in some developing countries can exceed 90% of their primary energy supply (IEA, 2011a). Hence, bio-energy is an essential energy option for a wide-range of applications and will remain an important source of energy in most developing countries for

the foreseeable future. However, the current utilisation of bio-energy in the continent is unsustainable and inefficient. Although there are huge prospects in deploying modern and more efficient biomass fuels in the continent, there is a lack of information and limited knowledge on the achievements made in harnessing bio-energy in Africa, the constraints and opportunities as well as future prospects for its development in Africa. There are many other barriers against successful and widespread exploitation of bio-energy on the continent, including ineffective supporting policy (and associated regulations and legislations) and lack of financial support. Bio-energy exploitation in Africa has therefore largely remained focused on unsustainable systems with negative impacts on livelihoods in the areas of health, environment and social impacts, including gender.

Bio-energy technologies such as power from small-scale gasification fuelled by agricultural residues or wood from sustainable sources exhibit promising potential for expansion. While small scale photovoltaic systems to provide household lighting and electricity for charging cell phones or a radio at an affordable price, gasifier systems produce electricity at scales starting around 10 kw, a scale where photovoltaic systems become costly compared to other alternatives such as diesel-fuelled generators. While a 10 kW could provide electricity to around 10 households in the US only, in rural Africa this scale is able to power water pumps, grain mills, mini-grids at trading centres, or medium-sized commercial loads powering for instance a telecommunication tower, thereby increasing the standard of living significantly in a whole community and region that previously had no access to electricity.

A widespread application of these bio-energy systems is however hampered by several factors including a lack of business models to run the units and the absence of frameworks to measure the potential ecological risks of putting an additional biomass-consuming system into place in an already constraint ecosystem. Implementing a biomass based electricity system can further contribute to these problems if the biomass fuel supply is not sustainably managed. While per capita wood consumption in sub-Saharan Africa is between 500 to 1,000 kg of dry wood per year, gathered mainly for cooking, a 10 kW gasifier placed in a community and providing basic electricity services would require an equivalent of another 7 kg of dry wood per capita and year. Therefore, for these systems to become truly sustainable, their design needs to consider ecological and social factors on the ground as well as fulfil larger policy goals within a regional context. Although many gasifiers that utilise agricultural residues exists, use of forest biomass residue is another alternative, but this has so far not been well developed in Africa. In order to be viable, a good understanding the forest biomass supply chain and identifying sustainable sources of biomass residues within the supply chain is needed.

2.2.5 Gender dynamics in the bioenergy sub sector

> "Energy decides our lives…If women are going to make decisions about their lives, they have to be able to make decisions about energy" ChitaroopaPalit, Narmada BachaoAndalan social movement

Affordable, clean, sustainable, reliable modern energy services, as well as gender equality are critical development-enabler for Africa by creating solutions to climate crisis and are essential for ensuring the global SDG 2030, in general and "the AU Agenda 2063 –The Africa We Want" in particular.

However, lack of access to energy sources for lighting, heating, cooking, agriculture and other productive activities inhibits the productivity of men and women and society at large. Furthermore, the lack of access to modern energy also affects at local and national level, children education, access to clean water, health and well-being. This is the reason why gender is important in the energy sector. The gendered division of labour creates different energy needs, as do different perceptions of the benefits depending on one's gender. This makes the access, use, and impact of energy services differ for women and men.

Improved access to energy can improve the quality of women's and men's lives, especially the poor women and girls in many ways, including time savings due to electrification, lighting for reading and access to entertainment via radio and television; and access to new jobs and improved livelihoods through energy sources, infrastructure and technology. Narrowing gender disparities is critical to reducing and boosting shared prosperity and growth.

Energy access and energy poverty have been defined and measured in various ways.According to the World Bank (IEA), in 2018 about 573 million people in Africa did not have access to electricity (World Bank, 2018).
Gender matters in the energy sector because energy affects women and men differently, as men and women have different roles and responsibilities in households, markets and their communities.This leads to differences in their access and use of energy, and the impact of energy services on their lives.Issues arise from women's primary role in cooking, fuel collecting, and their greater exposure to indoor air pollution associated with cooking. Other issues include women's lack of decision-making power and access to finance for improved cooking technologies.

It has been established that there is a clear linkage between energy and gender. We cannot reduce poverty and achieve growth and prosperity without universal access to reliable modern energy.Ensuring that both men and women are included in consultations on interventions in the energy sector is essential.

The main form of energy used in African continent is bioenergy, mostly due to its low cost and relatively easy and availability.In Africa, firewood and charcoal are the two main forms of biomass used for energy sources (UNEP, 2019). Wood-fuel is widely used in Africa, 850 million people rely on traditional, polluting cooking solutions in 2014 (World Bank, 2017). Traditional biomass is the energy source for the poor since it is generally freely available.

Energy poverty on the continent is gendered. Women and men have different energy needs linked to their gender roles. Rural women and girls are especially affected as the majority of energy is derived from traditional biomass fuel such as wood, charcoal and agricultural waste.According to IEA approximatively 730 million people in Africa rely on traditional uses of biomass.In many parts of Sub-Saharan Africa, more than 90 % of the population relies on biomass (Prebble & Rojus, 2018). Countries like **Burundi** and **Chad** have the highest percentage in traditional use and are largely dependent on biomass based energy sources.

In many agrarian settings, women and girls have the primary responsibilities for collecting household fuelwood and many have to walk for several hours, frequently under insecure conditions to do so.The more time spent collecting fuelwood (and water), the less time women have available for other activities including education, community participation, income-earning activities and leisure. In average, a woman spends 1,9 in **Burkina Faso**, 2,7 in **Benin**, 3,1 in **Senegal** and 3,1 hours in **Cameroon** collecting fuelwood for cooking, heating and lighting. (UNEP, 2017a).Women generally play a big role in collecting traditional fuels, although men and children are sometimes involved as well (e.g. **Benin**).Rural women and girls are especially affected as the majority of energy is derived from traditional biomass fuel such as wood, charcoal and agricultural waste.In refugee and conflict situations (**Burkina Faso, CAR, RDC, Chad, Cameroon, Mali)** women are particularly vulnerable to gender-based violence while collecting fuelwood.

Women are the main consumers of wood-fuels and are negatively impacted from the impacts of cooking. Energy combustion is mostly inefficient and toxic. With regards to the cooking environment, the combustion of biomass (including fuelwood) releases significant quantities of pollutants that damage the health of those who do the cooking, the vast majority of whom are women. Poor ventilation in kitchens is common in many parts of the world and increases the health risks associated with cooking. Exposure to indoor smoke has been found to be responsible for 39% of deaths due to chronic pulmonary disease in women, compared with 12% in men. About 600,000 people die each year as a result of household air pollution and approximatively 60% of these victims are women (WHO, 2012). These deaths which are due to lung disease, acute respiratory infections, lung cancer, and pneumonia, affect mostly women and young children who spend the most time near the domestic hearth. UN Women notes that illness indoor pollution result in more deaths of women and children annually then HIV/AIDS, malaria, tuberculosis, and malnutrition combined. Other health hazards from cooking with solid fuels in poorly ventilated stoves and kitchen include asthma, burns from cooking with open fires, and cataracts, which are the leading cause of blindness in developing countries. Annex 2 provide a detailed assessment of gender issues in Africa and the study target countries.

2.2.6 Bioenergy and sustainable development goals

Bioenergy is directly linked to SDG 7 as demonstrated by the target indicators in the text box

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Targets linked to the environment and Forestry:

Target 7.1:
By 2030, ensure universal access to affordable, reliable and modern energy services

- **Indicator 7.1.1:** Percentage of population with access to electricity
- **Indicator 7.1.2:** Proportion of population with primary reliance on clean fuels and technology

Target 7.2:
By 2030, increase substantially the share of renewable energy in the global energy mix

- **Indicator 7.2.1:** Renewable energy share in the total final energy consumption

Target 7.3:
By 2030, double the global rate of improvement in energy efficiency

- **Indicator 7.3.1:** Energy intensity measured in terms of primary energy and GDP

Target 7.a:
By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

Indicator 7.a.1: Mobilized amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment.

Target 7.b:
By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

Indicator 7.b.1: Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services.

3 OVERVIEW OF TARGETED REGIONS AND COUNTRIES

An overview of forest cover changes for the 15 target countries between 1990 and 2020 is presented below (Table 8). Central Africa is the most forested region while the least forested region is the Eastern Africa region. The rate of forest annual change varies between countries but the analysis show that the countries with the highest forest loss between 2010 and 2020 in Central Africa were Republic of Chad with 2.5% annual loss and the Democratic Republic of Congo with 0.8% forest loss. In West Africa this was Republic of Côte d'Ivoire followed by Republic of Benin with 3.3% and 1.5% annual forest loss respectively. In Eastern Africa, Burundi had a forest loss of 3.7%.

Table 8: Forest cover extent of target countries: 1990-2020

Forest area (1 000 ha)					Net annual change					
Country	1990	2000	2010	2020	1990 - 2000		2000 - 2010		2010 - 2020	
					1,000 ha/yr	%	1.000 ha/yr	%	1,000 ha/yr	%
Central Africa										
Democratic Republic of the Congo	150,629	143,899	137,169	126,155	-673.0	-0.46	-673.0	-0.48	-1,101.4	-0.83
Republic of the Congo	22,315	22,195	22,075	21,946	-12.0	-0.05	-12.0	-0.05	-12.9	-0.06
Central African Republic	23,203	22,903	22,603	22,303	-30.0	-0.13	-30.0	-0.13	-30.0	-0.13
Republic of Cameroon	22,500	21,597	20,900	20,340	-90.3	-0.41	-69.7	-0.33	-56.0	-0.27
Gabonese Republic	23,762	23,700	23,649	23,531	-6.2	-0.03	-5.1	-0.02	-11.9	-0.05
Republic of Equatorial Guinea	2,699	2,616	2,532	2,448	-8.4	-0.31	-8.4	-0.32	-8.4	-0.34
Republic of Chad	6,730	6,353	5,530	4,313	-37.7	-0.57	-82.3	-1.38	-121.7	-2.45
West Africa										
Republic of Benin	4,835	4,135	3,635	3,135	-70.0	-1.55	-50.0	-1.28	-50.0	-1.47
Republic of Senegal	9,303	8,853	8,468	8,068	-45.0	-0.49	-38.5	-0.44	-40.0	-0.48

Republic of Côte d'Ivoire	7,851	5,094	3,966	2,837	-275.6	-4.23	-112.9	-2.47	-112.9	-3.29
Republic of Mali	13,296	13,296	13,296	13,296	0.0	0.0	0.0	0.0	0.0	0.0
Burkina Faso	7,717	7,217	6,717	6,216	-50.0	-0.67	-50.0	-0.72	-50.0	-0.77
Togolese Republic	1,362	1,268	1,239	1,209	-9.3	-0.71	-3.0	-0.24	-3.0	-0.24
Eastern Africa										
Republic of Burundi	276	194	194	280	-8.3	-3.48	0.0	0.00	8.6	3.73
Republic of Djibouti	6	6	6	6	0.0	0.0	0.0	0.0	n.s.	0.35

Source: FAO, 2020

3.1 Status of Bioenergy and Regional perspective

3.1.1 Central Africa

Figure 10: Central Africa Map

Biomass resources in Central Africa come from a variety of sources - forests and agriculture, and by-products, residues or waste from the production of food, fiber or wood products **(WEC, 2016).** It is estimated that 90% of wood from forests, plantations and trees outside forests are the main sources of firewood and charcoal in Africa**(Lundgren, 2014).** In Central Africa 82% of households use wood as an energy source. Wood energy refers to any source of energy from biomass wood, including firewood, charcoal, ecological coal, forest wood residues (from supply chains and wood flows), industrial wood residues (from processing) and wood. The collected residues are either used directly without processing (used by households for cooking and/or heating), or is converted into a secondary product before using). Wood and its residues are also used for catering and handcrafts, especially in industries such as restaurants, bakeries, beverage production, brick or chalk production, drying tobacco in forges and aluminium smelters etc.

Table 9: Baseline data for the wood energy sector in Central Africa

Area (million ha)	**529**

Population (million inhabitants)	125
Forests (millions of ha)	256
Surface (millions ofha)	236
Surface (%)	45
Surface (ha) / inhabitant	2.2
Permanent stock (million ha)	45
Volume (m^3/ha)	194
Total volume (million m^3)	46,760
Biomass (m^3/ha)	315
Total biomass (million m^3)	74,199
Wood energy (1,000 m^3)	103,673
Industrial wood(1,000 m^3)	12,979
Sawwood(1000 m^3)	1 250
Energy wood consumption (m^3/hab)	0.99
Wood production energy/total wood production (%)	90

Source:**Marien, 2009**

Due to the importance of the wood industry in Central Africa, wood residues from processing (the case of sawdust) represent a strong potential for bioenergy production. In Central Africa, 67% of wood residues from wood processing are easily recoverable and usable **(Gouvello et al. 2008).**The amount of wood residue consumed varies by region. FAO(2012b)estimates an average consumption of 0.93 m^3per person per year in Central Africa and in rural central Africa, 15% of the population use charcoal and 85% use firewood, straws and wood processing waste (IEA, IRENA, UNSD, World Bank, WHO, 2020). However, in urban areas 7% of the population have access to electricity, 10% use natural gas and LPG,3% use kerosene, 35% use charcoal and 40% use firewood, straws and waste from wood processing **(BM and IEA 2017).**In general, Central Africa produces 110,109,852 m^3,imports 41 m^3,and exports 90 m^3 and consumes 110,109,803 m^3 of wood **(FAO, 2016b).**In Central Africa, biomass energy is used in two ways that depend on the average incomes of the population. Those with low income (50.97%) use biomass in a traditional way while those with high income (16.65%)use biomass in a modern way (UNEP, 2019).

With regard to the transformation of wood waste into electrical energy, the situation is still in its infancy as there are very few examples which are documented. It is noted, however, that in 2008, a study was carried out in the countries of the Congo Basin with a view to the installation of a cogeneration plant with the aim of transforming wood waste into electricity that can be used by the timber industries in the regional countries. Cameroon's Rural Electrification Agency (AER) conducted a study in 2009 that identified 37 sites in the country where a total of 37 MW of electricity can be produced using biomass, which accounts for less than 1% of the country's energy mix (Douard, 2016). In the same context, - Biomass Cameroon SA and La CompagnieGénérale des Granules SA have since 2016 had ambitions to engage in industrial valorization of biomass in Cameroon, thus helping to promote this form of energy production to meet electricity production deficit.

Table 10: Energy resources mix potential in Central African Countries

Energy sources	Countries' Central Africa						
	Central Africa Republic[1]	Cameroon[2],[3]	Gabon[4], [5]	Equatorial Guinea	Chad	Congo[6], [7]	Democratic Republic of Congo[8]
Hydro (MW)	2,800	23,000	7,002	2,400		14,000	100,000
Wood biomass (Gtons)	420	313	179	181	156	232	4,205
Wood biomass (Mtep)	1,547.59	1,009.23	577.75	58.24	502.83	747.52	1,352.13
Geo-thermic	-	-					5,037 l/s (debit)
Thermic (MWh)	-	1,291					
Solar PV[9] (TWh/year)	5,284	10,105	5,402	706	10,506	6,778	22,862
Wind[10] (TWh/Year)	79	979	-	36,361	9,165	-	2,173
LPG (Gm3) (Liquid Petroleum Gas)	-	134	28	36	20,000 tonnes	90	50
Peat	-	-					
Lignite (m3)	2.9 millions						
Nuclear (tons)	23,000						1,800
Wood charcoal (Mtp)	325.41	242.89	139.05	14.02	121.01	469.53	849.29
Wood charcoal (G tons)	525	392	224	22	195	290	525

1[1]https://info.undp.org/docs/pdc/Documents/CAF/Rapport%20de%20diagnostic%20du%20secteur%20%C3%A9nergie%20RCA% 0VF.pdf; https://hal.archives-ouvertes.fr/hal-01971335/document
1[2] https://maguysama.odoo.com/en_US/page/etat-des-lieux-du-secteur-energetique
1[3] https://www.seforall.org/sites/default/files/Cameroon_RAGA_FR_Released.pdf
1[4] https://www.doc-developpement-durable.org/file/Energie/biomasse-bois/Note%20tech%20sur%20bois-energie%20au%20Cameroun.pdf
1[5] https://www.jstor.org/stable/pdf/j.ctv941sr6.36.pdf?refreqid=excelsior%3Ace217eaa71f4b92d7dc54be170d65c11
1[6] http://helio-international.org/wp-content/uploads/2013/12/Congo-FR.pdf
1[7]http://helio-international.org/wp-content/uploads/2016/12/VARRDC.Fr_.pdf
1[8] http://ipsnews.net/francais/2003/02/26/energie-gabon-un-potentiel-energetique-enorme-mais-peu-valorise/
1[9]https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf consulted 03/08/2020
1[10]https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf consulted 03/08/2020

All countries in the Congo Basin for which data are available use more than 50% of biomass energy. While Gabon and Congo are only slightly above 50%, the Democratic Republic of Congo is one of the largest consumers of biomass energy, both in absolute terms and as a percentage of total energy consumption **(NU 2009; IEA 2010b; BM 2011; Hannah et al, 2013)**.

Energy profiles vary from country to country in Central Africa, depending on national wealth, access to electricity, availability and cost of fossil and wood fuels. In the Democratic Republic of Congo, renewable fuels and wood waste (mainly firewood and charcoal) accounted for 93% of total energy consumption in 2008, in a context where less than 12% of the population had access to electricity and fossil fuels met only 4% of the country's energy needs. In Gabon, dependence on biomass energy is much less, thanks to a large access to electricity grid and subsidized gas for cooking. In Gabon and the Republic of Congo, biomass fuels and waste account for just over 50% of energy needs. These countries also have similar rates of access to electricity, of about 37%. However, access to electricity is not necessarily a specific indicator of the use of biomass as an energy source. Although access to electricity is higher in Cameroon (nearly 23% of the population) renewable fuels and forest waste still account for more than 70% of total energy, which can be explained by the fact that consumers switch to a relatively cheaper biomass when faced with an increase in the price of fossil fuels **(NU 2009; IEA 2010b; BM 2011; Hannah et al, 2013)**. Table 12 presents general data for target countries in Central Africa that includes factors that influence energy profiles.

Demand for wood-energy, and charcoal in particular, continues to increase in Central African countries. This is not surprising given the population growth. Total wood-energy production in 2007 in the countries of the sub-region exceeded 100 million cubic meters, with the main producers being the Democratic Republic of Congo, with 71% of total regional production, followed by Cameroon (21%) **(NU 2009; IEA 2010b; BM 2011; Hannah et al, 2013)**.

Coal production in the Central Africa sub-region in 2007 was 2.4 million metric tons, of which nearly 75% came from the Democratic Republic of Congo. Cameroon is next with almost 10% of the sub-region's production, but per capita charcoal consumption is relatively low compared to other countries (Behrendt, Megevand, & Sander, 2013)**.**

Table 11: General data for target countries in Central Africa

	Cameroon	Gabon	Congo	RDC	CAR	Equatorial Guinea	Chad
Population[1] (million inhabitants)	25.87638	2.17258	5.38051	88.79057	4.74519	1.35599	15.94688
Growth rate[2] (%)	2.6	2.6	2.6	3.2	1.5	3.7	3
Area (Km2)	472 710	257 670	341 500	2 267 050	622 980	28 050	1 259 200
GDP[3] (USD billion)	38.76047	16.65782	10.82059	47.31962	2.22031	11.02677	11.31495
Forest Area (Km²)[4]	185 960	232 000	23 186	1 522 662.9	221 544	15 564	47 484
Logging (Atyi et al 2009)	Production of log Transforming wood Pulp and paper	Production of logs Transforming wood	Production of logs Transforming wood	Production of logs Transforming wood	Production of log Transforming wood Pulp and paper	Roundwood production Transforming wood Dring Roundwood	Production of log Transforming the pulpwood and paper
Access to electricity in rural areas[5] (%)	23	62.5	20.2	1.8	16.3	6.6	2.7
Access to electricity in urban areas[6]	93.3	96.7	92.4	50.7	55.2	90.4	41.8

[1] https://donnees.banquemondiale.org/indicateur/sp.pop.totl consulted 03/08/2020
[2] https://data.worldbank.org/indicator/SP.POP.GROW consulted 03/08/2020
[3] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD consulted 03/08/2020
[4] https://data.worldbank.org/indicator/AG.LND.FRST.K2 consulted 03/08/2020
[5] https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS consulted 03/08/2020
[6] https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS consulted 03/08/2020

Renewable Energy Sources (WhitePaper)	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro	Biomass Solar Wind Hydro

3.1.2 West Africa

3.1.2.1 General

In the ECOWAS (Economic Community of West African States) area, the extent of forest resources is estimated at 66.85 million ha, i.e. about 14% of the total area of the 15 ECOWAS States (FAO 2015). These forest resources undoubtedly constitute the main source of supply of fuelwood, service wood, timber and roundwood for export for a population estimated at almost 356 million inhabitants (ECOWAS 2016). They also provide these populations with various Non-Timber Forest Products (NTFPs) that contribute to the improvement of food security, health, and household incomes.

With regard to the state of bioenergy, on the specific level of cooking energy, the Center for Renewable Energy and Energy Efficiency (ECREEE) of ECOWAS estimates that 80% to 95% of the population in this area still use traditional biomass for cooking (ECREEE 2015), often unsustainably with inefficient stoves. As a result, the cost of cooking fuels continues to rise and the unsustainable supply chains for firewood lead to environmental degradation and deforestation, especially in areas close to urban centres. The alarming degradation of forests and their resources makes this energy dependence precarious and poses a threat to the entire sub-region if no action is taken to reverse the trend.

In a highly degraded state due to several natural and anthropogenic factors, forests in the ECOWAS space experienced an annual deforestation level of about 652,000 ha during the 2010-2015 period, i.e. a 1.08% forest loss (FAO 2015). In terms of forest exploitation, in almost all the countries in the region there is a lack of organisation of the different production chains (timber, fuelwood, NTFPs, etc.) which results in the non-professionalization of the actors (except for timber). However, in recent years and following a gradual awareness among States, significant efforts have been made to increasingly ensure sustainable management of forests in the sub-region by improving forest exploitation, improving knowledge of potential, making better use of geomatics for forest management, drawing up forest development and management plans and defining exploitation standards, improving monitoring of the implementation of management plans, improving the participation of the populations, etc.

The total production of wood energy is experiencing a progressive upward trend in all ECOWAS countries. The largest producers of wood energy remain, in order, Nigeria (almost 70,500,000 m^3 in 2005), Ghana, Guinea, Côte d'Ivoire, Burkina Faso, Sierra Leone and Senegal. Guinea Bissau, Gambia and Cape Verde have the lowest production. The production of woodfuel remains strongly correlated with its consumption of woodfuel and therefore with the demographic weight of the countries. Wood energy is also an export product, notably charcoal. Charcoal is indeed the third largest export product for countries in the sub-region, not counting unrecorded cross-border trade. While industrial wood is mainly shipped to Europe and Asia, most of the cross-border movement of wood energy takes place within the countries in the region.

The analysis of wood energy supply/demand shows that the supply of wood energy to the countries in this area is not sustainable because there is a progressive degradation of the resource. The demand

for wood energy is growing and is maintained by: (i) population growth, (ii) the rate of urbanization, (iii) cooking practices based on wood energy, and (iv); and the accessibility of wood energy (availability, price, etc.).

Aware of the unsustainable supply of wood energy due to unsustainable harvesting, countries have developed projects and programmes to disseminate improved stoves to increase energy efficiency in the sector. The outputs are often mixed at the country level, especially in the introduction of more efficient charcoal grinders. At the same time, alternative energy sources have been promoted in the region, such as butane gas, kerosene, bio-coal, etc., without much success. These experiences have been limited due to various constraints among which we can note (i) the relativity of the efficiency of equipment (still depending on the level of training of the actors), (ii) the absence or inadequacy of consensual standards, (iii) the still high prices of equipment and alternative energy sources and (iv); the irregularity of supply.

Regionally, all ECOWAS countries have a strategy oriented towards the decentralisation of forest resource management. In the arrangements put in place for decentralised forest management, the States, decentralised territorial collectivises and grassroots communities, the private sector (forest operators), civil society and NGOs each play key roles and responsibilities.

Total energy consumption

According to AFREC's[7] Energy Information System (EIS), TPEC in the six West African countries in the study is about 24.6 Mtoe per year (AFREC 2020). Wood and charcoal, used for domestic and commercial cooking, are the main energy sources and account for 61% of primary energy consumption (2017 data). Note, however, that biomass consumption in Senegal appears to be underestimated in these analyses. Modern commercial energy consumption consists of 8 Mtoe of petroleum products and 1.6 Mtoe of electricity (see Figure 11 below).

[7] African Energy Commission

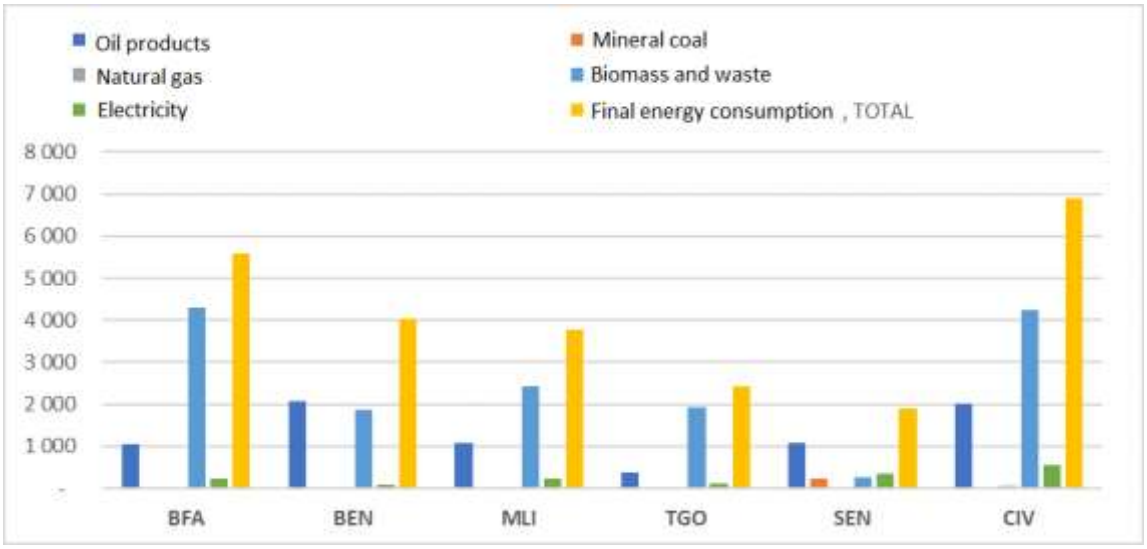


Figure 11: Final energy consumption in 2017 in the six West African Countries of the study

Source: [ktoe] (AFREC 2020)

Depending on the country in the ECOWAS area, there is a strong variation in the share of traditional biomass in total final energy consumption. Indeed, according to the SE4All initiative, in sub-Saharan and non-coastal countries such as Mali and Burkina Faso, wood and charcoal would account for about 85% of total final energy consumption in 2010; whereas in coastal countries, where the industry and transport sectors are more developed, due to the higher energy intensity per capita, the share of biomass was lower there, i.e. about 42% in Senegal and Togo and about 65% in Côte d'Ivoire and Benin (Figure 12).

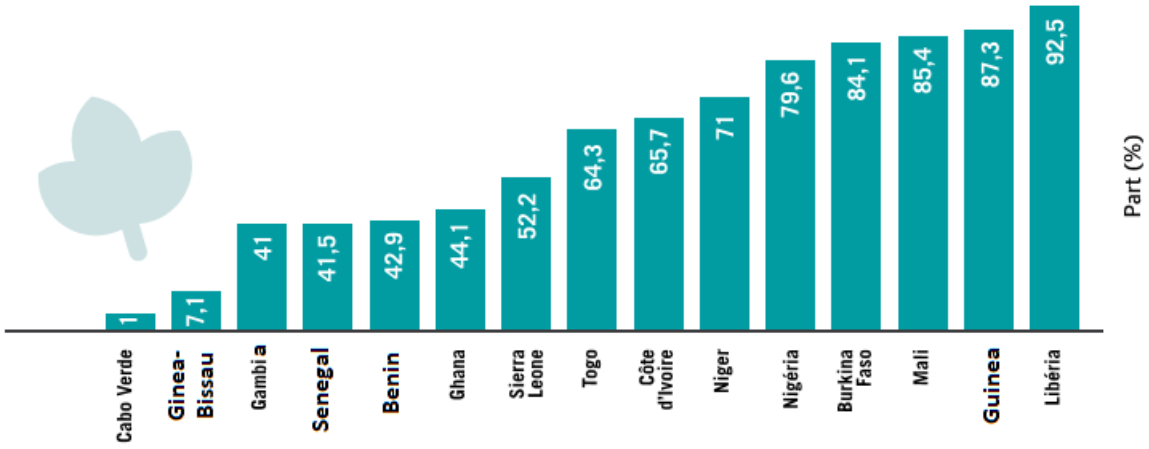


Figure 12: Proportion of traditional biomass in total final energy consumption in 2010 in ECOWAS countries

Source: (Global Tracking Framework 2013)

However, the percentages provided by AFREC's EIS for 2017 are significantly lower (77% for Burkina Faso but only 65% in Mali), compared to only 43% in Benin and up to only 15% in Senegal. This considerable reduction in 7 years would be due not only to a decreasing effect of the share of biofuels in the final energy mix over time, linked to the increasingly high rates of access to electricity and the growing consumption of the industry and transport sectors, but also to misjudgements in the quantification of biomass. For example, in Senegal, a country with a population of 16 million

inhabitants, similar to Burkina Faso and Mali (17 and 19 respectively), biomass consumption would be far below that of its sub-regional neighbours. In fact, there is very little literature on the subject, and even less that refers to all the countries of the sub-region at the same time. Methods for estimating biomass consumption are not homogenous in each country, and as the African Energy Database (AFREC 2019) points out, the human and technical means for obtaining reliable and correlated statistics are lacking, which explains these considerable discrepancies.

As explained above, the part of biomass in the energy mix is highly correlated with the national rate of access to electricity and the country's industrialisation. For example, in Côte d'Ivoire and Senegal, the national electrification rates are 75% and 65% respectively, compared to only 48% and 21% respectively in Mali and Burkina Faso (see Table 12, below). The large electricity grids mainly supply the main cities of most ECOWAS Member States and do not always extend to rural and peri-urban areas. The share of rural populations connected to the electricity grid in the six West African countries in the study varies from 44% in Côte d'Ivoire to only 3% in Burkina Faso.

However, better access to electricity does not perceptibly reduce dependence on wood energy, as the preferred cooking techniques remain traditional and therefore using biofuels, especially wood and its derivatives. In addition, electricity and butane gas or LPG remains an expensive resource in West Africa, despite efforts to make LPG more accessible in some countries; this does not really encourage technology change. In absolute numbers, biomass consumption continues to increase, driven by population growth. Thus, and due to the relatively low penetration of alternative fuels, the levels of biomass consumption per capita vary little between the countries under study: between 0.19 (Mali) and 0.25 (Togo) toe per capita per year in 2018 (AFREC 2020).

Table 12: Energy indicators 2018

	Burkina Faso	Benin	Mali	Togo	Senegal	Côte d'ivoire
Population (Millions)	20	11	19	8	16	25
GDP 2018 (Current US$ billion)[a]	16,2	14,2	17,1	5,3	23,2	57,7
GDP per capita (US$ 2018)	800	1 235	881	703	1 461	2 340
Primaryenergy production (ktoe)	4 657	2 815	5 254	2 652	1 501	9 143
Net primary energy import (ktoe)	1 586	2 556	1 720	632	4 222	3 666
Total Primary Energy Supply (TPES) (ktoe)	6 213 [c]	5 100 [b]	6 928 [c]	3 620 [b]	4310 [b]	10450 [b]
Electricalenergyconsumption (MWh)	2 350 612	1 199 727	3 085 829	1 272 220	4 871 544	7 123 408
CO2 emissions (tons of CO2)	90 556	22 280	24 795	33 429	72 121	52 337
TPES/Population (toe/capita)[c]	0,31	0,44	0,36	0,48	0,27	0,42
TPES/GDP (toe/thousand US$ 2018) [c]	0,38	0,36	0,41	0,68	0,19	0,18
TPES/GDP per capita (ktoe/ US$ 2018) [c]	7,76	4,13	7,87	5,15	2,95	4,46
Electricity consumption/capita (MWh/capita) [c]	0,12	0,10	0,16	0,17	0,31	0,29
CO2 emissions per energy consumption (t of CO2/toe)[c]	0,015	0,004	0,004	0,010	0,018	0,005
CO2 emissions per capita (t of CO2/inhabitant)[c]	4,5	1,9	1,3	4,4	4,5	2,1
CO2 emissions per GDP (t of CO2/thousand US$ 2018)[c]	5,590	1,569	1,450	6,307	3,109	0,907

	Burkina Faso	Benin	Mali	Togo	Senegal	Côte d'ivoire
CO2 emissions per GDP per capita (t of CO2/US$ 2018)[c]	113,2	18,0	28,2	47,6	49,4	22,4
Energy self-sufficiency rate (%) [d]	75	53	76	82	33	93
Electricity self-sufficiency rate (%)[d]	68	14	104	27	94	112
Part of RE in TPES (%)[d]	75	53	76	82	33	60
Part of RE in power generation (%)[d]	11	3	39	1	5	29
National electrification rate (%)[d]	21,3	29,22	47,87	45	65	74,52
Rural electrification rate (%)[d]	3,2	6,456	7,34	7	42,3	44,46
Average annual LPG consumption per household using LPG (kg)[c]	22	8	0	0	72	70
Energy intensity of the industry sector 2018 (toe/thousand US$ 2010)	158	0	0	0	0	0
Energy intensity of the service sector 2018 (toe/thousand US$ 2010)	62	0	0	0	0	0
Electricity consumption/capita (MWh/capita)	0,11611403	0,1	0,16	0,17	0,31	0,29

Source: Extracted from (AFREC 2020) (a) (World bank 2020), (b) OECD), (c) own calculations and (d) (WAEMU 2018)[8]

[8]Neglecting the rate that emerges from the analysis of Senegal's EIG for 2018, which visibly undervalues the biomass part in its overall balance, as commented above.

Also, a country's heavy dependence on fuel imports limits the development of the industrial (including power generation) and transport sectors, which favours the use of traditional biomass to meet the energy needs of the population. All ECOWAS countries are in this situation except five member states with proven oil reserves, namely Nigeria, Ghana, Côte d'Ivoire, Senegal and Benin, three of which have produced refined oil in 2014. Côte d'Ivoire is the only country where production exceeded consumption, demonstrating the sub-region's vulnerability to volatile world prices and supply disruptions.

Renewable energies

The part of renewable energy in the sub-region's total final energy consumption is relatively marginal, although it varies greatly from country to country. According to the Global Monitoring Framework of the Sustainable Energy for All (SE4All) initiative, Guinea-Bissau, Ghana and Sierra Leone were in 2010 the top three regional leaders in terms of the contribution of renewable energy to final consumption, at about 30%, 22% and 19% respectively. Their positioning is mainly due to their use of the resource called "modern biomass" by the SE4All initiative (see Table 13, below), and, for Guinea-Bissau and Sierra Leone, additionally by the fact that their electricity access rates are low.

Concerning the consumption of "modern biomass[9]", these are in particular power plants operating with residual biomass from mostly agro-industrial sites (sugar, palm oil or cotton production plants, etc.) and which directly supply the electrical needs of these sites. Except for Mali and Togo, the West African countries in the study have at least one agro-industrial site that uses its waste to generate its own electricity.

Hydropower is the second largest renewable energy source for final energy consumption in the ECOWAS region, with 6.7% of the total for Ghana in 2010, and a significant share in Togo (2.6%), Côte d'Ivoire (1.9%) and Mali (1.5%).

Table 13: Percentage of rrenewables in total final energy consumption (2010) [10]

	Modern Biomass	Hydroelectricity	Solar energy	Wind Energy	**Total**
Benin	8,7				**8,7**
Burkina Faso	0,8	0,4			**1,2**
Cabo Verde				0,5	**0,5**
Côte d'ivoire	7,8	1,9			**9,7**
La Gambia					**0**
Ghana	15,7	6,7			**22,4**
Guinea	0,5	1,1			**1,6**
Guinea-Bissau	30,3				**30,3**
Libéria					**0**
Mali	1,4	1,5			**2,9**
Niger	2,8		0		**2,8**
Nigéria	8,8	0,4			**9,2**
Senegal	0,2	0,8	0		**1**

[9]Biomass produced in a sustainable manner from wastes and solid residues from agriculture and forestry.
[10]Biomass produced in a sustainable manner from wastes and solid residues from agriculture and forestry.

Sierra Leone	18,9	0,1			**19**
Togo	9,2	2,6			**11,8**

Source: Global Tracking Framework (2013)

Renewable energy technologies would account for nearly 30% of the sub-region's total installed and grid-connected capacity in 2010 (see Table 14, below). Hydropower has been used for decades in the sub-region and even accounts for more than 99% of the existing renewable energy capacity (ECREEE/REN21/UNIDO 2014) but the installed capacity is not expected to increase significantly in the coming years. Biomass accounts for only a negligible part of the overall energy mix.

Table 14: Installed renewable energy capacity (grid-connected) of ECOWAS Member States in 2014

	Modern Biomass	Hydroelectricity	Solar energy	Wind Energy	**Total**	Part of renewables in the total mix[11]
Benin	0	2	0	0	2	1,9
Burkina Faso	0	29	0	0	29	14,7
Cabo Verde	0	0	6,4	26	32,4	23
Côte d'ivoire	3	604	0	0	607	42,9
La Gambie	0	0	0	1	1	0
Ghana	0	1580	1,92	0	1581,92	56,9
Guinea	0	126,8	0	0	126,8	29,7
Guinea-Bissau	0	0	0	0	0	0
Libéria	0	4,6	0	0	4,6	21
Mali	0	300	0	0	300	65,5
Niger	0	0	0	0	0	0
Nigéria	0,5	1977	0	0,03	1977,53	16,2
Senegal	0	0	0	0	0	0
Sierra Leone	0	56	0	0	56	35,6
Togo	0	65,6	0	0	65,6	28,8
	3,5	**4745**	**8,32**	**27,03**	**4783,85**	**28,8**

Source: (ECREEE/REN21/UNIDO 2014)

The installed capacity of grid-connected renewables (excluding hydropower) (wind, solar and modern biomass) is only 39 MW and is concentrated mainly in Cabo Verde (wind farm) and to a lesser extent in Ghana, Gambia and Nigeria, which are regional leaders in this sector (Figure 13).

[11] Including installed renewable and non-renewable energy capacity

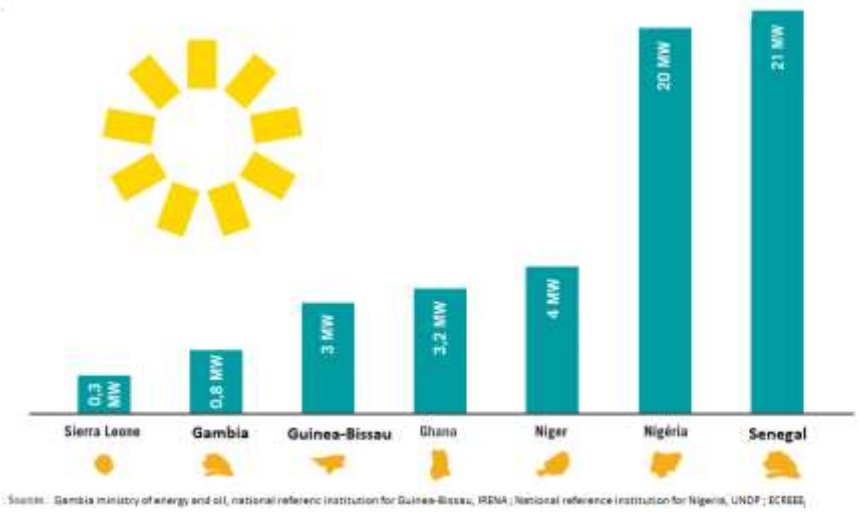


Figure 13: Installed capacity of grid-connected renewables in West Africa

While significant off-grid capacity has been added in recent years through various renewable energy technologies, in particular solar photovoltaics, there are few consistent and reliable data at the sub-region level (ECREEE/REN21/UNIDO 2014).The deployment of renewable energy in electricity generation is expected to increase in the coming years as a result of the targets set for electricity from renewable energy sources, the supporting policies implemented in most Member States, the continued efforts of the EERCECA to streamline policy making processes and the increasing number of development projects including renewable energy.

3.1.3 Eastern Africa - Burundi and Djibouti

Figure 14:Map of Eastern Africa countries

Wood fuel remains an important source of energy in the majority of household across Eastern Africa. Of the total wood removed in the subregion over the last two decades, wood fuel extraction represented over 90 percent. In response to this demand, a Bio-energy Development Strategy and Investment Plan for Eastern and Central Africa is being formulated. This process which kicked off in 2019 has been initiated by the African Union Commission (AUC) in partnership with the UN Economic Commission for Africa (ECA) and New Partnership For Africa's Development (NEPAD) Planning and Coordinating Agency (NPCA). The strategy and investment plan is aimed at increasing the pace of investments in bio-energy projects considering the bio-energy resources abundant in different regions and the specific circumstances of each region (African Union, 2018). A profile of the energy mix for the two countries targeted in this study is provided below.

Burundi: In Burundi, the total primary energy supply is composed of biomass (96%), petroleum (1.65%) and electricity (2.2%).

Biomass: Over 90% of energy requirement is met by wood, charcoal or peat. Fuel-wood accounts for the vast majority of Burundi's energy consumption. However, potential wood consumption in the country is forecast to require production of 180,000 hectares, which surpasses the current forest coverage of 174,000 hectares, suggesting the need for reduction of consumption and the

implementation of re-forestation programs. The total sustainable firewood biomass supply from all sources was estimated at 6,400,000 m^3 in 2007.

Hydropower: Hydro power provides the majority of the country's electricity power supply (98%). Burundi energy supply depends on 95% hydro from 7 hydroelectricity plants, which has a combined installed power capacity of 30.6 MW (International Business Publications, 2018) (IBP, 2018). The resource, however, is not fully exploited yet. There is considerable potential for further development, including micro, mini and small hydro power. Burundi's theoretical hydropower capacity is 1,700 MW, however, roughly 300 MW is seen as economically viable, and only 52 MW has been functionally installed (International Business Publications, 2018). The electricity sector in Burundi is under-developed and the electrification rate is 11% (World Bank).

Solar energy: Average solar insolation stands at 4-5 kWh/ m^2/day. There is a large potential for PV electricity generation in rural parts of Burundi as most regions are not grid-connected. Solar energy is being investigated and utilised as a means of off-grid electrification for rural areas. Institutions such as the Solar Electric Light Fund have also invested in small solar systems for public buildings, such as health centres.

Wind energy: Data on wind patterns has been recorded by the Institute for Agronomic Sciences of Burundi (ISABU), primarily for agricultural purposes, giving a mean wind speed between 4 and 6 m/s. More potential sites probably exist in the higher elevations. Pilot private-sector schemes are currently operational.

Geothermal: Geothermal resources have been identified in the West Rift Valley region in neighbouring eastern DR Congo. Several geothermal indicators exist in Burundi, but there is little available data to assess commercial viability.

Biogas: According to the World Development Indicators, there is no data on Biogas as well as all forms of cooking fuel LPG, natural gas) for Burundi. This does not mean that there are no biogas installations in Burundi, but that the statistics on the installations and capacities are not available. The biogas industry in Burundi flourished in the 1980s and 1990s, with 320 – 1100 units installed in 1993, but data after this date remains scanty. In 1992, there were 206 small-scale biogas installations, and 84 institutional plants with digester volumes of over 100m^3 (NDF, 2017). Ever since the beginning of the 2000's, biogas use has been decreasing steadily even though there is widespread knowledge and skills on the use of this technology, which was facilitated by international organizations in the '80s and '90s such as the German Technical Cooperation (GTZ, now GIZ), French Technical Cooperation (FTC), Belgian Technical Cooperation (BTC) and others.

Djibouti: The country's is supplied primarily by thermal plants (about 120 MW) and some imported hydro energy from Ethiopia. Electricity demand has been increasing at three to five percent per year. 70% of the population live in the capital Djibouti-Ville, and another 13% in secondary towns. Kerosene is in high demand for household needs such as cooking, but the volatility in petroleum products prices makes it very expensive. The share of renewable energy in the total TFEC was 34.8 per cent in 2012. Traditional biofuels formed 34.5 per cent of TFEC. The proportion of renewable sources as a share of

electricity capacity was 0.8 per cent in 2012 (World Bank, 2015). The main source of energy is described below.

Solar energy: Average daily in solation is 5.5-6.5 kWh/m^2 over the whole country. Djibouti had set a target of achieving electrification of 30% of the rural population by solar photovoltaics by 2017. In addition, the government sees solar power as a key tool in electrification and development, and has set several technical and economic targets for the technology.

Wind energy: Studies conducted in the 1980s indicated that average wind speeds across Djibouti peak at 4 m/s, indicating a moderate potential for wind energy. Government studies in 2002 concluded that Goubet, at the entrance to the Gulf of Tadjourah, has the potential for a 50 MW wind farm, and that GaliMaab Wein and Bada also have significant wind potential.

Biomass energy:With the majority of the country being semi desert, Djibouti'spotential for large-scale power production from biomass is expected to be of limited feasibility since both woodwaste and agricultural residues are lacking. However, no formal assessment has yet been made into the country. Predominant use of traditional biomass resources for domestic purposes is inefficient and potentially harmful, particularly the predominant use of charcoal and firewood. World Bank has made recommendations to the government of Djibouti to promote the use of bottled LPG as an alternative, and improve home energy efficiency.

Geothermal energy: Djibouti has installed capacity of about 120 megawatts (MW) and one of the three major geothermal sites in the northern Lac Assal region will add 50-100 MW when completed. The development of the new plant is under implementation through World Bank and other sources of funding.

Hydropower: The electricity sector in Djibouti has not seen much progress for several decades and the electrification rate is 60.4% (World Bank). The equipment is old and inefficient so peak production capacity is considerably lower than installed capacity. Most demand is from the city of Djibouti and it has been growing at a rate of 5 per cent a year. Forecasts put the maximum energy demand for 2025 at 810 GWh/yr. There have been power interconnections with Ethiopia in recent years, and this has accounted for about 46 per cent of the country's guaranteed electricity production.

Table 15 presents general data for Burundi and Djibouti that includes factors that influence energy profiles in the two countries.

Table 15: General data for Burundi and Djibouti

Data	Burundi	Djibouti
Population (2018)	11,175,378	958,920
Population Growth Rate	3.2	1.6
Are (KM2) (thousands)	27.8	23.2

GDP (USD billion)	3.104	2.956
GDP Growth per Capita	1.6	5.5
GNI per Capita (USD)	280	3,190
Forest area (KM2) (thousands)	2.8	0.1
Energy use (kg of oil equivalent per capita)	-	-
Carbonemissions (metric tonnes per Capita)	0.045	0.804
Electric power consumption (KWh per Capita)	-	-
Access to electricity in rural areas (%)	11	60.4
Access to electricity in urban areas (White Book)		
Renewable Energy Sources	Biomass Solar Wind turbine Hydroelectric	Biomass Solar Wind turbine Hydroelectric Geo-thermal
Share of renewable energy in the total final energy consumption (TFEC)		34.8

4 FOREST BIOMASS RESIDUES: KEY PLAYERS AND SOURCES OF RESIDUES

Because of its diverse resources, the forest value chains involve multiple actors, at varying levels and with interests more often divergent than converging. The identification of actors is necessary for the development of any sustainable management approach to the forests. These actors are involved in the entire forest resource management process from decision-making to implementation and evaluation and monitoring. A good understanding of the interactions between the different actors and their implications in forest resource management require an analysis of the forest value chain in the formal and informal sectors.

4.1 Central Africa

4.1.1 Forest value chain in Central Africa

The forests of the Congo Basin are increasingly integrated into global value chains, which in addition promote sustainable forestry management, providing opportunities to integrate into the global economy. Overall, forest management actors were categorized into several categories under the FORAFRI (*Programme de capitalisation et transfert des résultats des recherches menées dans les forêts denses humides d'Afrique*) project between 1996-2002. These potential players are either directly or indirectly involved in the forest biomass of Central Africa:

- Management actors: Water and forest administration and environment, public or para public Organization, private industrial organization, private artisanal organization, NGOs, people, natural resource management communities.
- Training: Universities, forestry and environmental colleges and schools.
- Financing actors: multilateral donors, bilateral and national donors.
- Research actors: institutes, forestry schools, universities, researchcentres, etc.
- Advisory support players: private companies and design offices, international organizations and NGOs Networks, etc.
- Political actors.
- Exploitation actors: These are actors who are directly involved in the management of forest biomass sources, biomass harvesting, primary processing, and secondary processing and are present in consumption sites.

The value chain of all Central African countries have common forest products. The three key markets are the Asian, European and African markets. This value chain represents all stakeholders (actors) involved in the forestry sector. It includes players ranging from production to consumption of forest products through, operators, processors, transporters and merchants. Figure 15 summarizes all the players and their activities and the resulting products.

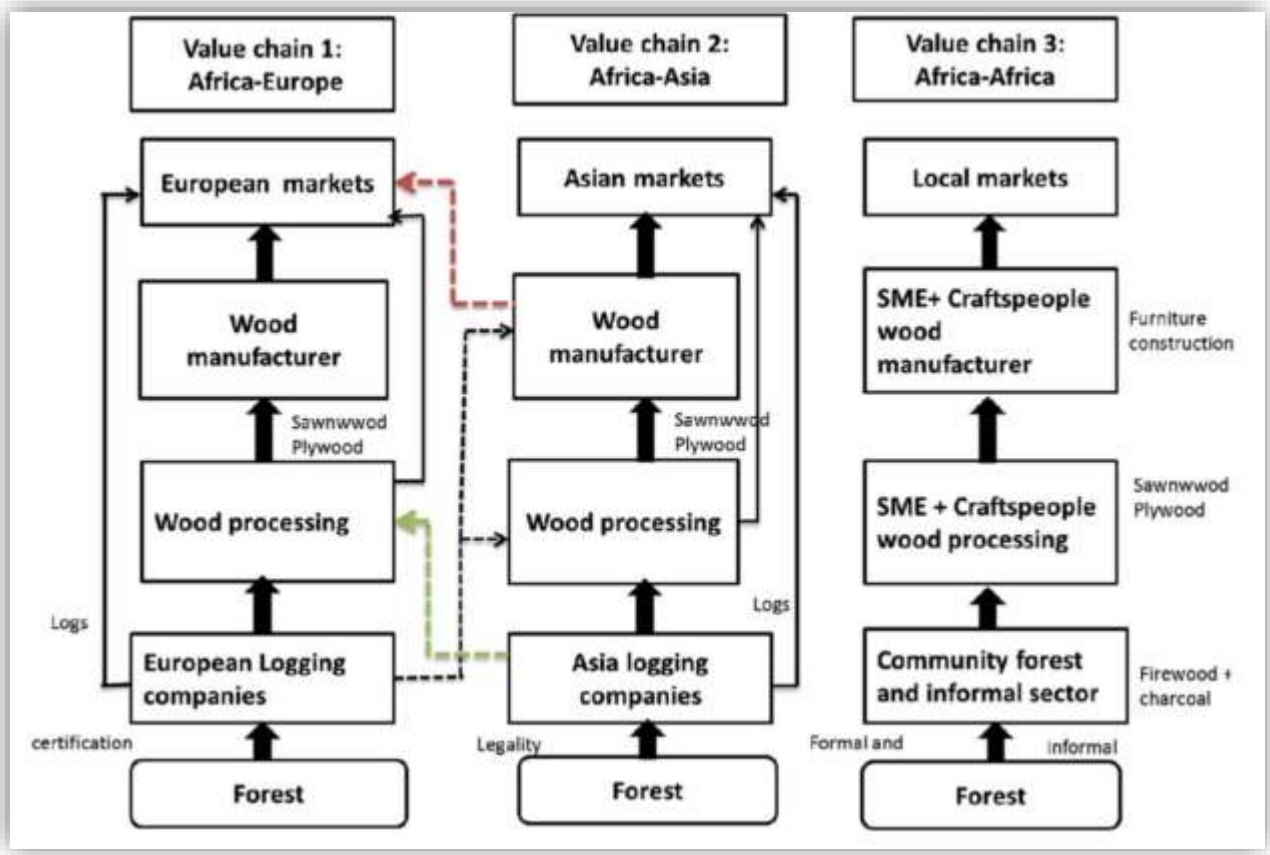


Figure 15: Forest value chain in Central Africa Source: (Bakouma, 2017)

4.1.1.1 Key players involved in forest biomass management

Actors in the Central Africa forest value chain operate at varying levels and can each have a direct or indirect impact on the management, processing and conservation of forest resources. In the Central Africa sub-region, they include government, public, private or parapublic timber mining enterprise companies, indigenous communities and environmental NGOs:

- Government institutions:
  - Water, forest and environment administrations: These administrations are responsible for implementing government-specific forestry policies. Their role is fundamental in the management of forests and environment because, in the vast majority of Central African countries, forests belong to the state that manages them through state institutions and administrations. They also have a role, that is, to set standards and rules, and sanction when necessary. Much of the forest management is granted to private companies (for different purposes ranging from logging to forest tourism, etc.). The main technical directorates include: the Directorates in charge of Forests, Wildlife and Hunting, Protected Areas, Environment, Inventories and Developments, to which could be added the Directorates of Studies and Planning who are more represented at the national levels;
  - Other ministries have more or less direct influence on sustainable forest resource management: Land Planning, Economy and Finance, Agriculture, Rural Development, Tourism, Mines and Energy, Justice, Interior and Territory Administration.

- Public and parapublic bodies: The management of protected areas is most often entrusted to public or parapublic bodies that have management independence. They are involved not only in the management of protected areas but also in the management of the activities of the wood subsidiary as well as public works. The agencies provide the public service (management of national parks, public works, scholarships and internships, activities of the wood sector...).
- Private mining companies: The logging sector is one of the engines of the national economies of Central African countries. Most forest concessions and permits are operated by large groups of European and Asian origin. The large group includes operators: Danzer, Feldmeyer, Man Fai Tai, RimbunanHijau, Rougier, Sonae, Thanry and Wijma. Most of them are present in several countries in the sub-region and operate at the local level. In theory, the role of the forestry industry is to supply wood. These companies are also committed to the implementation of a development plan and sustainable operation. This is the case, for example, of the CEB (*Compagnie Equatoriale des Bois*), Leroy-Gabon or Rougier based in Gabon.
- Aboriginal communities: The involvement of people in the management of forest resources can be according to their own initiatives or based on local water and forest management institutions. These populations are structured in organized groups that are officially in charge of forest resource management. These groups contribute to the regulation of the use of land for subsistence and commercial exploitation, as well as in the control of the exogenous populations involved in the exploitation of cash crops and products (hunting, gathering, agriculture).
- Environmental NGOs: Are directly involved in forest resource management actions. They have a relay of state action and help fill some gaps (**Goyet, 2001**). For example, World Wildlife Fund (WWF) and Wildlife Conservation Society (WCS) are involved in conservation, forest management and the development of ecotourism. Some national NGOs are involved in the local and sustainable conservation and development of forests and are organized in a network, as is the case of the African Forest Action Network (RAAF) which operates beyond the Congo Basin (CEFDHAC, 2006) (Bakouma, 2017; Moulongui, 2014).

In the Central Africa sub-region as well as in other sub-regions, access or exploitation of forest resources is based on standards and regulations dictated by forest resource management actors.

4.1.1.2 Forest biomass harvesters

The right to exploit forest resources is generally assigned to harvesters or mining actors. These categories of forest biomass players get their income directly from forest resources. At the same time, access to these resources is done in several ways:

4.1.1.3 Large forest owners/producers

As mentioned above, in Central Africa, the state is the main owner of all national forest areas. According to FRA, 2015, two categories of homeowners are defined: public owners and private owners.

- **Public properties (the state):** A forest owner who licenses the management while regulating and controlling the wood sector up to the end customers or borders (export), but also as an

investor in the logging areas. There are also state-owned public services at the national and sub-national government level.

- **Private properties (non-Natives):** Forests owned by oil producers: they are forests allocated to individuals or families who can exploit or delegate production on the basis of agreement with producers against a remuneration or share of the production. There are also forests belonging to private entities or institutions (non-natives). These are forests that are owned by companies, cooperatives, companies and other commercial entities and private organizations such as NGOs, associations for the conservation of nature, religious institutions, educational institutions, etc.
- **Forests belonging to local communities and indigenous/tribal (indigenous) communities:** Forest belonging to a group of people from the same community living within or near a forest or forest area belonging to communities of indigenous or tribal populations. Community members are co-owners who share exclusive rights and duties and the benefits contribute to community development.

4.1.1.4 Transporters or logistical operators

Procurement, production, distribution, sales, recycling and valorisation processes involve material flows. The transporters or logistics operators in Central Africa use four modes of transport (road, rail, river and sea) as well as logistic nodes (river and seaports, railway stations). Depending on the type of forest resources, carriers can be distinguished from wood forest products (logs, charcoal, sawmill residues) and non-wood forest products (farming products).

4.1.1.5 Merchants

Actors in primary and secondary transformations

Wood processing capacity in Central Africa is limited to primary processing. Primary transformations are limited to sawing, unwinding, cutting, plywood manufacturing, veneer and charcoal. However, secondary transformations generate moldings, plating dry and contoured wood. Furniture production is still in its infancy. These industrial wood processors operate in the private sector and are for the most part owners of concessions. In the processing sector, several players can be identified: national or international industries, craftsmen, carpenters, etc.

One of the major players here is the French company Rougier, which is the most exploitative forest resource in Central Africa and present in the entire value chain (exploitation, processing, distribution and marketing). Other industries like CIFO, Alam, SOMNAB are also present. Figure 16 below shows the wood product processing value chain from harvesting to secondary processing.

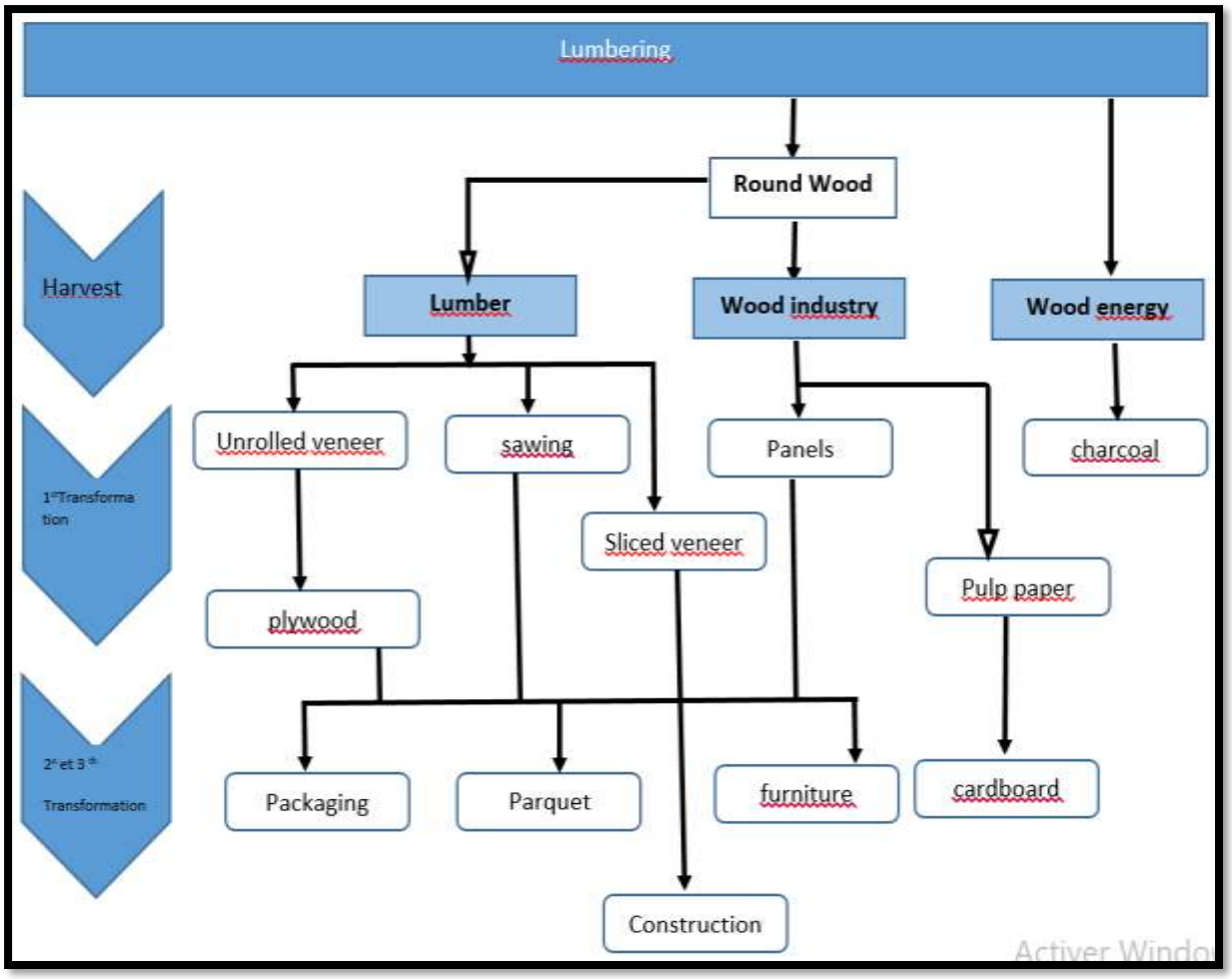


Figure 16: Main products from the mining industry in the Congo basin

Consumption

The consumption of forest resources in Central Africa is in large urban areas and rural areas. One can distinguish primary consumption, secondary consumption. Primary consumption is generally limited to charcoal and firewood collected from forests or collected from processing sites. The use of sawmill waste represents secondary consumption.

- The European, Asian and African market
- The wood depots
- Households
- Restaurants, bakeries etc.

4.1.2 Mapping of forest value chains in Central Africa target countries

The mapping of value chains in each of the countries in the Central Africa sub-region shows commonalities in terms of the destination of flows and products but also in terms of players involved in each destination. As mentioned before, the value chains consist of three layers superimposed and between the layers are the gateways that make the value chain dynamic. Below are some key examples of forest value chain in some selected countries in Central Africa.

4.1.2.1. Case of the Democratic Republic of Congo (DRC)

4.1.2.1.1 Forest resources in DRC

The DRC has enormous forestry potential over an area estimated over 145 million hectares, which represent 54% of the national extent. It is considered as one of the most important African countries because of its extraordinary specific genetic richness. It is indeed home to a wide range of biomes, ecosystems and habitats which give it the first place among African countries in terms of species diversity for several taxonomic groups with more than 11,000 species of angiosperms including 3,200 endemic. From these forests, we distinguish forests on hydromorphic soil, Primary forest, Secondary forest, Plantation, Regeneration and agriculture and Savannah. Eight physiognomic types of vegetation are found in the Democratic Republic of the Congo, namely: dense humid evergreen forests, dense humid semi-deciduous forests, mountain forests, edaphic forest formations, dense dry forests, open forests, mangroves and savannas (wooded and grassy) (Kamungandu, 2009).

Protected areas consist of 10 national parks, totalling over 10 million ha in area (including 9.3 million ha of forest), four of which are listed as UNESCO World Heritage Sites. The DRC also has three biosphere reserves totalling nearly 300 000 ha in size, managed under the supervision of the National MAB (Man and the Biosphere) Committee, five botanical gardens covering 100 000 ha and 57 hunting reserves of around 10 000 000 ha, of which only 21 have been maintained in recent years by the Congolese Institute for Nature Conservation[39].

Various natural regeneration studies have led to certain conclusions about operations to promote seed-trees, such as vine removal, clearing and so forth, which can multiply seeding by an average 100 to 400 percent. The cover afforded by shelter wood also favors natural regeneration. A number of planting techniques have also been tested, such as standardization from the ground up, strip methods, row-planting, the plot method, planting in full sunlight etc. Terminalia spp. are among the main timber species planted for industrial purposes. Eucalyptus spp., Acacia spp., Pinus spp. and Gmelinaarborea tend to be used for fuelwood, as well as for soil protection (Amsallem, 2002).

The volume of wood produced in 2010 was estimated at 1,314,281 m^3 and 1,405,421 m^3 in 2012. Of these volumes of wood produced, 589,833 m^3 were processed in 2010 and 595,981 m^3 in 2012. Over one million of wood products were exported each year between 2010 and 2012, which allowed a contribution of 8.8% in 2010 and 3% in 2012 on the country's GDP and 0.22% on tax revenues. The forestry sector every year between 2010 and 2012 generated more than 7,000 direct jobs and more than 5,000 indirect jobs (Wasseige, Flynn, Louppe, Hiol, & Mayaux, 2014).While these immense resources constitute a major asset for the sustainable development of the country, it is no less true that they pose many problems of conservation, management, sustainable use and development. These problems are political, legislative, scientific, material, financial, social, economic and cultural.

4.1.2.1.2 Forest value chain in DRC

DRC's forest value chain has three destination points for products and involves various types of players. This chain is composed of the Europe, Asia and Africa chain. Figure 17 below represents DRC's forest value chain.

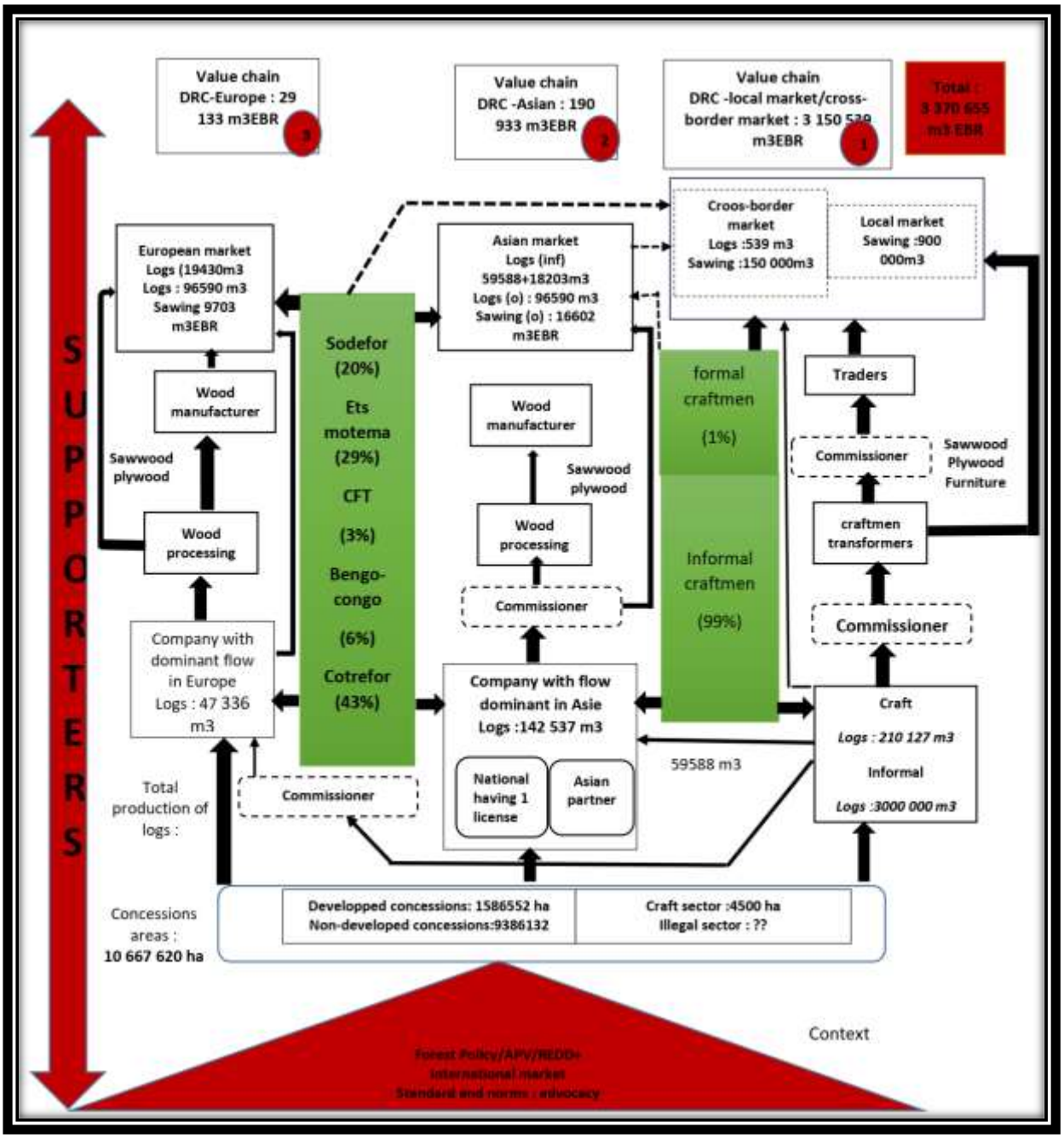


Figure 17: Forest value chain in DRC[12]

Source: (Bakouma, 2017)

4.1.2.1.3 Players involved in the forest value chain in the DRC

- **The public** sector: being the guarantor of forests, the State ensures participatory management of forest resources while promoting dialogue between the various actors (stakeholders), defining the forest resource management policy technical services of the State that deal with forest management (Direction of Forest Management - DFM), Direction of inventory and

[12]**http://www.fonaredd-rdc.org/wp-content/uploads/2018/12/Rapport-3-Projet-FAO-Rapport-de-synth%C3%A8se-r%C3%A9gional-Version-semi-finale.pdf**

forest development (DIAF) and Green spaces advisory committee (GSAC). Other public sector actors are:

- The Congolese Institute for Conservation of Nature (ICCN) which is responsible for the management of national parks, wildlife reserves and hunting grounds. More specifically, it implements forest guarding and anti-poaching systems, conducts monitoring, different studies, surveillance and service tracks, the installation of hospitality facilities (hotel facilities, camps, supply system bridges, etc.) and communication.
- The Institute of Zoological and Botanical Gardens of Congo (IJZBC) manages the conservation of woody and non-woody resources outside their natural environment. Its activities are the acquisition of new species, the provision of veterinary services for animals in captivity, scientific research (experimentation, taxonomy, ecology, ethology, agronomy, forestry, horticulture, etc.), herbaria management and land management.

- **The Administration** is composed of two distinct levels: centralized administration working directly with the Government and decentralized administration (Provincial Government /Territory/Sector, Chiefdom, Cities or Municipalities / Groups / Villages).
- **The private (industrial)** sector: this sector operates in concessions granted by the public sector and operates it according to the development plan approved by the administration. In addition to logging, this sector maintains relationships with governments, stakeholders and participates in negotiations and decisions for sustainable forest resource management. The artisanal sector, on the other hand, operates informally and is not well structured to participate in the management of forest resources.
- **The NGOs:** local (or civil society representatives) are numerous and are interested in various fields. These NGOs quickly collect field information and serve as whistle-blowers to international NGOs (Greenpeace, WWF, Friends of the Earth, Global Witness, Rainforest UK and Rainforest Norway, etc.) that relay and strengthen the means of investigation and communication. In addition, NGOs are recognized stakeholders in pre-certification consultation processes (such as FSC).

4.1.2.1.3.1 Actors in the extraction (harvest) of forest resources

Forest harvesters derive their income directly from forest resources. The harvests are done according to the regulations defined by actors in charge of forestry management. This category includes forest owners, industrial mining companies, artisanal operators, extractors, transporters and merchants.

- The owners of the concessions: the State being the owner of the forest areas grants forest concessions to public, parapublic and/or private enterprises via its administrations and ministries for the exploitation of forest resources according to the regulations in place.
- Industrial wood companies Contractors: These include Forester, SAFBOIS, TRANS-M, FORABOLA, SIFORCO, ITB, SODEFOR, FORABOLA, SODEFOR, COTREFOR, SOFORMA, ITB, SEDAF / SIFORCO and SAFO.
- Artisanal operators: they are national entrepreneurs from the Democratic Republic of Congo.
- Local authorities: are the local customary authorities. Under local custom and practice, they impose new conditions of access to the resource beyond those legally recognized.
- Local communities: they are the local populations (including traditional authorities), with rights over customary areas where exploitation takes place.

- The machinists and its helpers are natural persons who carry out the logging, cutting and sawing of timber.
- Owners of large trucks who transport wood from the loading site to point of sales.
- Handlers: this is the labour recruited locally by artisanal operators for the evacuation of wood from the cutting site at the place of loading. It brings together members of local communities and indigenous people.
- State and parastatal services: are the services committed to collecting various taxes and royalties FFN (National Fund Forestry), Environment, OCC and DGDA (General Directorate of Customs and Access)).
- Wood traders: are intermediaries that facilitate the exchange between operators and exporters.
- Wood exporters: feeds the state pockets by exporting and selling Congolese timber abroad.

4.1.2.1.3.2 Actors in primary and secondary transformations

Industrial sector

The Congolese industry consists of two sub-sectors:

- The primary subsector: the first transformations.
- The secondary subsector: including all manufacturing industries.

The primary subsector is for the external market while the secondary subsector is for the domestic market. DRC has a strong potential for the development of its industrial sector due to an abundance of natural resources, a permanent workforce and a high energy potential) (FAO, n.d.). Wood processing includes several operations that contribute to the manufacturing of products such as sawing products, panels, plywood, furniture, packaging, paper, etc. These operations involve:

- Workers' groups such as: log park agents, operators, electro-mechanics, sharpeners and drivers.
- Maintenance officers: forest machinery mechanics, truck mechanics, light vehicle mechanics and mechanics-planters (turners, millers, planers, grinders, etc.)

The main players in the transformation of woody resources in the DRC are private sector companies. These are subdivided into large enterprises, medium-sized enterprises and small businesses. The wood sector in the DRC is very dynamic. The DRC in 2019 had a total of 29 wood processing companies and 15 in operations.

- Major public sector industries: SODEFOR which is based in Kinshasa and Nioki. it exports unprocessed wood. It has a sawmill and plywood manufacturing plant. The supply of timber from the forest concessions and the supply of the internal market are via the river.
- Private sector industries operate in both the primary and secondary subsectors. Unprocessed wood is exported to neighbouring countries and Asian and European markets. The secondary subsector consist of slicing, plating and drying; Wood panel factories and wood-impregnating factory; Building carpentry, cabinet makers, parquet factories; Packaging industries; Cork products, mats and brushes; Furniture manufacturing; Making pulp, paper and cardboard. The main wood processing companies in operation include: MANIEMA UNION, FORABOLA and BOOMING GREEN, CFT, IFCO, SOMIFOR and KITENGELOLA. These companies have moved to eight provinces that are qualified as forest provinces: ITURI, KASA, EQUATEUR, MA-NDOMBE, MONGALA, TSHUAPA, TSHOPO and SUD-UBANGI (ATBIT, 2019).

Craft Sector

Artisanal mining has the likes of cutting, shaping and transporting wood or any other wood products as well as taking other forest products for economic purposes. This sector of activity is still informal. For example, the company CONTREFOR and CFT (ATBIT, 2019).

4.1.2.1.3.3 Consumers

Consumers here bring together all the players who are the end users. Here we find households, hotels, restaurants, carpenters etc.

4.1.2.1.3.4 Sources and types of forest biomass residue in Democratic Republic of Congo

The main sources of forest biomass residue are public and private forests in Democratic Republic of Congo. Waste is also generated through primary processing (e.g, by wood saw milling companies, owners of pulp mills and charcoal producers) and secondary processing of wood, mainly from wood products and by-product workshops (e.g. furniture).

A summary of the main sources of forest biomass residue is presented in Table 16 below.

Table 16: Sources of forest biomass in DR Congo

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Produce wood residues during wood harvesting
Primary processors	- The industrialists (the company CONTREFOR, CFT, etc.) - The producers	Harvesting of trees leaving wood residue on harvesting sites
	- Transporters	Leave wood residue at site when transporting
	- Merchants, farms, wood/charcoal merchants - Examples: MANIEMA UNION, FORABOLA et BOOMING GREEN, CFT, IFCO, SOMIFOR et ETABLISSEMENT KITENGELOLA	Production of wood residues (chips, sawdust, etc.) during processing
Secondary processors	- Pulp mill owners (SODEFOR) - Wood saw milling companies	Production of wood residues (chips, sawdust, etc.) during processing
Consumers	- Charcoal producers	Produce small amounts of forest residues
	- Wood products and by-product processors and workshops (e.g. furniture)	
	- Wooden construction sites	
	- households, hotels, restaurants, carpenters	

Availability of forest biomass residue and conclusion

There are large amount of quantities of wood that is produced in the Democratic Republic of Congo. These generates a lot of logging residues at the harvesting sites. 283,397M^3 of wood is transformed in Congolese companies, and it is estimated that about 60% of wood for processing are residues, i.e about 170,038.20 M^3. However, this varies from year to year and as mentioned elsewhere in this report, 589,833 m^3 were processed in 2010 and 595,981 m^3 in 2012. The forest value chain in the Democratic Republic of Congo therefore has huge potential in generating forest biomass residues for bioenergy, especially at the wood harvesting and primary processing stages.

4.1.2.2. Case of Cameroon

4.1.2.2.1 Forest resources in Cameroon

Several types of forests exists in Cameroon namely: Dense humid evergreen forest, Dense humid semi deciduous forest, Deciduous forest Gallery forest, Swamp forest, Other natural forests, Plantations, Shrub formations, Fallow land, Tree savannah Bare soil. These forests according to the FAO inventories between 2003 and 2004 covered 21,236,475 ha of the national territory and the wooded lands cover an area of 12,714,956 ha. These values differ slightly from those obtained by FRA 2005 where they estimated at 21,245,000 ha of forest and 14,758,259 ha of woodland (FAO, 2014). Rainforests cover over 40 percent of the area of Cameroon and constitute a significant part of the Congo Basin forest ecosystem (FAO, 2020).In terms of biodiversity, Cameroon is one of the most diverse countries in Africa from an ecological point of view. The main reason for the high biodiversity of these forests is that they constitute an old and very stable system, in particular the forests of the littoral plain. It is estimated that 9,000 plant species are found in Cameroon: at least 156 are endemic, including 45 on Mount Cameroon alone. A study identified more than 200 species of woody plants on a site of 0.1 ha of coastal forest, one of the highest levels of diversity observed in the world. More than 1,000 species of butterflies have been recorded in the forests of the Gulf of Guinea (Mbous, 2002).

Forest resources encompass a multitude of riches in Cameroon and forests are important in terms of extent, potential and biodiversity. In terms of extent, Cameroon is ranked 2nd in Africa: around 20 million hectares. In terms of potential, the Cameroonian forests contain 300 marketable species, of which only sixty are subject to regular exploitation. The exploitable potential of forest products (Medicinal plants, nutrients, service plants, etc.) on the basis of timber market conditions amounts to around 750 million m^3.

Forest harvesting in Cameroon began around the end of the nineteenth century, and it is likely that the first silvicultural trials also date from that time. It had been decided from the outset that loggers should plant from three to ten seedlings of the same species for each tree logged. In 1947, after World War Two, natural regeneration was promoted in Cameroon in the forest areas of some regions, only to be replaced in the early 1960s by plantations, the results from natural regeneration having proved unimpressive. The natural regeneration technique in use at that time was confined to simple operations of vine clearing, devitalization, and release clearing around regenerated trees. These practices had virtually disappeared by 1960-1980. Savannah plantation programmes for fuelwood and service wood production and windbreaks for soil conservation and crop protection were successfully implemented after World War Two. From 1946-1957, tree-planting schemes for soil rehabilitation were also introduced in the Mokolo and Yagoua regions.

Production forests under Forest Management Units (FMUs) in 2001 covered an area of over 3.8 million hectares, only 200,000 hectares of which comprised pilot projects submitted at the same time as the management plans approved by the forest service (i.e. 11 management plans for 11 FMUs). Others are in the planning or final stages.

Two procedures for enriching natural forests through tree-planting have been used in Cameroon, the strip method and parcels:

- The strip technique was introduced in Mbalmayo over 60 years ago.
  The main species were ayous (Triplochitonscleroxylon), mahogany (Khayaivorensis), sapelli (Entandrophragmacylindricum) and bibolo (Lovoatrichiloides).
- The parcel procedure was based on the conventional notion of "support points", averagesized plots of 10 m x 20 m distributed in accordance with a square mesh of roughly 100 meters. After harvesting, the plots are planted with commercial species (Amsallem, 2002).

With a GDP per capita of US $ 2,000 and a forest cover of "20,009,000 hectares (tropical forests), the forests of Cameroon represent one of the main sources of tropical timber in the world with 2,437,300 logs produced among which 1,070,900 are processed into various products and 1,414,468 m^3 are exported to the international market. As a result, timber exports in Cameroon will constitute a very important part of foreign exchange earnings, given the decline in oil deposits and the fall in the prices of industrial crops such as coffee and cocoa. The forestry sector since 2006 employs more than 13,000 people each year with 150,000 indirect jobs (Amsallem, 2002; Mbous, 2002).

Forest value chain in Cameroon

Like the DRC, Cameroon's forestry value chain has three destination points for products and involves various types of players. This chain is composed of the Europe, Asia and Africa chain. Figure 18 below represents Cameroon's forest value chain.

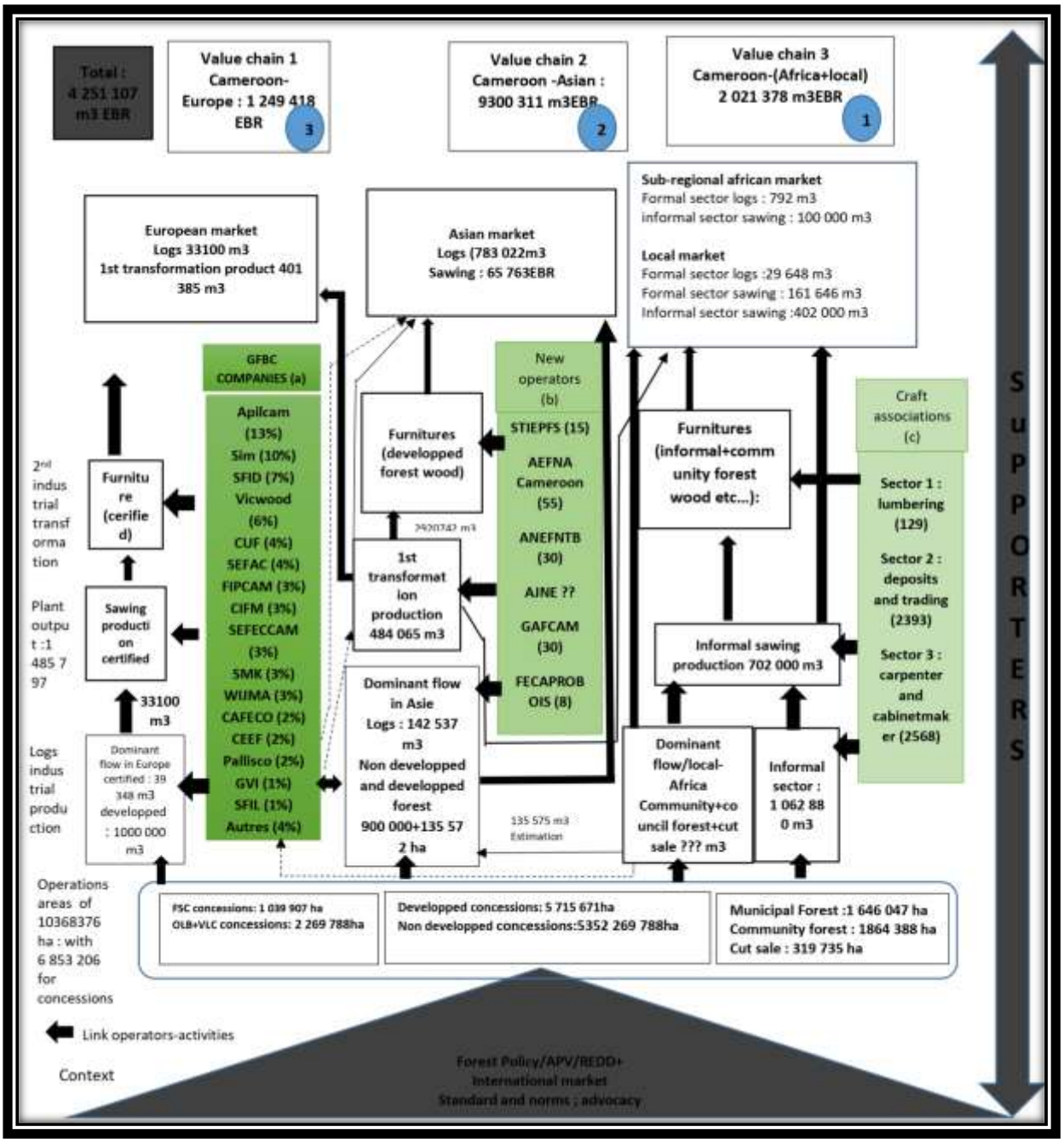


Figure 18: Forestry value chain in Cameroon Source: (Bakouma, 2017)

Players involved in Cameroon's forest value chain

<u>Forest management and conservation</u>

- The State and Ministry of Forest and Wildlife (MINFW): The state being the owner of all the forest areas of Cameroon is the main player in the design and implementation of the forestry strategy in the sector. This includes the executive, the legislative and the judicial at the national and decentralized levels. The state here operates direct control through government organizations. It defines the policy of forest resource management. It promulgates laws including that on the forest, it appoints the senior officials of the Ministry in charge of the forestry field, grants accreditations and ensures strategic choices in the sector.

The Prime Minister as the head of government is in charge of the implementation of policies: exercises regulatory power, enacts forest classification texts of the Permanent Forest Estate, grants various logging titles, and appoints some senior officials of MINFW (Ministry of Forest and Wildlife) MINFW is the main player in the forestry sector. It manages the sector in particular through the implementation of forest policy in collaboration with other state actors. Other relevant government ministries involved in the forestry sector include: Ministry of Agriculture and Rural Development (MINADER), Ministry of Livestock, Fishing and Animal Industries (MINEPIA), and Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED) are constantly interacting with MINFOF because they operate in same territories and with the same farmers, herders, lumberjacks, coal miners, hunters, gatherers. These ministries are also guarantor of the conservation of natural heritage and sustainable management of the land.

- The private sector is the major player in all the production and development of forest resources. Businesses are the main component of economic growth in four levels: investment, value added, wealth and employment. The private sector contributes to forest resource management activities at all levels: studies, forest management activities, exploitation of forest and wildlife resources, development and processing of wood and non-wood forest products, and other forest and wildlife services in production and conservation areas.
- Civil society includes non-governmental organizations, associations and other forms of groups of common interest, trade unions, forums, etc. that intervene directly on the ground or at the national level. Civil society is multifaceted and multicultural. Civil society in the forest and wildlife sector is extremely active, participating in all major reflections on sustainable resource management and at all levels of society. Civil society put in evidence overall concerns on the management of forests, protected areas, national heritage, governance of financial resources, consideration of local communities along the river, etc.
- Neighboring communities are divided between those who get their living from forest resources and those who live in the forest, the most vulnerable populations.
- International agencies and organisations: They assist the government in the development and implementation of the- forest sector policy through the coordination of programs, but also on the ground in support of institutions and organizations. All of these organizations are members of the PFBC (Partnership for the Forests of the Congo Basin),a Type II organization that brings together all the major players in forest management in Central Africa, and use the Convergence Plan as a reference for planning their activities in COMIFAC (Central Africa Forest commission) member countries. These include:
    - Sub-regional cooperation within COMIFAC, the CEEAC's specially regulated forestry body, bringing together the 10 Central African states using the Convergence Plan as a common tool for coordinating forest actions, and whose headquarters and executive secretariat are in Yaoundé;
    - Bilateral cooperation (France, Netherlands, UK, Norway, Canada, Germany, EU, Japan, USA, etc.)
    - Multilateral cooperation: United Nation Agencies (UNDP, FAO, UNEP);
    - Financing institutions, World Bank, AfDB, FFBC, IFAD, IDB, etc.;
    - Specialized forest and conservation research organizations and institutions (IUCN, CIFOR, WWF, OIBT, ICRAF, WCS, FTNS, IRAD, CIRAD, etc.) (MINFOF, 2012).

Exploitation / harvesting actors

The pattern of the forest exploitation chain (e.g. wood) can be segmented into four distinct levels: upstream, downstream, meso and transversal. Different categories of actors are in each level

- Upstream of the production of wood forest products (wood harvesting) are the economic operators holding licenses of access to the forest resource. With this in mind, Cameroon's logging legislation provides, among other things, for exploitation titles giving access to wood and/or non-wood forest resources: forest concession, communal forest, logging sale, community forest, timber license and personal logging permits, as well as hunting permits. In 2019, MINFOF declared 93 forest concessions, 38 communal forests, 142 logging sales and some 50 community forests valid in the first quarter of the year. These forest titles are managed by 59 large international or national companies, 46 medium-sized enterprises and 38 rural municipalities owners of communal forests.
- At the meso level of the logging chain, we mainly meet the economic companies/operators of the wood processing niche. They process wood into various products (including cut, veneers, plywood, furniture, etc.). In this sense, the forestry administration maintains an updated list of companies/operators authorized to act as wood processor (UTB).
- At transversal level, a category of private actors operates cross-cuttingly along the wood production chain in Cameroon. These are the carriers of woody products, either in the form of logs or in the form of processed products. However, this category of economic operators (transporters), although influential in the activities of logging, do not fall under the technical tutelage of MINFOF. Because of the nature of their activities (road transport, railway and maritime transport), it escapes directly from the grip of the forestry administration.
- The downstream production of wood is structured around economic operators who operate either as exporters of raw and processed wood products (logs, cut, veneers, plywood and other finished or semi-finished products), or as traders or commodity brokers.

Figure 19 represents the logging chain in Cameroon.

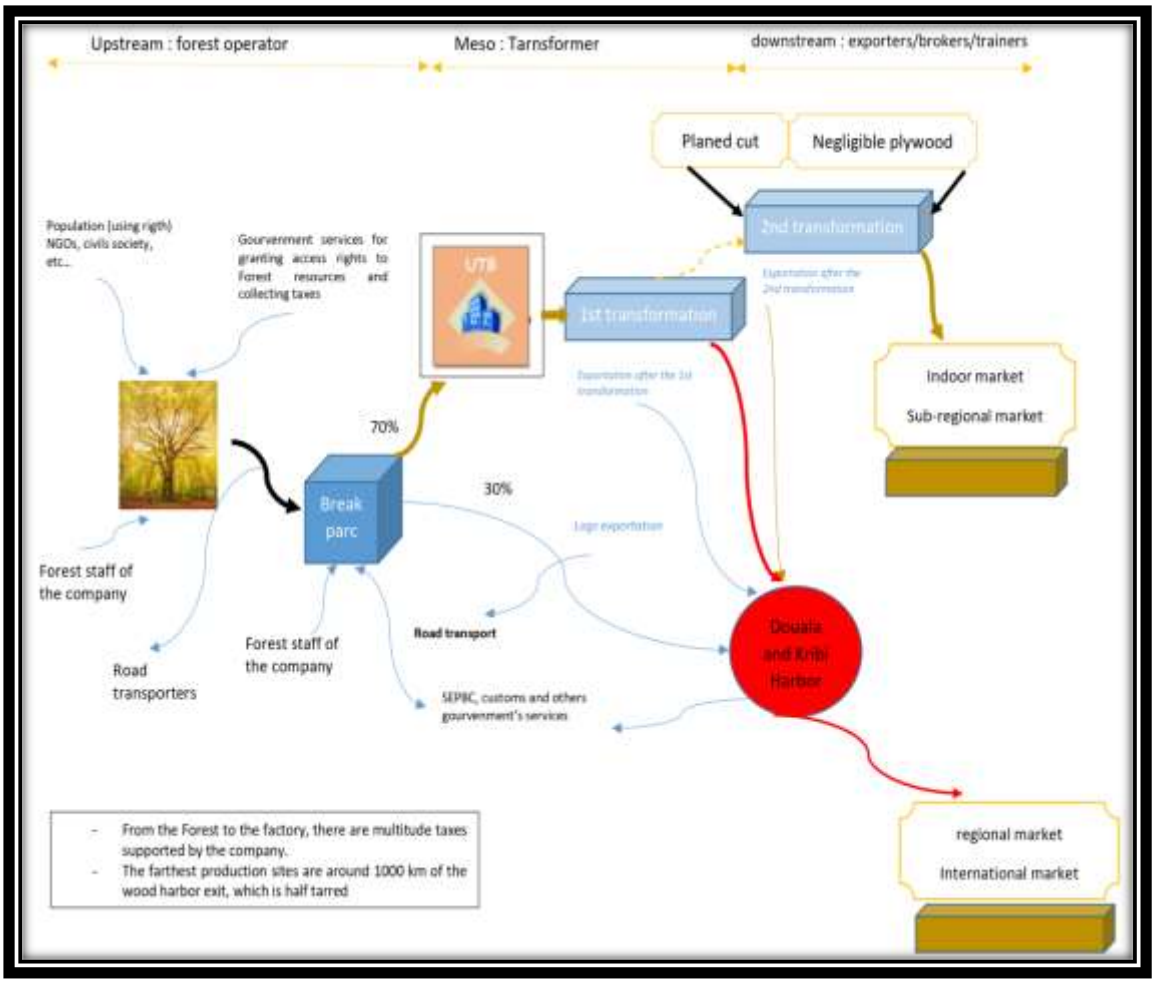


Figure 19: A logging chain in Cameroon Source: (MINFOF, 2012)

Another category of exploitation of wood forest products involves craftsmen who operate in the informal sector. The products from their processing are destined for the domestic market. They are classified as the fourth category of wood processing unit (UTB). Figure 20 represents the chain of artisanal timber destined for the domestic market.

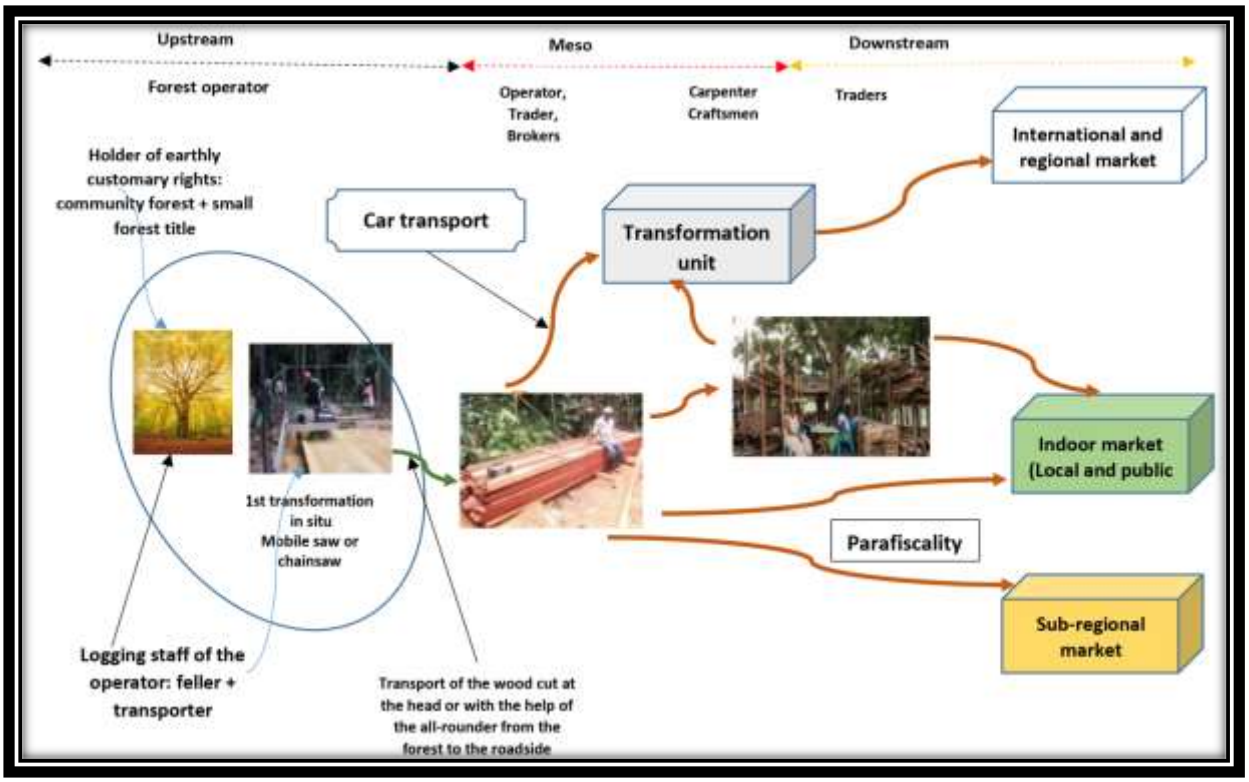


Figure 20: Production chain of artisanal lumber Source: (HiolHiol, 2019)

Overall, from the forest massifs to the two export ports of Douala and Kribi the wood production chain is segmented as follows:

- Operator - Processor- Exporter (control of the entire wood value chain);
- Supplier operator (FMU-Forest Management Units, communal forests, logging sales, community forests);
- Transformer - Exporter (operates in two niches);
- Exporter/trader (operates in a niche) located in Kribi and Douala (HiolHiol, 2019).

Forest resource harvesting actors includes local communities, forestry companies, forestry administration, administrative authorities and political authorities. Since the Cameroonian government is at the forefront of forest resource management, it provides through its ministries and agencies concessions to public and private enterprises for the harvesting or exploitation of forest resources.

Forestry companies: Since 1999 there have been 479 forest companies that secured concessions awarded by the government. These companies include public companies, domestic and foreign private companies. These companies operate both in the harvesting and processing of forest products. We can distinguish:

- Subsidiaries: ThanryCoron, Alpi, Hazim,Rougier, Delcovenareare, Itallegno, Vastolegneault, Pasquet,etc. ;
- Large groups dealers: VISWOOD, ROUGIER,SEFAC, KHOURY, Bolloré, ALPI, PASQUET, PatriceBois, WIJMA,etc...

In terms of supply areas, there is an asymmetrical mesh. The area and number of concessions are invariable from one region to another. There is high concentration in the eastern regions followed by the southern region. The following table 6 includes all the concessions and their locations.

Table 17: Forest operators and administrative location

Name of the attributor	Administrative location	Surfaces (ha)
SFF	Djoum/Mintom	59,238
SFB	Yoko	51,45
STBK	Yokadouma Yokadouma Yokadouma	81.3975 2.2453 7.007
CIBC	Moloundou	130,273
CUF	Ma'anEbolowa / Mvangane / AmbamEbolowa/Ambam/Ma'anEbolowa / Akom 2 / Bipindi / Lolodorf /Kribi	56.1923 8.2474 4.8663 5.1031
SFCS	Yokadouma	57,996
SEBC	Yokadouma/Salapoumbé	122,294
SCIEB	Ma'an Ma'an Camp	88.1477 6.0024
SFID	Lomié / Mbang	67,942
Sab	Salapoumbé	48,554
SFDB	Messok	46,922
GRUMCAM	Ndélélé Abong-Mbang/Mbang	86.0968 2.308
SEFAC	SalampoumbeYokadouma Moloundou/Yokadouma/ Salampoubé	59.3407 2.7276 6.688
KHOURY J.	Ngambé Mat	88,05
GREEN VALLEY	Yokadouma	66,183
SODETRANCAM	Lomié Lomié / Mindourou Mindourou	64.9614 4.2496 6.861
PLACAM	Belabo/Bertoua	28,387
SEBAC	Yokadouma / Salapoumbé	92,287
CFC	Yokadouma	69.0182
Leave	Nanga EbokoYoko	48.0625
EDEATHECH	Edea	100
CFK	Edea/Kribi/Bipindi/Messondo	125,563
ANAFOR	Belabo Akonolinga	2.500 1.000
INC Sarl	Yoko	49,64
LOREMA	Djoum/Mintom	138,652
SOBOCA	Mvangane	40,363
Yes	Yokadouma Yokadouma	82.5713 5.090
ALPICAM	Garingombo/Yokadouma	126,988
Lfm	Lomie/AbongMbang	47,585
PALLISCO	LomieHautNyong Messok	41.2024 7.2415
CAMBOIS	Messok/Mindourou	147,463
FIPCAM	AbongMbangEbolowa/ MvanganeHtNyong	54.4477 3.59747.241
SCTB Sarl	Doume/AbongMbang Batouri/Mbang	70.2834 4.5005 4.222
PANAGIOTIS MARELIS	Belabo	149,079

CSTC	Moloundou	68,916
SFIL	GarigomboMbang	71.4104 7.823
SOCIB	Djoum	75,366
SOPFCO	Eseka/Then/Lolodorf mvengue/Bipindi/Messondo	59,295
SIBM	Djoum/Oveng/Sangmelima	30,088
CAFECO	Eyumedjock	80,8
SEFECCAM	Eyumedjock/Mamfe/Akwaya Manyu	43.8445 4.807
SMK	Ngambe-Mat	45,21
SIENCAM	Ndikimeneki/Makenene/Yingui/Makombe	94,917
DINO and Son	Messamena/SomalomoDja/Mindourou/Lomie	40.7807 9.579
KAKOUANDE	Batouri/Mbang	57,137
SOFOHNY	Oveng/Mvongane/SangmelimaHautNyong	42.5566 6.607
THE FOREST COTIERE	Belabo/Bertoua	97,123
SOCIB	Djoum/Mintom	44,698
THE ROSIE	Top Nyong	52,186
ENJC	Nkam/Moungo	38,195
SFEES	Top Nyong	31,803
MULTI-SERVICES PLUS	Top Nyong	77,692
SCIFO	Top Nyong	74,464
GRACOVIR	Top Nyong	52,021
IBC	Top Nyong	77,551
BOTAC	Moloundou Ngoyla	49.7505 1. 342
Cofa	AmbamDja Oveng/Mvangane	25.0002 5.0005 4.822
HABITAT 2000	Meloundou	50,752
Ets TONKAM Marcel et Co.	Adi	89,962
SBAC	Top Nyong,HautNyong	32.6753 8.013
CAMTRANS	Djoum/Oveng	63,865
THE FILIERE BOIS	Moloundou	115,9

Source: https://www.atibt.org/wp-content/uploads/2020/03/Rapport_Etat-des-lieux-Secteur-priv%C3%A9-Cameroun2019.pdf

Local communities

In this group of actors, we distinguish between farmers and hunters:

- Farmers: Forests have always been their main economic activity. The purpose of agriculture is to supply large metropolises with both woody and non-woody forestry resources. Chainsaws are used to cut down trees to create the spaces needed for agriculture. The felled trees are cut down and the small pieces serve as firewood and the bulk used for charcoal production.
- Hunting in communities is one of the commercial activities. The forest resources that are extracted are mainly large mammals, including buccaneering meat (Ngoufo & Tsalefac, 2006).

Actors in primary and secondary transformations

The Cameroonian government is the owner of forest areas and is responsible for managing and controlling the exploitation of forest resources. The operation and processing activity is entrusted to the industrials. MINFOF in 2019 mentions the presence of 203 wood transformation units (UTB)

present in Cameroonian territory spread over six regions: South, EST, Littoral, Central, West and Southwest. These different transformation units are separated into four categories:

- First category, fixed capacity greater than 5000 m^3
- Second category, fixed or mobile capacity between 1000 - 5000 m^3
- Third category, fixed or mobile capacity less than 1000 m^3
- Fourth category, other craft units registered as processors.

Installed industrial capacity is concentrated in four regions of the country. The economic operators have the equipment for further processing of wood (cut, veneer, plywood, and other semi-finished products). These are mainly located in the eastern regions (Boumba and Ngoko), the coast (Douala) and the Centre (Yaoundé and its surroundings).Table 18 shows the geographical distribution of these UTBs.

Table 18: Geographical distribution of UTB

Name	Location	Seat
ALPICAM (group)	Mindourou 1 and Bonaberi	Douala
CAMEROON UNITED FOREST (CUF)	Ebolowa	Douala
CIFM/PALLISCO	Mindourou 2	Douala
FIPCAM	Mfou	Yaounde
PANAGIOTIS MARELIS (PM)	Belabo	Douala
SFIL	Ndeng	Douala
SFID	Mbang and Djoum	Douala
SEEF	Douala	Douala
SEFECCAM	Douala	Douala
SEFAC	Libongo	Douala
Yes	Ahala 2	Yaoundé
SMK	Ngambe-Mats	Douala
VICWOOD Thanry (Group)	Ngola 35,	Douala
STBK	Batouri	Batouri
WIJMA (Groupe, CFK)	Bidou	Douala
EFMK		
SOFOHNY	Yaoundé	Yaoundé
SIENCAM		
NAMBOIS	Douala	Douala
CCT	Douala	Douala
PLACAM	Douala	Doual

Source: https://www.atibt.org/wp-content/uploads/2020/03/Rapport_Etat-des-lieux-Secteur-priv%C3%A9-Cameroun2019.pdf

4.1.2.2.1.1 Transporters/logistics actors

Transporters (or carriers) of forest products in Cameroon must have a legal document signed by the departmental head of forest administration and indicating, among other things, the quantities and specification of the products transported, as well as their origin (Armand, 2010).
The modes of transport commonly used are road network, the railways and maritimeways.

- **The road** is the most used in the territory. Large trucks with trays transport log from the forest to the processing units that are located either closer to the port or to the forest, depending on the strategy of the company. Trucks are also used on routes from processing units to the port. In eastern Cameroon, for example, trucks carry the cut wood to the Belabo railway

station. Road transport can be carried out either on its own account, when companies have a personal fleet, or otherwise by transportation companies.

- **The rail way** is operated by The Cameroon Railways (CAMRAIL).
- **The maritime transport** is carried out by two major consignment in Cameroon, namely DELMAS and MSC. However, other companies such as MESSINA, an Italian company or MAERSK are also present (EYENGA, 2009).

4.1.2.2.1.2 Merchants and consumers

These are merchants who might be the domestic market tankers, the exporters of raw forest products and/or processed forest products. There are also traders, brokers, and forwarders who are located mainly in the port areas of the country (Kribi and Douala). There exist companies that occupy the three links of the logging chain (operator, processor, exporter), others that operate only in one of the links as a processor or exporter, and some that occupy the two links of processor-exporter (HiolHiol, 2019). Wood forest products are consumed within the country or outside the country. One can have furniture, handicrafts, timber, firewood, charcoal, waste from sawmills, etc. Depending on these forestry products, one can distinguish several consumers: households (building houses, cooking with charcoal or firewood), hotels, restaurants, decoration industries, etc.

4.1.2.2.2 Sources and types of forest biomass residue in Cameroon

The main sources of forest biomass residue are government and community forests in Cameroon at harvesting sites and through primary and secondary processing as shown in Table 19.

Table 19: Sources of forest biomass in Cameroon

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Produce wood residues during wood harvesting
	- The industrialists - The producers	Harvesting of trees leaving wood residue on harvesting sites
	- Transporters - Examples: Cameroon Railways (CAMRAIL), DELMAS et MSC, MESSINA, MAERSK, MACK	Leave wood residue at site when transporting wood
	- Merchants, farms, wood/charcoal merchants	Production of wood residues (chips, sawdust, etc.) during processing
Primary processors	- Pulp mill owners - Examples: CAMEROON UNITED FOREST; CIFM/PALLISCO; FIPCAM; SFID; SEFECCAM; SEFAC; SIM, STBK, WIJMA (Groupe, CFK); EFMK, NAMBOIS, PLACAM	Production of wood residues (chips, sawdust, etc.) during processing
	- Wood sawmilling companies - Examples: ALPICAM; CAMEROON UNITED FOREST; FIPCAM; SEFECCAM	

	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture) - Examples: SEFAC, WIJMA (Groupe, CFK), EFMK	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites - Examples: CAMEROON UNITED FOREST, CIFM/PALLISCO, SEFAC, SIM, NAMBOIS	Production of wood residues (chips, sawdust, etc.) during processing
Consumers	households (house building, charcoal or firewood/wood cooking), hotels, restaurants, decorating industries	Produce small amounts of forest residues

4.1.2.2.3 Availability of forest biomass residue and conclusion

As mentioned before, Cameroon represent one of the main sources of tropical timber in the world with 2,437,300 logs produced among which 1,070,900 are processed into various products and 1,414,468 m^3 are exported to the international market. Amount of forest biomass residues generated is about 1, 245,791.32M^3 from various forest exploitation sites mainly at the level of sales cuts, community forests, cutting authorizations and forest concessions according to 2013 data. The forest value chain in Cameroon therefore has huge potential in generating forest biomass residues for bioenergy, especially at the wood harvesting and primary processing stages.

4.1.2.3. Case of Congo

4.1.2.3.1 Forest resources in Congo

The forest covers an area of 22.4 million hectares (7 million are flooded), or 66% of the national territory. The exploitable potential of marketable and promotional tree species is estimated at 170 million cubic meters with the possibility of extracting 2 million cubic meters per year without compromising the regeneration capacity of the forest. Logging contributes 5.6% to the GDP of the Republic of Congo (2012), it is therefore the second national source of income after the hydrocarbon sector, which contributes 79% to the country's GDP. The forestry sector is the second largest provider of jobs in the country. The logging and processing activities of wood generate 7,424 direct jobs and 14,848 indirect jobs[1]. The forestry sector generates a turnover of around USD 179089million per year and contributes USD 35.81million to state tax revenue[2]. In addition to these revenues, mining and processing activities have spillover effects in the concession areas, although they have not yet been evaluated (EU, 2016).

Congolese forest harvesting, selectively targeting just a few high-value species, arose out of dawning European awareness of the value of these woods in the early nineteenth century, with Europe becoming the prime export destination. The earliest reforestation efforts date back to 1937, but commercial reforestation as such took off only in 1947 with ironwood (Casiasiamea), teak (Tectonagrandis), limba (Terminalia superba) and a few others. From 1948 onwards, 6,500 hectares of limba were established in the Mayombe forest area. In the aftermath of World War Two, with the opening of the Office des bois de l'Afrique based in Libreville, modern harvesting of the natural forests was launched under a few major national forestry enterprises based in the southern part of the country.

The main species planted in rainforest areas are okoumé (Aucomeaklaineana), limba, bilinga (Naucleadiderrichii), moabi (Baillonellataxisperma), pao-rose, (Swartiafistuloïdes) and tiama (Entandrophragmaangolense). Species planted in savanna areas are pines (P. caribaea, P. oocarpa), Eucalyptus spp., Araucacia spp. and Acacia spp. Congolese forestry silvicultural research has obtained some impressive results with selected local species, especially limba; with fast-growing exotics, mainly eucalyptus and pines; and with industrial plantations of these species. Eucalyptus cloning techniques with fast-growing Eucalyptus spp had already been developed by 1976, and were later extended on an industrial scale. Limba, a sun-loving species, has been used since 1949 following the partial or total destruction of forests by manual or mechanized methods. Plantation spacing can be as wide as 12 m x 12 m. Natural forest improvement is also practiced in Congo. The forest cover is opened for the first time by commercial harvesting. Complementary selective thinning of the dominant secondary species follows immediately to favor the growth of the dominant commercial species. This mixed regeneration/shelter cut is also intended to stimulate the long-term regeneration of commercial species.

In the matter of protection and follow-up of the state-owned forest, the administration of water and forests are responsible, according to the management plan at national, regional and local levels that the authorized activities in this area don't lead to forests destruction, but assure their sustainability, their extension and harvesting in rational conditions. These activities must be carried out in the framework of rational management of forest resources, on the basis of sustainable management of forest ecosystems, assuring a sustainable forest yield and environment conservation, notably in regards to biological diversity (Amsallem, 2002)

4.1.2.3.2 Forest value chain in Congo

In Congo-Brazzaville, the economic performance of the forestry value chain is linked to trade with Asia, notably China and the Middle East, Europe and Africa, and the dynamism of the informal sector. The players involved in Congolese forestry are represented in Figure 21.

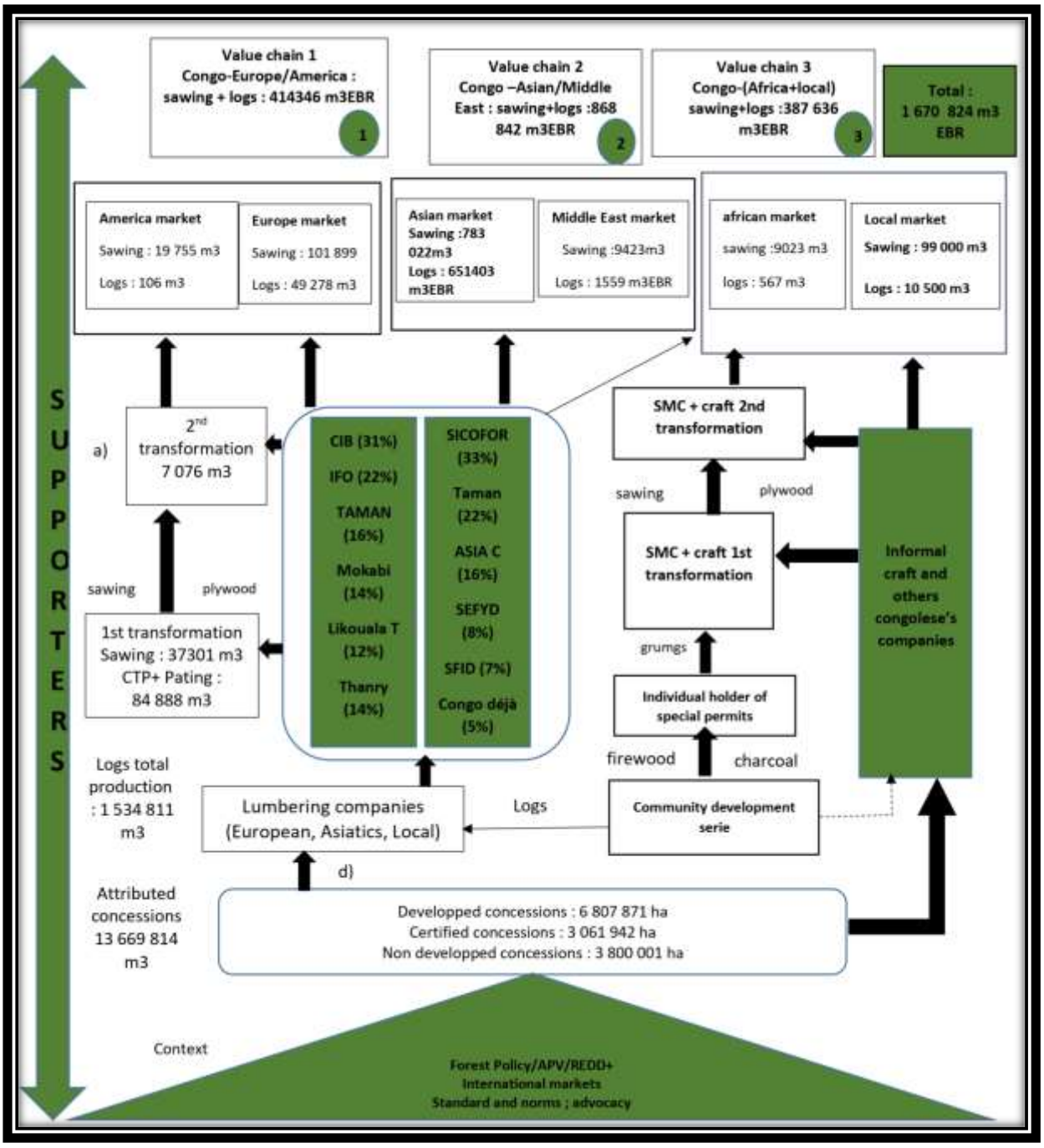


Figure 21: Value chain of forest of the Congo Republic Source: (Bakouma, 2017)

4.1.2.3.3 The players involved in the forestry chain of the Republic of Congo

In Congo, there are several types of forest management and some allow communities to exercise certain rights for access, management or ownership of the forest resource. Overall, the management of the forest sector in the Republic of Congo involves the management of forest products, the development of forest resources, afforestation and reforestation. Like in other Central African countries, Congo's forests belong to the state that manages them through ministries and institutions.

- Forest resources in Congo are managed at the institutional level by the Ministry of Economy, Forestry and Sustainable Development (MEFDD).It is based on two major structures for the

management of forest activities throughout the country. These two major structures are under the control of the General Inspectorate of Forest Economics and Sustainable Development (ISGSEFDD):

- The Directorate General of Forestry Economics (DGEF), which has five (5) central and twelve (12) departmental branches;
- The Directorate General for Sustainable Development (DGDD), which has four central branches.

To ensure the rational management of renewable resources, Congolese forest authorities have put in place a policy of sustainable exploitation of forest ecosystems and advocate for sustainable protection of the environment. In this regard, strategic planning exercises such as the National Forest Action Plan (NFPP), the National Strategy and the Biological Diversity Action Plan (SNPADB) and the Interim Poverty Reduction Strategy Document (IPSD) have been developed.

The Forest Code challenges neither the roles and responsibilities of the various stakeholders, leading to institutional reform and leading to the creation of the MEF (Ministry of Forestry economic) but also the General Inspectorate of Forest Economics (IGEF), the Forest Products Control Service for Export (SCPFE), the General Monitoring Society (SGS), the Forest Fund (FF) and the National Centre for Forest And Wildlife Inventory and Management (CNI). The projects Congo Sustainable Forest Management Support (PAGEF), the National Forest Inventory (IFN), the Congo Basin Ecosystem Conservation Support, and the sustainable management of Pericopciselata/Afrormosia in the Congo Basin are hosted by the CNIAF (*Centre National d'Inventaire et Aménagement forestier*). Its attributions are:

- Implement national forest and wildlife inventory programs;
- Process, conserve and update inventory data on forest, wildlife and protected areas;
- Develop and update national mapping;
- Develop national forest management plans;
- Propose and follow the possible revision of forest and protected areasmanagement plans ;
- Assist and monitor regional water and forest services, public bodies and private companies in the forestry and wildlife sectors in conducting and monitoring of inventory and management of forests and protected areas (MEF, 2017).

Apart from the state that manages through its institutions, the private sector plays a significant role in the management of forest resources. This is to ensure the sustainable use of these resources. This private sector consists of domestic and foreign companies that are public, parastatal or private. They have limited shares in concessions granted by the government.

Indigenous peoples have a collective and individual right to property, possession, access, and the use of the land and natural resources they traditionally occupy or use for subsistence, pharmacopoeia, and work. People consider certain forests to be sacred forests and management is to protect these forests and their resources for traditional purposes (Faure, 2013).

The role of NGOs in forest management lies mainly in the level of support of the council. Similarly, the State entrusts the management and conservation of wildlife to these NGOs (Wildlife Conservation Society - WCS, World Wildlife Fund –WWF. Some of their activities include:

- Full protection of certain animals and their habitat;
- Development of all wildlife through the creation and management of parks and protected areas;

- Promotion of ecotourism;
- Hunting settlement

4.1.2.3.3.1 Exploitation / forest harvesting actors

As in other Central African countries, the actors involved in the exploitation of Congo's forest resources are those who live from forest resources and/or those living in forests. The exploitation of forest resources ranges from extraction to marketing through export, processing and transport. In the Republic of Congo, exploitation is mainly at the level of concessions granted by the state. There are: The main actors involved in harvesting are:

- The administration that is responsible for defining laws and strategies related to the exploitation of forest resources.
- Indigenous peoples who take forest resources such as firewood, charcoal and non-wood forest resources. This is to supply the markets of the major metropolises.
- National and international industrialists that may be public, parastatal or private. The most influential in Congo are CIB-OLAM, IFO, Likouala Timber, Thanry, Asia Congo Industries, SICOFOR, TAMAN, MOKABI, BPL, CDW

However, operators must hold an operating license that gives them the right to collect the quantities of forest resources. Operating opportunities include industrial processing agreements(ITCs), development and processing agreements(CATs), plantation timber logging permits and special permits. Table 17 shows owner of forest exploitation licenses (Mertens, Minnemeyer, Nsoyuni, & Steil, 2007).

Table 20: Forest concession holders

Company	Total area (ha)	Capital origin
ADL	42 594	Congo
COFIBOIS	55 061	Congo
SOBODI	55 954	Congo
SFIB	73 423	Congo
SFGC	79 129	Congo
SPIEX	91 671	Congo
SADEF-CONGO	100 790	Congo
KASSA WOOD	112 490	Congo
AFRIWOOD	114 668	Congo
Pour	152 159	Congo
CITB QUATOR	167 866	Congo
SOFIA	509 217	Congo
NEW TRABEC	152 036	Europe
ITBL	318 353	Europe
LIKOUALA TIMBER	582 855	Europe
MOKABI	583 445	Europe
FORALAC	846 635	Europe
Ifo	1 422 890	Europe
CIB	1 657 219	Europe
BPL	200 811	Lebanon
TBI	315 470	Lebanon
SIFCO	521 307	Lebanon
SOFIL	300 242	Malaysia
TAMAN INDUSTRY	498 547	Malaysia
ASIA CONGO INDUSTRY	618 109	Malaysia

CIBN	661 633	Malaysia
SEFYD	129 578	China
THANRY-CONGO	467 988	China
SICOFOR	804 726	China

Source:**http://pdf.wri.org/gfw_congo_atlas_v1_francais.pdf**

4.1.2.3.3.2 Primary and secondary forest resource transformation actors

The exploitation of natural forests in the state domain is done, in accordance with Article 65 of the Forest Code, by the Industrial Processing Convention(CTI), Management and Transformation Convention(CAT) or by a special license. The Industrial Certification Convention (CTI) guarantees its holder the right to extract forest resources on a given concession and transform these resources only its industrial unit.

- The first transformation (wet sawmills) includes sawmills (CIB-OLAM, IFO, Likouala Timber, Asia Congo industries, Thanry, SICOFOR, TAMAN, SEFYD, SIFCO, Afriwood...), the manufacture of veneers and plywood (Asia Congo industries, SICOFOR, TAMAN, BPL, CDWI) and the laminated panels (IFO, Likouala Timber),
- The second transformation (dried sawing) is characterized by various activities that require the implantation of wood drying cells:
  - Industrial production: furniture, carpentry are done at CIB POKOLA, Likouala Timber, SEFYD and SIFCO;
  - Construction of structures, building development and civil engineering workshops (for the production of eco-friendly wooden and wood-frame houses at CIB POKOLA, Likouala Timber and IFO);
  - Industrial furniture production is carried out by industries such as CIB, Likouala Timber, SEFYD and SIFCO

Table 21: Primary and secondary transformation industries

Companies	Types of activities	Location	Department
FORALAC	Unwinding	Matalila	Lékoumou
SICOFOR	Unwinding	Black Point	Black Point
Taman Industries	Unwinding	Price	Kouilou
Aci	Unwinding	Dolisie	Niari
Aci	Slicing	Dolisie	Niari
FORALAC	Plywood	Matalila	Lékoumou
Aci	Plywood	Dolisie	Lékoumou
SICOFOR	Plywood	Black Point	Black Point
Taman Industries	Plywood	Price	Kouilou
SICOFOR	Sawmill	Black Point	Black Point
BPL	Sawmill	Lopola	Likoula
MOKABI SA	Sawmill	Moualé	Likouala
LT	Sawmill	Bétou	Likouala
THANRY CONGO	Sawmill	Ipendja	Likouala
CIB-Olam	Sawmill	Loundoungou Toukoulaka	Likouala
CIB-Olam	Sawmill	Massacre	Sangha
Ifo	Sawmill	Ngombé	Sangha
SIFCO	Sawmill	Speak-Speak	Sangha
FORALAC	Sawmill	Bivéla	Kouilou
FORALAC	Sawmill	Makabana	Niari
COFIBOIS	Sawmill	Black Point	Black Point
CITB QUATOR	Sawmill	Black Point	Black Point
SOFIA	Sawmill	Ollombo	Trays
SEFYD	Sawmill	Cabosse	Sangha

Taman Industries	Sawmill	Price	Kouilou
CIBN	Sawmill	Mossendjo	Niari
AFRIWOOD	Sawmill	Black Point	
SADEF	Sawmill	Bouenza	Bouenza
KIMBALALA &Cie			
CDWI	Sawmill	Mbomo, lolotoumba	West Bowl
SFIB	Sawmill	Ngoua II nord	Niari
GLOBAL WOOD	Sawmill	Vindoulou	Black Point
WANG SAM	Sawmill	Makoua	Bowl
Pour	Sawmill	Mapati	Lékoumou
Entrep.Christelle	Sawmill	Talas	West Bowl
KASSA WOOD	Nd	Liranga	Likouala
SPIEX	Sawmill	Lékoumou	
BTC	Sawmill	Bouenza	
COTRANS	Sawmill	Kouilou	
SEFYD	Indust carpentry.	Cabosse	Sangha
CIB-Olam	Carpentry	Massacre	Sangha
Ifo	Laminated and glued	Ngombé	Sangha
CIB	Laminated and glued	Massacre	Sangha
LT	Laminated and glued	Bétou	Likouala
CIB-Olam	Moulurage	Massacre	Sangha
CIB-Olam	Drying	Massacre	Sangha
MOKABI	Drying	Moualé	Likouala
LT	Drying	Bétou	Likouala
SIFCO	Drying	Speak-Speak	Sangha
Ifo	Drying	Ngombé	Sangha
SEFYD	Drying	Cabosse	Sangha
Taman Industries	Drying	Price	Kouilou
CIB-Olam	Drying	Loundoungou	Likouala
		Toukoulaka	
SIPAM	Drying	Mapati	Lékoumou
SICOFOR	Drying	Mapati	Lékoumou
THANRY-Congo	Drying	Ipendja	Likouala
CIB-Olam	Cogeneration	Massacre	Sangha
SNBI	Impregnated wood	Black Point	Black Point
ZEBRA-TESSAF	Wood shavings	Port Auton. PointeNoire	Black Point
FL-GROUP	Resin extraction	Madingou	Bouenza
CFF BOIS INTERN.			

- The crafts and any artisanal production are essentially informal. These actors and their partners are mostly neglected. They mainly feed the domestic market. They are mainly wood carvers, basket makers, carpenters, coal miners, hand-craftsawers

Table 22: List of selected craftsmen

Names and first names	**Type of business**	**Location (Department)**
NGABOUACK SEP Vivien	Physical person	**LIKOUALA**
NZENE Simon	Physical person	**LIKOUALA**
BOLEMONDZO Jean Paulin	Physical person	**LIKOUALA**
OLOL Edgar Fiacre	Physical person	**SANGHA**
NTSIBA Frédéric	Physical person	**SANGHA**
MABIALA Jean Flavien	Physical person	**LEKOUMOU**
NTSAKALA PépineFlorence	Physical person	**LEKOUMOU**

TOUKOUNZEBI Harold Lomard	Physical person	**BOUENZA**
COMBO MAKITA Louis	Physical person	**BOUENZA**
MBOUILA MOUANDZA	Physical person	**Bowl**
ONGALI Pépin Nestor	Physical person	**Bowl**
MAMADOU Dramé	Physical person	**Bowl**
MAMADOU ADAMOU DAZIMI Salamso	Physical person	**WEST** BOWL
ASIA Dominique deMarseille	Physical person	**WEST** BOWL
OKOUO NGALOUOPrinceGilmar	Physical person	**WEST** BOWL
DILOBO Jean Christian	Physical person	**NIARI**
MAMADOU BOCOUM	Physical person	**NIARI**
MONGO Médard	Physical person	**NIARI**
MASSAMBA Rodrigue	Physical person	**NIARI**
TETE Misery Leopold	Physical person	**NIARI**

Source : https://www.atibt.org/wp-content/uploads/2020/02/RAPPORT-FINAL-Etat-des-lieux-acteurs-fili%C3%A8re-bois_AT_final.pdf

4.1.2.3.3.3 Transporters/logistics actors

The supply of processing industries and markets is done through carriers either in the form of logs or in the form of processed products. They are indispensable in the forest value chain. As in other countries in the Congo Basin, there are three types of transport i.e. hipping, land and rail. Table 20 includes Congo's major forest resource transporters.

Table 23: Selected transporters

Actor	Activity
CLAUDE Sarl	Forwarder
AFRICONGO	Forwarder
SOCOTRANS	Carrier
La Générale des Services Maritime	Forwarder
Transformé Congo Sarl	Forwarder and carrier
Trans construction	Carrier
SOPADI	Forwarder
UNIBOIS	Carrier
UNICONGO	Carrier

Figure 17 presents the logging chain of Congo

Figure 17. Logging chain of the Republic of Congo

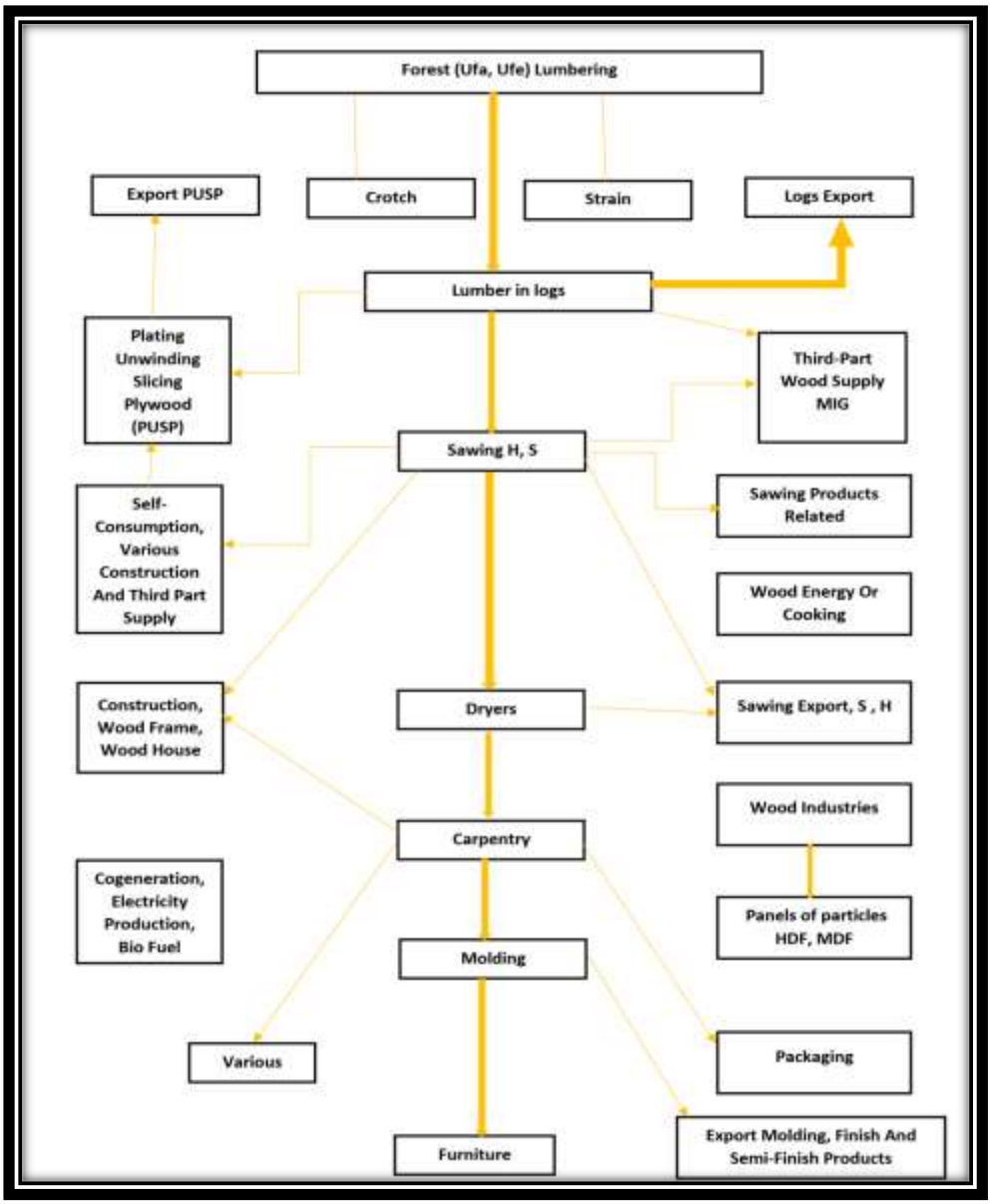


Figure 22: Logging chain of the Republic of Congo Source: (Am, 2019)

4.1.2.3.3.4 Merchant and consumer actors

This category of player concerns the merchants who are the suppliers of the internal market, the exporters of raw forest products and/or processed forest products. There are traders, brokers, and forwarders located mainly in the port areas. Operating companies are represented for most of the time throughout the entire chain of operations. Forest products can be consumed outside the country or within the country. The products consumed are diverse and can be firewood, moldings, plywood, furniture, panels, industrial wood, carved products, charcoal, etc. Depending on type of products consumers can be households, hotels, restaurants, carpenters, wooden house construction, cogeneration, biofuel production and electricity, etc.

4.1.2.3.3.5 Sources and types of forest biomass residue in Republic of Congo

The main sources of forest biomass residue are government forests in Congo at harvesting sites and through primary and secondary processing, mainly by licensed operators and concession holders as shown in Table 24.

Table 24 : Sources of forest biomass in Congo

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Harvesting of trees leaving wood at harvesting sites
	- Industrialists and producers - Examples: CIB-OLAM, IFO, Likouala Timber, Thanry, Asia Congo Industries, SICOFOR, TAMAN, MOKABI, BPL, CDW	
	- Transporters - Examples: CLAUDE Sarl,AFRICONGO, SOCOTRANS, La Générale des services maritimes, Transformé Congo Sarl', Trans construction, SOPADI, UNIBOIS, UNICONGO	When transporting wood, leave wood residue
	Merchants, farms, wood/charcoal merchants	
Primary processors	- Pulp mill owners	Production of wood residues (chips, sawdust, etc.) during processing
	- Wood saw milling companies - Examples: CIB-OLAM, IFO, Likouala Timber, Asia Congo industries, Thanry, SICOFOR, TAMAN, SEFYD, SIFCO, Afriwood	
	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture) - Examples: CIB POKOLA, Likouala Timber, SEFYD et SIFCO	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites - Examples: CAMEROON UNITED FOREST, CIFM/PALLISCO SEFAC, SIM, NAMBOIS	
Consumers	- households, hotels, restaurants, carpenters, wooden house construction, cogeneration, biofuel production and electricity	

Availability of forest biomass residue and conclusion

Amount of forest biomass residues generated is about 842,603.40M^3 from various forest exploitation sites (mostly sawmill) and consists of sawdust, slabs and shavings according to 2018 data. The forest value chain in Congo therefore has huge potential in generating forest biomass residues for bioenergy, especially at the wood harvesting and primary processing stages.

4.1.2.4. Case of Gabon

4.1.2.4.1 Forest resources in Gabon

With an area of 267,677 km^2, Gabon is a rich forest country. About 85% of the country's land area is forested, or nearly 22 million hectares. Gabon ranks first among African forest producers with its ratio of forest area per capita (22 ha per capital), one of the highest in Africa. The Gabonese vegetation belongs to the Guinean-Congolese rainforest. It stretches across the country and is divided into two large groups; dense humid forest and savannah which respectively cover 85% and 15% of the land area. This vegetation is rich and varied. It includes 6 large forest formations which contain many woody species whose economic exploitation is interesting, and which are:

- Forest of the coastal basin (Forests in Okoumé, Ozouga, anonaceae, Irvingiaceae, Myristicaceae and various legumes);
- Central forest (Okoumé, ozigoSorro and Legumes with inclusion of Terminalia Superba (Limba));
- Northern Forest (semi-deciduous) (Gradual disappearance of Okoumé and Sorro, appearance of Terminalia and TriplochitonScleroxylon (Ayous));
- Mangroves, forest galleries (On the seafront, in Estuaries, deltas, near lagoons along rivers and streams); Bushy, wooded grassy savannahs (In the drier parts of the country).

Forests have always played an important role in the way of life of the populations and in the economic activity of the country. Indeed, were the main wealth of the country before being overtaken by oil in the early 1970s. Currently, the forest sector ranks second in the revenues that the State derives from the exploitation of its resources. Natural resources remains the second largest employer after the State with more than 20,000 direct jobs and 5,000 indirect jobs (FAO, n.d; Wasseige, Flynn, Louppe, Hiol, & Mayaux, 2014).

The volume of wood produced in 2010 was estimated at 1,861,116 m^3 and 1,709,413 m^3 in 2011. Of these volumes of wood produced, 827,637 m^3 were processed in 2011. Over 700,000 of wood products were exported each year between 2011, which allowed a contribution of 1.7% in 2010 and 1.8% in 2011 on the country's GDP and 0.22% on tax revenues. The forestry sector every year between 2010 and 2012 generated more than 7,000 direct jobs and more than 5,000 indirect jobs[72].
Timber harvesting in Gabon began at the close of the nineteenth century and continued virtually unregulated up to the year 1913. The resumption of logging at a much faster pace following World War One made regulation of the sector imperative. In September 1924, a law was passed defining the various types of logging permits. This was paralleled by research and planting trials in 1928 on okoumé (Aucoumeaklaineana), the major forest species harvested in Gabon. Some 30,000 ha of okoumé were established, particularly in the early 1950s in the Mondah, N'koulounga, Bokoué, Mvoum, Haut Como and Mbiné forests. Forest tree improvement work was also done on these stands from 1950 to 1957. The main actor at that time was the STFO (*Société technique de la forêtd'Okoumé*), now replaced by the DGEF (*Drection générale des Eaux et forêts*). Other fast-growing species were also introduced (Pinus spp., Eucalyptus spp.) for plantations and for research. Various timber species were planted from 1985 to 1993, especially in the Bokoué stands, for clear felling. These included framiré (Terminalia ivorensis), limba (Terminalia superba) and bilinga (Naucleatrillesii).

A total of 15 species are now harvested from natural forests, a figure projected to rise to 30 species by the year 2010 and 60 by 2025. The main productive species in Gabon are red wood (Pterocarpussoyauxii), ebony (Diospyros spp.) and okoumé (Aucomeaklaineaina), the foremost species. A great many studies have been done, especially on natural regeneration of okoumé. Natural forest improvement (or natural regeneration) by means of seed cutting and single shelter were tested. Once forest cover has been opened for commercial harvesting, a complementary selective clearing of the dominant secondary species follows immediately to promote the long-term growth and natural regeneration of the dominant commercial species. The objective is forest tree composition improvement. The “okoumé method” is also based on existing natural regeneration and takes its inspiration from the “futaierègulière par parquets” technique. This involves forest inventory and silvicultural techniques which include counting mature okoumé (technical harvesting diameter 70 cm) and thinning to bring final stem density of okoumé up to 80 stems/ha.

In the last ten years or so, Gabon has embarked upon a reform of its forestry and environmental sectors. The new forest harvesting policy is designed to increase and maximize the forest sector’s contribution to Gabon’s economic and social development by setting up fairly extensive forest concessions entailing regulatory provisions for forest harvesting and sustainable forest management, including obligatory local processing. The resource management strategy is to maintain forests in the long term through the consolidation and implementation of Sustainable Forest Management (SFM) programmes and institutional capacity building (Amsallem, 2002).

4.1.2.4.2 Forest value chain in Gabon

Gabon's forest value chain has the same characteristics as those of other Central African countries. The main driver of this chain is the Chinese market, but other Asian and European markets are not to be neglected. Figure 18 represents Gabon's forest value chain.

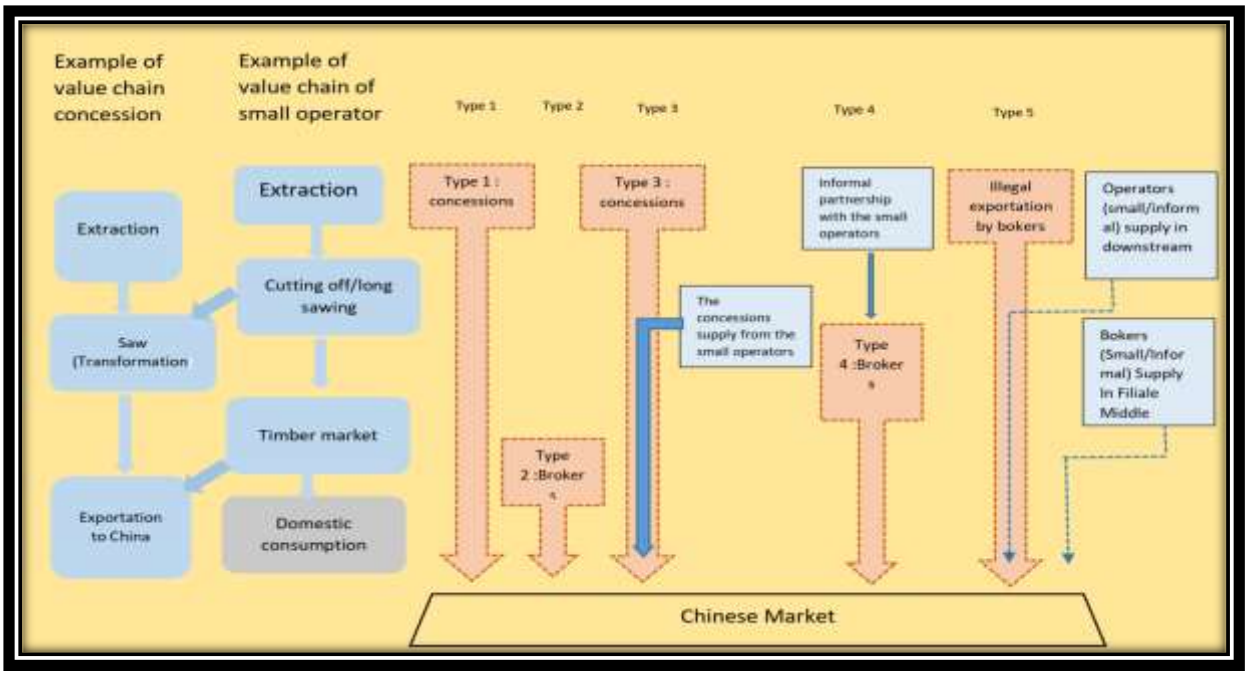


Figure 23: Gabon's forest value chain

Source: (Weng, et al., 2014)

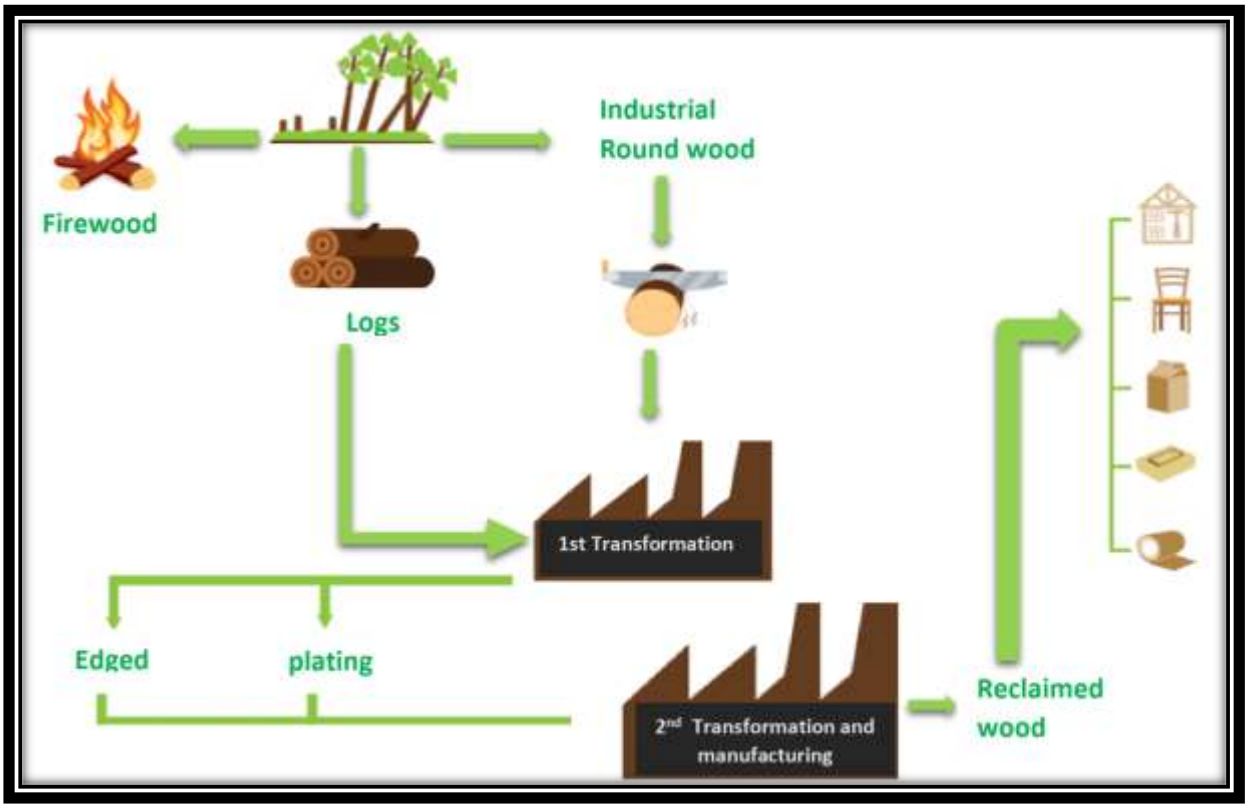


Figure 24: Gabon's fuelwood value chain

Source: (GSEZ, 2018)

4.1.2.4.3 The players involved in Gabon's forestry chain

The forest in Gabon has several categories of management actors: government, intergovernmental and administrative institutions (political actors), private operators, and NGOs (civil society), etc.

- Government, intergovernmental and administrative institutions

These actors play key roles in the development and implementation of forest policies at the international, regional, national, provincial or local levels. They conceive and define the policy framework:

- The Ministry in charge of Waters and Forests is the main actor at the top of the pyramid. It is the first administration created to manage natural resources in the fields of fauna, flora and aquatic environments. Through the General Directorate of Waters and Forestry (DGEF), it is in charge of the management of the forest domain, wildlife, general control and enforcement of forest regulations in state owned forests.
- The legislative bodies are made up of the Senate and the national assembly. Those of the technical commissions in charge of the forestry issue are involved in the construction and validation of forest laws.
- Organizations such as FAO, UNEP, UNDP, and ITTO are involved in the management of forest resources in Gabon by influencing policy design.
- Other political actors include governors, prefects, sub-prefects, representatives of the state or institutions.
  - The NGOsare the are involved in the development, conservation of forest concessions and the development of ecotourism. They are also involved in the local and sustainable conservation and development of forests.
  - Private operators: all stakeholders have in common the participation in the management of forest resources. Private players are concession companies exploiting forest resources. As stipulated in the Gabonese forest code, the management of certain territories is entrusted to private operators but remains conditioned by the application of state directives. There are companies like CEB, Rougier, etc. NGOs are committed to the implementation of a development plan and sustainable operations. One can find NGOs such as WWF, WCS, Friends of pangolin, the Action Centerfor Sustainable Development and the Environment, World Promus, Adventures Without Borders, Brainforest, Carpe, etc.
  - Local people also have a big role in forest resource management. Their actions are limited to the level of the community forests that they protect (Moulongui, 2014).

Table 25: Gabon's forest resource management actors

Management players	Characteristics	How to participate
Economic operators (sub-sector industry and timber trade)	Private companies. Interested or involved in forest management and certification. Varied levels in wood processing	Collaborate and comply with legal requirements including compliance with operating rules, national forest management standards and traceability of processed products
Specialized suppliers in exploitation, forest management and wood processing	Consulting firms or individual consultants	Perform the activities of their expertise in accordance with the rules and principles of certification of the GDF and the quality of the products

Village association for participatory and community management of the forest	Poorly organized village structures to participate in sustainable management without financial autonomy	Strengthen the awarenessof populations on reforestation and wood processing operations
The Professional Associations of the forest sector	Grouping of forest and/or industrial processing industries	Internal organization and the development of an inter-union platform
Ministry of Forestry and Environment in charge of Climate Plan development	The development of public policies on the management of natural resources and the development of the timber industry Responsible for monitoring the implementation of management tools Ensure the legality forest exploiters and wood industries developers	Creating the conditions for successful processes (sustainable management, development, certification, APV FLEGT) Strengthen monitoring and evaluation activities
Decentralized administration (councils, association of neighbouring councils)	Territorial collectivity with legal status and financial autonomy.	Maintaining a peaceful environmental
Civil society (NGOs, Association of neighbouring villages)	Organizations of society attentive to the socio-economic conditions of populations	Technical support for NGOs and maintaining peaceful environmental for development associations
Other Ministries (in charge of trade and industry, labour, justice, transport, economy, research, etc.)	Intervene in the fields of trade and the wood industry, guide the development and tax conditions, research on silviculture	Working together to strengthen synergy between institutions Create a partnership with national agencies and improve management methods and techniques

4.1.2.4.3.1 Exploitation of forest resources in Gabon

Logging includes all harvesting activities that comply with regulations, from site planning to storage. In Gabon, as in other countries in the Congo Basin, timber extraction is mostly done for commercial purposes. Private concessionaire companies practice the extraction of forest resources. Forestry activities include the exploitation of forest products and non-lumber products, the wood processing industry, the marketing of products on the local and international markets. The various policies, strategies, programs, action plans and projects are implemented for the benefit of all stakeholders in the public sector, the private sector, local authorities, professional associations, and the population.

- Extracting forests resources: it is both technical and commercial activity. Resources are shaped, dotted and classified for export, domestic or international market or made available to processors.
- Industrial transformation: the first and second industrial transformation. The nature of the products resulting from this transformation depends on the technology used to develop the wood material.
  - ✓ For the first transformation: sawmill, ties; unrolling of unrolled veneers and plywood; panels, particle or fibre panels, slicing of sliced veneers; making pulp and cardboard.
  - ✓ For the second processing: using products from the first processing to obtain finished or semi-finished products.
- Commercial distribution: bring together products from previous transformations and offer them to different consumers.

These actors are available in eight regions of Gabon: Estuary, HautOgooue, Middle Ogooue, Ngounie, Nyanga, OgooueIvindo, Ogooue Lolo, Ogooue Maritime, WoleuNtem (ITTO, 2006).

Figure 19. Logging in Gabon

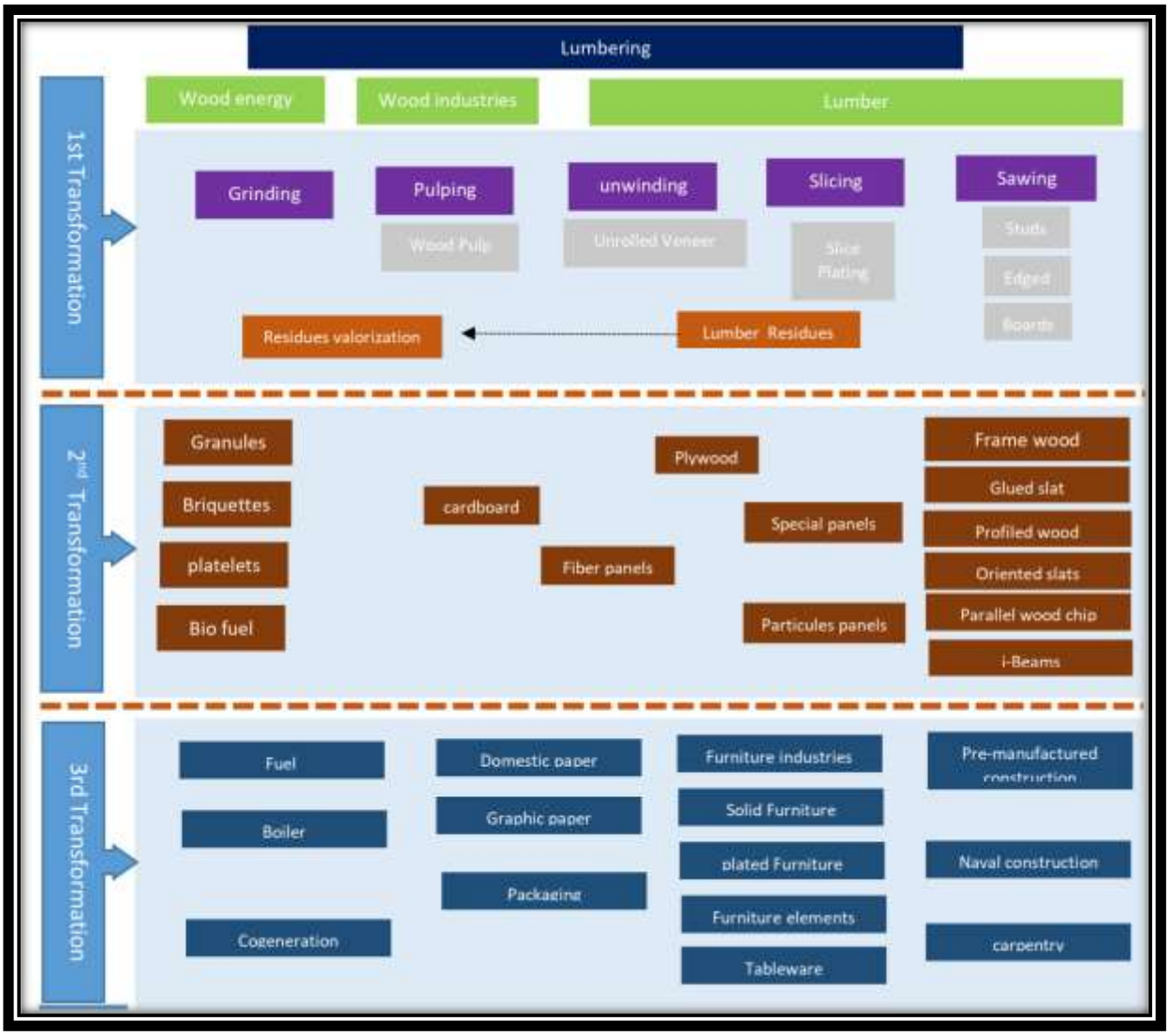


Figure 25: Loggin in Gabon

4.1.2.4.3.2 Actors involved in the extraction of forest resources

- The administration that is responsible for defining laws and strategies related to the exploitation of forest resources.
- Indigenous peoples who take forest resources such as firewood, charcoal and non-wood forest resources. This is in order to supply the markets of the major metropolises.
- National and international industries that are public, parastatal or private. These industries in this case are dealers. The companies extracting these resources are also responsible for their transformation. In Ogooue Maritime for example the companies CFAD PGG, PFA, CPAET, SBL EGG, Precious Woods (CEB), SEEF, etc. have forest concessions with licenses to exploit.

4.1.2.4.3.3 The actors of primary and secondary transformations of forest resources

- The government owns all forest areas and is responsible for managing, controlling the exploitation, and transformation processes of all forest resources. It ensures its control through the laws and the signing of conventions. This is the case with Article 14 of Act 16/01, which states that "the exploitation, harvest or processing of any natural product, free of charge or commercial, is subject to prior authorization from the Administration of Waters and Forests. The interim Development-Exploitation-Transformation (CPAET) agreement allows the owner of the concession to express his willingness to embark on the forest management and transformation process.
- The industrial sector: according to the forestry administration in 2016, Gabon has 162 logging and industrial units in its territory.
  - The industrial sector: according to the forestry administration in 2016, Gabon has fifteen (15) attributes and one hundred and sixty two (162) records corresponding to one hundred and sixty two (162) logging and industrial companies 65 wood processing units are vertically integrated (ie 40.1% of the total); for the remainder, they are horizontally integrated units that do not have concessions forestry (i.e. 59.9%)Ogooué Lolo and Ogooué Maritime each hold 9 wood processing units,
  - Sawing and veneer units all over,
  - Across the country, there is only one slicing unit in Estuaire (Madingou, Mabiala, & Nziengui, 2019).

Table 26: Gabon's logging industry

Company	Address	Specifications
Groupe China Cheng Tong (CCT) • Sunry Gabon	Oloumi, Libreville	Wood exploitation, trading and transportation
GroupeRougier	Zone Industrielled'Oloumi	Wood exploitation, trading and transportation
• Rougier Gabon • Compagnie Industrielle et Forestière du Haut-Ogooué (CIFHO)	Division Industries Akournam 2	Wood exploitation, trading and transportation
Compagnie des Bois du Gabon (CBG)	Port Gentil	Wood exploitation, trading and transportation
Tali Bois/Senchuan • Tali Bois Gabon • Senchuan Timber Gabon	Libreville	Wood exploitation, trading and transportation
Compagnie Dan Gabon (CDG)	Face SOBRAGA (Route abattoir), Owendo	Wood exploitation, trading and transportation
Corà Wood Gabon (CWG)	Port-Gentil Bureau de Libreville Immeuble Frangipaniers	Wood exploitation, trading and transportation
Hua-Jia S.A.	Owendo	Wood exploitation, trading and transportation
Bois et Sciage de l'Ogooué (BSO)	Glass, Libreville	Wood exploitation, trading and transportation
Wanchuan-Timber SARL (WCTS)	Libreville	Wood exploitation, trading and transportation
Exploitation Gabonaise de Grumes (EGG)	Libreville	Wood exploitation, trading and transportation
Groupe MPB/TBNI • Mont Pelé Bois (MPB)	Zone Industrielle de Barracuda, Owendo	Wood exploitation, trading and transportation

• Transport Bois et Négoce International (TBNI) • ForestryDevelopment Gabon (FDG) • Mitzic Exploitation Forestière (MEF) • Compagnie Forestière des Abeilles (CFA)		
John Bitar Gabon S.A.	Owendo	Wood exploitation, trading and transportation
Groupe BSG/GWI • Bois et Scierie du Gabon (BSG) • Gabon Wood Industries (GWI)	Siège de Libreville Face Mbolo-CCF (à Côté de l'ancien siège de la BEAC)	Wood exploitation, trading and transportation
	Siège de Nkok Zone Economique à Régime Privilégié (ZERP) de Nkok	Wood exploitation, trading and transportation
Peng Xin Bois SARL	Carrefour ACAE Libreville	Wood exploitation, trading and transportation
Société de Sciage de Moanda (SSMO)	Zone Industrielled'Oloumi	Wood exploitation, trading and transportation
Grande Mayumba Development Company/Nyanga Forestry Operations (GMDC/NFO)	Quartier Sablière Libreville	Wood exploitation, trading and transportation
Groupe RFM • Rain Forest Management (RFM) • Rain Forest Management GSEZ (RFM-GSEZ)	Libreville Cité Damas Siège de Nkok Zone Economique à Régime Privilégié (ZERP) de Nkok	Wood exploitation, trading and transportation
Société des Bois de Lastourville (SBL)	Libreville	Wood exploitation, trading and transportation
Société Equatoriale d'Exploitation Forestière (SEEF)	ACAE	Wood exploitation, trading and transportation
Tropical Timber Industry Board (TTIB)	Face Foyer du Marin, Oyem	Wood exploitation, trading and transportation
Sheng Yang International Bois Gabon (SYIBG)	Owendo Libreville	Wood exploitation, trading and transportation
TaurianRessources Gabon	Libreville	Wood exploitation, trading and transportation
CompagnieEquatoriale des Bois-Precious Woods (CEB PWG)	Rue KringerRendjombè,	Wood exploitation, trading and transportation
Pat Timber	Libreville	Wood exploitation, trading and transportation
Xinwang Bois	Libreville	Wood exploitation, trading and transportation
Gabonaise d'Exploitation de Bois (GEB)	Pont Nomba (Route Sapeurs-Pompiers), Owendo	Wood exploitation, trading and transportation
Société Forestière des Bois Tropicaux (SFBT)	Libreville	Wood exploitation, trading and transportation
Groupe ENB/TLP/Hua-Jia • Export et Négoce du Bois (ENB) • Tropical Logs Production (TLP) • Hua Jia	Libreville	Wood exploitation, trading and transportation
La Gabonaise des Forêt et des Industries du Bois (LGFIB)	Libreville	Wood exploitation, trading and transportation
Evandzi Bois du Gabon (EBDG)	Nombakélé, Libreville	Wood exploitation, trading and transportation
Luso Location (LUSOLOC)	Libreville	Wood exploitation, trading and transportation
Société Nationale Bois du Gabon (SNBG)	Centre-ville, Libreville	Wood exploitation, trading and transportation
Compagnie Africaine d'Exploitation de Bois (CAEB)	Libreville	Wood exploitation, trading and transportation
Gabonaise de Transformation du Bois Bouléndé (GTBB)	Port d'Owendo, Owendo	Wood exploitation, trading and transportation
Industrie Bois Négoce Gabon (IBNG)	Barracuda, Owendo Libreville	Wood exploitation, trading and transportation
Lynn Timber	Libreville	Wood exploitation, trading and transportation
Gabonaise d'Exploitation Forestière et de Remorquage SARL (GABEXFOR)	Port -Gentil	Wood exploitation, trading and transportation
Sun Harvest Ventures (SHV)	Owendol , Libreville	Wood exploitation, trading and transportation
Forestière d'Exploitation et d'Export (FOREEX)	Agondjé, Akanda	Wood exploitation, trading and transportation
Groupe RimbunanHijau: • RimbunanHijau Gabon • Industrie Forestière de Koulamoutou (IFK)	Razel, Owendo Libreville	Wood exploitation, trading and transportation

• Société Forestière et Industrielle de Koula-Moutou (SFIK) • Bordamur Toujours Vert		
Plantations Forestières de la Mvoum (PFM)	Libreville Owendo	Forest plantation, wood exploitation and trading
New Oriental International Investment Co. LTD (NOII)	Libreville	Wood exploitation, trading and transportation
Tian BeiForêt (TBF)	Libreville	Wood exploitation, trading and transportation
KHLL FORESTRY SA	Owendo , Libreville	Wood exploitation, trading and transportation
Africa View S.A.	Zone Economique à Régime Privilégié (ZERP) de Nkok	Wood exploitation, trading and transportation
Gabon MeublesModernes (GMM)	Zone Economique à Régime Privilégié (ZERP) de Nkok	Wood exploitation, trading and transportation
FG GZES	Zone Economique à Régime Privilégié (ZERP) de Nkok	Wood exploitation, trading and transportation
Société International Company of Timber (SICT)	Owendo, Libreville	Wood exploitation, trading and transportation
Bois et Menuiserie du Gabon (BMG)	Libreville	Wood exploitation, trading and transportation
Société d'Inventaire d'Aménagement et d'Exploitation Forestière du Gabon (SIAEFG)	Libreville	Wood exploitation, trading and transportation
Mavémbé	Libreville	Forest exploitation, wood exploitation, transformation, trading and transportation
Exploitation Forestière Quentin (EFQ)	Libreville	Wood exploitation, trading and transportation
Exploitation Gabonaise de Bois (EGB)	Libreville	Wood exploitation, trading and transportation
Dhara Wood Gabon	Alibandeng, Libreville	Wood exploitation, trading and transportation
Friends Timber Company (FTC)	Libreville	Wood exploitation, trading and transportation
Reine de Construction Bois (RCB)	Libreville	Wood exploitation, trading and transportation
Gabon Huan Dong Investissement (GAHUDI)	Okolassi, Ntoum Libreville	Wood exploitation, transformation, trading and transportation
Simati	Libreville	Wood exploitation, trading and transportation
Société de Transformation Intégrée des Bois du Gabon (STIBG)	Owendo, Libreville	Wood exploitation, trading and transportation
International Forestry Timber of Gabon (IFTG)	Libreville	Wood exploitation, trading and transportation
CECOMI	Haut de Gué-Gué, Libreville	Wood exploitation, trading and transportation
Arboris	Libreville	Wood exploitation, trading and transportation
Exploitation Gabonaise des Grumes (EGG)	Libreville	Wood exploitation, trading and transportation
Exploitation des Bois de l'Estuaire (EBE)	Libreville	Wood exploitation, trading and transportation

Source:https://www.atibt.org/wp-content/uploads/2020/04/Gabon-RapportEtudeSP.pdf

Table 27: Key actors at provinces

Provinces	Actors
Estuary	DG Forests, DG Industries Bois, DG ANPI, DG Taxes,ADGA GSEZ/NKOK, DG Customs, DG National Statistics, UFIGA, UFIAG, SIAG, CAPPP,
	BOLLORE TRANSPORTS and LOGISTICS,GSEZ/NKOK
Ogooué-Lolo	SBL, SBK, SPG, SFIK/RIHBUNAN HIJAU, EGG,Precious Wood (ex CEB)
Ogooué-Maritime	SOM, FTC, CBG/CPBG, CORA WOOD GABON,MBP

4.1.2.4.3.4 Transporters / logistic operators

The means of communication of forest and industrial companies depend on their location in relation to transport infrastructure. In Gabon, as in other countries, rail, sea, and land transport are used. Bolloré Transport and Logistics, SETRAG, etc. are examples of transporters. However, most companies doing forest exploitation are also transporters. In addition to transporters that supply the local market,

there are also other transporters that supply the international market. They are exporters, forwarders, logisticians and are more present in port areas (Madingou, Mabiala, & Nziengui, 2019).

4.1.2.4.3.5 Merchants and consumers

Merchants are represented at the national level (supply the local market), for example wood depots, craftsmen, coal miners, etc. and internationally (supply the global market). There are traders, brokers, forwarders who are located mainly in the port areas, and some present in train stations. Operating companies are represented for most of the time throughout the entire chain of operations from extraction to merchant service.

Many products come from logging for several categories of consumers: carpentry, cabinetry, shipbuilding, prefabricated construction, frames, restaurants, households, hotels, decoration houses, wooden houses, etc. Figure 20 presents the activities and products of primary, secondary and tertiary transformations.

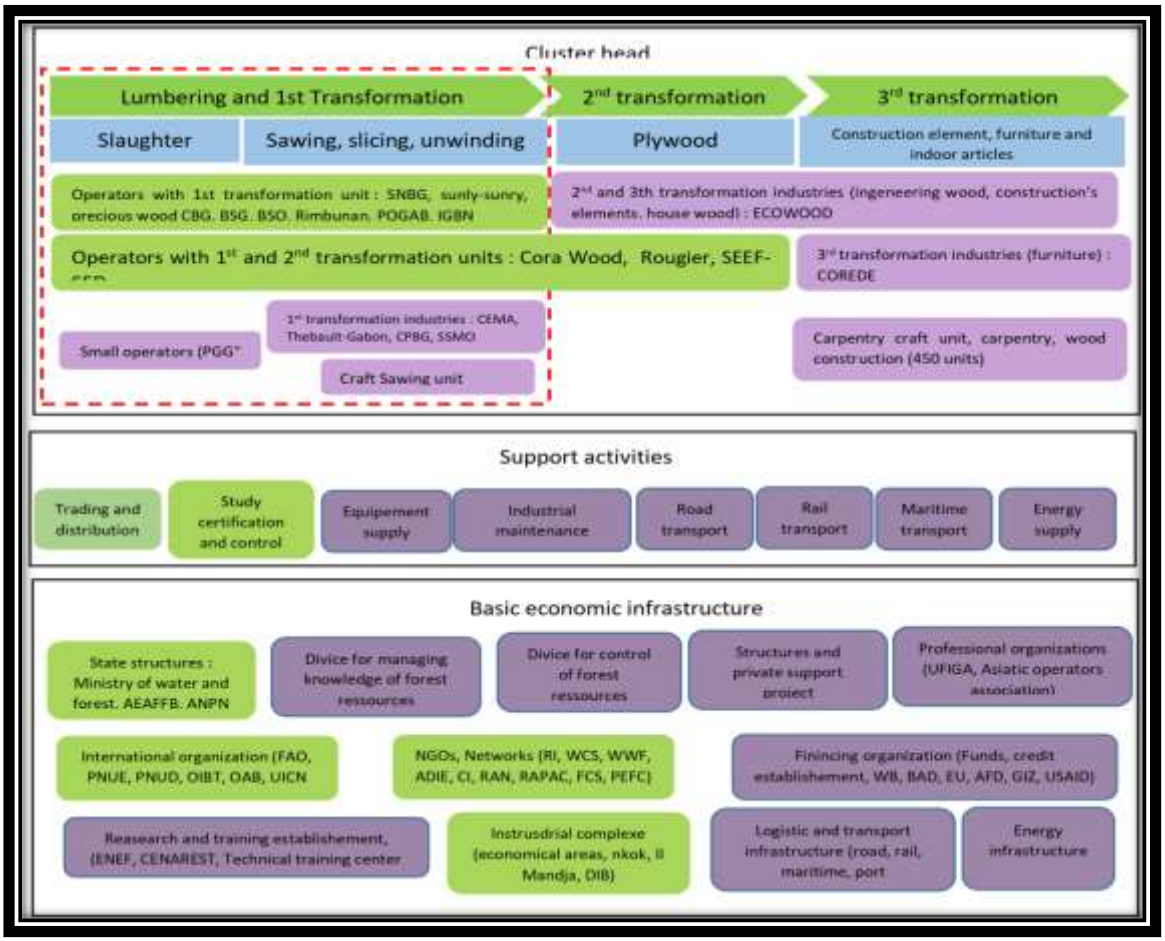


Figure 26: Activities and products of the processing industries Source: (Madingou, Mabiala, & Nziengui, 2019)

4.1.2.4.3.6 Sources and types of forest biomass residue in Gabon

The main sources of forest biomass residue are government forests in Gabon at harvesting sites and through primary and secondary processing as shown in Table 28.

Table 28: Sources of forest biomass in Gabon

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Harvesting of trees leaving wood at harvesting sites
	- Industrialists and producers - Examples: CFAD PGG, PFA, CPAET, SBL EGG, Precious Woods (CEB), SEEF	
	- Transporters - Examples: Bolloré Transport et Logistics, SETRAG	When transporting wood, leave wood residue
	Merchants, farms, wood/charcoal merchants	
Primary processors	- Pulp mill owners	Production of wood residues (chips, sawdust, etc.) during processing
	- Wood saw milling companies - Examples: Compagnie des Bois du Gabon (CBG), SNBG, SUNLY-SUNRY, PRECIOUS WOOD CBG, BSG, BSO, RIMBUNAN, POGAB, IGBN, CEMA, THEBAULT	
	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture) - Examples: COREDE, ECOWOOD	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites - Examples: ECOWOOD	
Consumers	- joinery, cabinetwork, shipbuilding, prefabricated construction, carpentry, restaurants, households, hotels, decorative homes, wooden houses	

Availability of forest biomass residue and conclusion

Amount of forest biomass residues generated from two types of forest titles in Gabon: CFAD and CPEA in 2011 was 735,028.94M^3. The forest value chain in Gabon therefore has huge potential in generating forest biomass residues for bioenergy if all forest areas are included.

4.1.2.5. Case of Equatorial Guinea

4.1.2.5.1 Forest resources in Equatorial Guinea

Equatorial Guinea is covered over nearly 60% of its territory by dense forests over an area of nearly 1.6 million hectares at altitudes ranging from 0 to over 1500 m. Most forests are between 300 and 1000 m altitude. The east of the country includes many areas of marshes as well as woody fallow formations (young secondary forests). Several types of forests are found in Equatorial Guinea. The

forest type most represented is the humid dense forest of low and medium altitude. This type of forest suffers a lot from heavy logging. There are still primary forests in the country which may soon disappear if commercial exploitation continues at the same rate. The young forest of low and medium altitude is also very represented and dominated by Okoume.

A significant part of the continental zone supports permanent or temporary marshy formations. Dense sub-montane forests are found in the highest regions of the country on Bioko Island. However, this type of forest represents only a small part of the national forest cover (Mugnier & Santiago, 2009). Lowland rainforest was replaced by cocoa and coffee plantations in the late 17th century. Over 90,000 ha had been converted to cocoa plantations by the end of the 19th century. Trees have been logged since the 1920s, mainly in the coastal part of the country, with operations continuing up to the close of the colonial era in 1968. During the 1960s, plantation trials with Aucoumeaklaineana were introduced, but the results were not promising. Due to the great expense involved, no industrial forest plantations were established. Forest projects prior to independence mainly dealt with the need to inventory resources. Major logging activities in the 1960s came to a virtual standstill with the departure of the Spanish business sector, only to be re-launched in the mid-1970s, and then further expanded in the early 1980s with the arrival of new logging companies (though never matching the pace of the early 1960s). Forest production has doubled since 1993-1994.

In the light of the country's high rate of forest cover and successful natural regeneration, there has been no forest planting (Amsallem, 2002). The volume of wood produced in 2010 was estimated at more than 300 thousand m^3. Of these volumes of wood produced, 16,790 m^3 were processed. Over 35,000 m^3 miles of wood product were exported in 2010, which allowed a contribution of 0.01% on the country's GDP. The forestry sector since 2007 has generated more than 2000 direct jobs (Wasseige, Flynn, Louppe, Hiol, & Mayaux, 2014).

The forest sector's management and conservation strategy is written into Equatorial Guinea's Tropical Forests Action Plan (TFAP) approved in 1990. The objectives of Equatorial Guinea's new forest development policy are to upgrade the forestry administration, work for rational, sustainable and diversified use of forest resources, including their protection, observe the principle of multiple use while maintaining ecological equilibrium, and aim at sustainable management of protected areas and wildlife. The trend in the forest sector is also to enhance the efficiency of forest product harvesting and marketing systems. Public participation in natural resource management is also on the upswing (Amsallem, 2002).

Forest value chain in Equatorial Guinea

The value chain of all Central African countries including Equatorial Guinea have common forest products. The three key markets are the Asian, European and African markets. This value chain represents all stakeholders (actors) involved in the forestry sector. It includes players ranging from production to consumption of forest products through, operators, processors, transporters and merchants

4.1.2.5.2 Players involved in the forestry chain in Equatorial Guinea

The government is at the top of the country's forest resource management and manages forest resources through its ministries and departments. Law 1/1997 recognizes two types of forests, a

production domain and a protection domain. Several legal provisions reinforce the legal and political framework for the protection of forest ecosystems in harmony with the socio-economic development of Equatorial Guinea. The National Forestry Policy (NPFP) defines the country's major forest objectives (Amsallem, 2002).

- The Ministry of Agriculture, Livestock, Water and Forest and Environment is responsible for the management of forest resources. Its duties are to direct and enforce the laws of the forestry, fisheries and environmental sectors. It is also responsible for the conservation, management and sustainable use of natural resources for sustainable economic development.

  Directorate General of Waters and Forests is the ultimate authority responsible for the administration, exploitation and conservation of forest resources. It grants the concessions for exploitation and takes care of everything related to the management of the woodlands. OCIPEF (*Oficina de control, información y promoción de las especiesforestales*) is responsible for coordinating the control, marketing, evaluation and classification of wood production. It must also promote, monitor and control the export of wood.
- NGOs such as FAO and UNDP assist the government in planning and coordinating the management and administration of forest resources.
- The civil society organizations like ANDEGE, ADICOR, ADMAD, AMICFLORA, ASAMA, COSA, SARA et REFADD
- Regional and international institutions :like COMIFAC (Commission des Forêts de l'Afrique Centrale), CEFDHAC (Conférence sur les écosystèmes de forêts denses et humides d'Afrique centrale), IUCN/CARPE (International Union for Conservation Nature/Central AfricaRegional Program Environnemental), CI (Conservation Internationale), ZSL (Zoological Society of London), WRI (World Ressources Institute), WCS (Wildlife Conservation Society), PACEBCo (Programme d'appui de la conservation des ecosystème du bassin du Congo) and INDEFOR-AP ((InstitutoNacional de DesarrolloForestal y ÁreasProtegidas)
- Community are involved in the management of forest resources in order to secure land and resources from forests. The exploitation of community forests is then accompanied by a specification containing clauses between the village community and the forest operators for the socio-economic benefits to the community.
- The industrial sector: the exploitation of forest resources is done by national and international private companies to which the State attributes concessions and cull permits. The duration of operation depends on the size of the concession. However, each operating company must have a development plan for sustainable operation and improved management (Amsallem, 2002).

4.1.2.5.3 Actors involved in the extraction of forest resources

The Equato-Guinean State in 1997 established a law on the use and management of forests to regulate natural resources management. This law sets out regulations on the sustainable exploitation and use of forest resources to prevent their disappearance. Private and public companies exploit the concessions granted by the government. Table 29 shows logging companies in Equatorial Guinea.

Table 29: List of forest companies

Companies	Area of action
ANISOK	Carretera del aeropuerto Equatorial Guinea
FIAG SA	Carretera de LubaBata-Equatorial Guinea
MERIDIEN TIMBER	Bata-Equatorial Guinea
SAFI	Bata-Equatorial Guinea
SHIMMER INTER	Bata-Equatorial Guinea
FOREST SOCIETY OF EQUATORIA GUINEA	CalleZambiaBata-equatorial
TROMAD	Avenida Juan Pablo II

Source: (GoAfricaOnline, n.d.)

4.1.2.5.4 Actors in primary and secondary transformations of forest resources

According to Decree No. 61/2007, the Equatorial Guinean government bans the export of raw forest products and encourages local industrial processing. Processing companies transform wood into veneer (unwinding) and sawing. There are about 5 industrial units (veneer and sawmill) in the country and 4 are located in Bata. There are also small sawmills that supply the local market with lumber. Table 25 presents the wood processing companies in Equatorial Guinea.

Table 30: Wood processing companies in Equatorial Guinea

Companies	Activities
MMSG	Wood sawmills
VICHELO S.L	Wood sawmills
SOCIEDAD GUINEANA DE ECOLOGIA	wood chips producer
Ghc Group	Wood sawmills
Better Work	Wood sawmills
TriunfoverdeserviciosS.L	Wood sawmills
MICOSERA CORPORATION S.L.	Wood sawmills
stocazzo.it	Wood pellet producer
La SombraForestal	

Source: (FORDAQ, n.d.)

4.1.2.5.5 Transporters / logistic operators

Forest products are transported from cutting sites to processing plants or to local and international markets by transporters through the sea, rail and roads. These include forwarders, log operators, exporters and importers. Table 31 shows some transport companies present in Equatorial Guinea.

Table 31: Timber transport companies in Equatorial Guinea

Companies	Activities
MADERA 2020	logs exporter
ETC " EMPRESA DE TRABAJOS DE CONSTRUCION	Lumber importer
FILL WOOD S.L	logs exporter
PorMar Guinea Ecuatorial S.L.	logs exporter

Source: (FORDAQ, n.d.)

4.1.2.5.5.1 Merchants and consumers

These actors are located downstream of forest value chains. At the local market level, there are lumber traders, craftsmen, coal miners, households, carpenters, restaurants, hotels, etc. TRADEFLOT GUINEA S.L. is one of the Equatorial Guinean companies that is responsible for the sale and distribution of processed wood products.

4.1.2.5.5.2 Sources and types of forest biomass residue in Equatorial Guinea

The main sources of forest biomass residue are government forests in Equatorial Guinea at harvesting sites and through primary and secondary processing as shown in Table 32. As mentioned in this report, there are about 5 industrial units (veneer and sawmill) in the country and several timber.

Table 32: Sources of forest biomass in Equatorial Guinea

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Harvesting of trees leaving wood at harvesting sites
	- Industrialists and producers - Examples: CFAD PGG, PFA, CPAET, SBL EGG, Precious Woods (CEB), SEEF	
	- Transporters - Examples: Bolloré Transport et Logistics, SETRAG	When transporting wood, leave wood residue
	Merchants, farms, wood/charcoal merchants	
	- Wood saw milling companies - Examples: Compagnie des Bois du Gabon (CBG), SNBG, SUNLY-SUNRY, PRECIOUS WOOD CBG, BSG, BSO, RIMBUNAN, POGAB, IGBN, CEMA, THEBAULT GABON, CPBG, SSMO	
	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture) - Examples: COREDE, ECOWOOD	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites - Examples: ECOWOOD	
Consumers	- joinery, cabinetwork, shipbuilding, prefabricated construction, carpentry, restaurants, households, hotels, decorative homes, wooden houses	

Availability of forest biomass residue and conclusion

In 2019 Equatorial Guinea produced 7,961.27 m^3 of wood. About 46% of the wood produced and processed is waste which is about 3,662.18M^3 which is too small for bioenergy production potential in absence of other waste when compared to other countries in Central Africa region.

4.1.2.6. Case of the Central African Republic (CAR)

4.1.2.6.1 Forest resources in Central African Republic

The Central African Republic (CAR) covers an area of 623,000 km^2 and has about 23 million hectares of forests, or about 37% of its total area. The forest-timber sector operates from the southwestern forest massif where only industrial logging is carried out. Currently, eleven (11) forestry companies are operating, with an average annual production of approximately 400,000 m^3. Exports of logs and sawnwood are approximately 160,000 m^3 and 40,000 m^3 respectively. The forest-timber sector contributes 11% of the GDP and 13% of the country's export earnings. The main destinations for Central African timber are Europe (47%) and Asia (49%).

Annual production rose from around 670,000 m^3 at the turn of the century to around 420,000 m^3 in 2016. It hit an all-time low in 2014, at around 235,000 m^3, but has been increasing since then. As in the other Congo Basin countries, a reduced number of species represents between 70% and 80% of total production. During the past six years, there has been a decrease in the production of ayous (*Triplochytonscleroxylon*) and an increase in the production of mukulungu (*Autranellacongolensis*), tali (*Erythropleumivorense*) and iroko (*Miliciaexcelsa*) (Cerutti, Mbangolo, Nakoe, Vandenhaute, & Hubert, 2018).

Forest conservation efforts have their origin in colonial laws passed in 1916 concerning the establishment of national parks and reserves. The first national park was established in 1933, and the first game reserves also date from the 1930s. Because CAR is a landlocked country far from international markets, the southwestern forests were not opened to commercial logging until 1945, and even then on a fairly small-scale basis, with a few logging companies working in Lobaye to produce sawn wood for the local market. In the early 1950s, an inventory programme was designed and implemented by the national forest service, and later by the Tropical Forest Technical Centre (CTFT). The objective was a detailed review of the state and size of exploitable rainforest and the potential value of the standing crop of high-value forest species. CAR was one of the first African countries to undertake forest inventories and to call for detailed regulations and management plans as a prerequisite to harvesting permits. In 1967, the first forest harvesting permits (temporary harvesting permitswere issued in the prefectures of what are now Haute Sangha and Mambéré-Kadei. At that time, a logging company could only move in after a convention had been signed between the company and the Ministry of Forestry (Amsallem, 2002).

Unallocated public domain forest covers some 1.3 million hectares. This includes 0.3 million hectares of forest reserves, comprising 250,000 hectares of reserves and parks and 50,000 hectares of classified forests in the southwestern zone. Unallocated area thus totals about one million hectares, but much of this is made up of secondary forest[92].The area currently under forest plantations is estimated at 3,000 hectares. Plantation programmes established by the Ministry in charge of forests are still in the experimental stages, and planted areas are quite small for lack of an effective reforestation policy[92].

CAR's greatest timber assets feature a small number of commercially valuable species. The main forest species logged are ayous (*Triplochitonscleroxylon*) and limba (*Terminalia superba*) for plywood, sipo (*Entandrophragma utile*), sapelli*(E. cylindricum*), tiama (E. angolense) and dibetou (*Lovoatrichiloides*). Experimental designs have been in place in the Mbaiki region since the 1980s to study the dynamics

of natural forest under various silvicultural treatments so as to devise silvicultural practices that successfully reconcile conservation with sustainable forest production. The dimensions studied were: the dynamics of untouched natural stands, tree growth in a natural stand following harvesting with or without thinning, general stand behavior, etc. The silvicultural rules laid down by the forest code concern reduced impact logging to enable natural regeneration and avoid high-grading (skimming off the cream of the forest crop), stipulating minimum harvest diameters, and the protection of young trees during the extraction process. Forest plantations are only in the very earliest stages in CAR. Leaving out the teak (*Tectonagrandis*) plantations established by FAO in the Bimbo forests in the 1960s, tree-planting efforts only truly took off in 1972. The plantations generally included fast-growing species with an estimated felling cycle of 40 years, including Eucalyptus, Cedrella, Cordia and all red wood species processed or used for veneering. *Gmelinaarborea, Terminalia ivorensis* and Pinus spp. were also planted. In the Mbaiki plantations, timber production is the only objective, and so the species planted include sapelli (*Entandrophragmacylindricum*), sipo (*Entandrophragma utile*) and tiama (*Entandrophragmaangolense*). These plantations were not successful, however, for lack of maintenance and monitoring, and at present the reforested area amounts to just a little over 3,000 hectares, mostly full plantations, and about 80 hectares of in-forest strip plantations.

There has been a substantial shift from centralized forest management focussed on timber production to multi-use management enlisting, to a growing extent, the participation of local people. There is a clear trend towards greater consideration of the needs of local people, and the integration of the logging sector into the local economy, as the base of the new sustainable forest management approach. The new guidelines of forest ecosystem management now concern four sectors: planning processes, protected area management, the establishment of “community” or “village” forests, and, lastly, forest management for timber production. A further and striking event of the last decade concerns the introduction of institutional reforms and new forest legislation based on a new determination to decentralize forest management[92].

4.1.2.6.2 Forest value chain in Central African Republic

The CAR's forest value chain involves different categories of actors ranging from management actors, consumers, producers, to actors in the transformation as well as transporters and merchants.

4.1.2.6.3 The players involved in the CAR forestry chain

4.1.2.6.3.1 Forest resource management and conservation actors in CAR

In the Central African Republic, forest resource management places emphasis on combating land and forest degradation. There are several actors operating at different levels: public administration, research institutions, the private sector, NGOs, sub-regional organizations, international organizations and individuals (Global Mechanism, 2018).

- The public administration acts through its ministries: they maintain management rights and responsibilities within the limits specified by law. The Departments responsible for the management of forest ecosystems are the Ministry of Water, Forests, Hunting and Fishing and the Minister of Environment and Sustainable Development.

The Department in charge of Forests has for main missions the development and implementation of government policy in the areas of water, forests, hunting and fishing. One of its responsibilities is to promote the conservation and sustainable management of natural resources by developing and popularizing national development techniques. It is made up of the following structures:

- The General Directorate of Forests, Hunting and Fishing (DGEFCP) is responsible for designing and implementing sectoral policies in the areas of water, forests, hunting and fishing. One of its responsibilities is to ensure the rational exploitation of forest, wildlife and fish resources;
- The General Directorate of Studies, Planning, Legal Support and Regional Services (DGEPAJSR) is responsible for planning research work in the areas of competence of the ministry, centralizing and disseminating the results of research work in matters of water, forests, hunting and fishing;
- The Forestry Data Center is responsible for the monthly and annual production of the data necessary for the Forestry Administration and all other users for efficient decision-making within the framework of rational management of natural resources and also for updating. sub-regional databases for the harmonization of forest management in the Congo Basin;
- The Economic Observatory of the Wood Sector has the mission, among other things, to provide the State, forestry companies, civil society and development partners with the information necessary for monitoring activities concerning the profitability of the wood sector in order to '' optimize its operation;
- The Unit responsible for the implementation and verification of FLEGT license documents. Its mission is to implement and monitor the application of forest regulations, governance and trade;
- The APV / FLEGT Permanent Technical Secretariat is responsible for monitoring the implementation of the Voluntary Partnership Agreement between the Central African Republic and the European Union within the framework of the FLEGT process;
- The Forest Development Fund's mission is to finance development programs (forest management, reforestation, forest regeneration, soil restoration, agroforestry and the fight against soil degradation), research in the fields of forestry, hunting, fishing and the counterparts of the Programs / Projects and the commitments made with sub-regional and international organizations in terms of national contributions in favor of the forestry sector;
- The AGDRF (Sustainable Forest Resources Management Agency), formerly the PARPAF Project, supervises and supports forest operators in carrying out development plans. But this Agency was restricted to a simple Coordination (at the level of a general directorate) following a government decision reducing the number of Agencies in the country ;
- The Mobile Control Brigade: In addition to the sovereign activities of the Mobile Control Brigade (BMC) relating to the fight against artisanal and illegal logging, the Mixed Mobile Brigade for Intervention and Verification (BMIV) of the FLEGT Unit are presented as a tool for verifying, strengthening and improving governance and sustainable management of forest resources.

➢ The private sector intervenes in the management of forest resources through a forest management plan. In CAR, it is the State which is involved in the drafting of the development

plan as the contracting authority through the PARPAF project in the years 2000 to 2011 and in recent years with the AGDRF. The private sector is involved in the decision-making process for the drafting of the development plan and is responsible for the technical, financial and inventory implementation of the development. The formal forestry sector is largely dominated by forest companies with foreign capital. To date, the country has 11 logging companies (and 14 Exploitation and Development Permits) with varying levels of activity. They are: SCAD, SEFCA, VICA, Thanry, IFB, SOFOKAD, SINFOCAM, STBCA, ROUGIER SANGHA MBAERE, CENTRABOIS (Boisrobert & Bégoto, 2010).

- NGOs: in the countries of Central Africa as well as the CAR, NGOs play a relay role for the State in the management of forest resources. They are particularly involved in the maintenance, advice and protection of forest resources. There are NGOs such as WWF, WCS, CIEDD, I3D, Maison de l'Enfant et de la Femme Pygmée, Femme BATA GBAKO. NGOs and Associations working in the field of environment and forests are grouped together in a Platform called "Sustainable Management of Natural Resources and the Environment"
- Sub-regional and international organizations like the Central African Forests Commission (COMIFAC), the Central African Forests Observatory (OFAC), CIFOR, WCS, European Union, AFD, the World Bank, the FAO are present in CAR (N'Gasse, 2002).
- The populations: in CAR, the so-called unmanaged forests belong to the indigenous community.

4.1.2.6.3.2 Actors involved in the exploitation of forest resources in CAR

In CAR, logging is located in the forest massif in the south-west of the country. The logging scheme presents upstream resource extraction and downstream consumption. Thus, there are several players: extraction actors, transformation actors, transporters, merchants.

The State is the main actor in the management of forest resources and grants the exploitation permit through the Department in charge of Forests. The only formal logging title in the CAR is the Exploitation and Development Permit (PEA). This permit grants the right to industrial exploitation, according to the national standards in force supplemented by the specific clauses of a development agreement which is equivalent to specifications. In return, the manufacturer pays rent per area and a tax linked to the volumes produced and exported. The concessionaires pay the reforestation tax (based on exported logs) because, after logging, the Ministry of Water, Forests, Hunting and Fishing (MEFCP) must take care of the reforestation of deforested areas in order to protect the forest.

Industrial operators: This category of actor concerns the owners of forest areas. There are dealers and individuals. It should be noted here that the concessionaires have operating permits accompanied by a management plan. This is the case, for example, for companies such as Thanry Centrafrique, IFB, SCAD, SEFCA, SOFOCAD, VICA, Timberland Industrie SA, STBCA, SINFOCAM, RSM, CENTRABOIS (Cerutti, Mbangolo, Nakoe, Vandenhaute, & Hubert, 2018).

Communities: People who use chainsaws for felling trees, farmers and hunters are most often found. The extraction of woody or non-woody resources is for commercial purposes. Coal miners are included in this category, they either exploit whole trees or the residues from woodcuts to make charcoal or use as firewood.

4.1.2.6.3.3 Primary and secondary forest resource transformations

- The government is the main player in the logging sector. In CAR as in other countries, only forest companies that commit to implementing forest management plan as provided by the forest code can process wood on the national scale. The wood processing players are private and public sector companies that hold concessions and operating permits.
- Private sector: Article 44 of the Forest Code obliges all holders of an Exploitation and Development Permit to process on site at least 70% of first category wood, i.e. the most sought after species, and defined in the development plan. Thus, the CAR currently has nine primary processing plants (simple sawnwood and sawn drying). The only secondary processing plant (plywood) has been in hiatus since 2010. Tables 3 and 4 below respectively present the distribution of logging titles and wood processing sites as well as their areas of action in CAR (Boisrobert & Bégoto, 2010).

Table 33: Breakdown of the various operating titles for the year 2018

Situation	Nom PEA	Operating companies	Areas ha
Attributed	SEFCA 174	Société d'Exploitation Forestière Centrafricaine	395 856
Attributed	VICA 184	Vicwood en Centrafrique	388 520
Attributed	RSM191	ROUGIER Sangha Mbaëré	269 417
Attributed	THANRY 164	Thanry Centrafrique	225 323
Attributed	SOFOKAD 175	Société Forestière de la Kadéï	188 692
Attributed	IFB 169	Industries Forestières de Batalimo	186 596
Attributed	SCAD 171	Société Centrafricaine de Déroulage	475 589
Attributed	SEFCA 183	Société d'Exploitation Forestière Centrafricaine	325 563
Attribué	IFB 165	Industries Forestières de Batalimo	207 640
Attribué	CENTRABOIS192	Centrafricaine des Bois	156 531
Attribué	IFB 186	Industries Forestières de Batalimo	218 618
Attribué	STI 188	Société Timberland Industries	229 025
Attribué	STBCA 189	Société de Transformation de Bois Centrafricain	211 155
Attribué	SINFOCAM190	Société Industrielle Forestière Centrafricaine et d'Aménagement	234 465
		Total	3 712 9**90**

Source: Annuaire Statistique des secteurs forestier et cynégétique 2018 (à paraitre) Fiche signalétique des sociétés forestières

There are around 10 unit wood processing in CAR[13]

Table 34: Wood processing industries in Central African Republic

Companies	**Action sites**	**Capacity m³**	**Years**	Situation
Industries Forestières de Batalimo IFB	Batalimo (Lobaye)	44 400	1970	Sawnwills Fonctional
	Ngotto (Lobaye)	10 000	1998	Sawnwills sttoped
	Lessé (Lobaye)			No sawnwills
Société Centrafricaine de Déroulage SCAD	Loko (Lobaye)	35 000	Construite en 1950 rachetée en 1984	Sawnwills sttoped
	Ndolobo (Lobaye)	31 200	Construite en 1980 rachetée en 1992	Sawnwills sttoped
Société d'Exploitation Forestière Centrafricaine SEFCA	Mbaéré (Mambere Kadei)	120 000	1995	Sawnwills Fonctional
	Mambélé (Sangha-Mbaéré)			Sawnwills Fonctional
THANRY CENTRAFRIQUE	Bamba (Sangha-Mbaéré)	90 000	1998 Reprise en 2001	Sawnwills sttoped
VICA Vicwood en Centrafrique	Mambéré-Kadéï			No sawnwills
Société Forestière de la Kadéï SOFOKAD	Dédé (Dede-Mokouba)	20 000	2001	Sawnwills Fonctional
TIMBERLAND Industries SA	Berbérati, Nola (Mambéré-Kadéï) (Sangha Mbaéré)	3 000	Début de construction en 2017	Sawnwills Fonctional
Société de Transformation de Bois Centrafricain (STBCA)	Nola (Sangha Mbaéré)			No sawnwills
SINFOCAM	Bayanga (Sangha Mbaéré)			No sawnwills
ROUGIER Sangha Mbaëré	Nola (Sangha Mbaéré)			No sawnwills
CENTRABOIS	PK 9 (Ombella Mpoko)			Sawnwills Fonctional

Source: (Cerutti, Mbangolo, Nakoe, Vandenhaute, & Hubert, 2018)

4.1.2.6.4 Transporters / logistic operators

Logging goes from cutting to consumption, including possible processing methods. However, the flow of forest products supply is closely related to the type of transport. Transporters are therefore an essential link in the value chain. In the CAR there is only one transport route used by carriers, and that is the road route. The products are transported from the loading site to the port of Douala by road. On Cameroonian territory, some companies then use trams or trains via Belabo or Bertoua to get to the port of Douala.

[13]Monographie par usine

4.1.2.6.5 Merchant and consumers

Markets for the CAR forest products are Asian, European and African. The market and consumer players encountered in CAR are diverse and depend on the types of forest products encountered on the market or in processing sites. The wood industry, for example, is still precarious. Existing product are from sawing, unwinding, slicing, debit drying and plywood. The main merchants and consumers are:

- Timber Depot Managers: There is currently no industrial sawn timber depot in the country, as some companies have stopped making sawnwood for local sales. CENTRA-BOIS is trying to supply the city of Bangui with industrial sawnwood but orders are limited. A few wholesalers buy various packages of sawnwood from the companies IFB Batalimo and SEFCA 174 in Mambélé. They complement the other deposits of illicit artisanal sawnwood, which are in the majority;
- Joinery: the furniture is made with different products from industrial sawnwood or illegal artisanal sawnwood. But there is a serious problem of hardness, quality (furniture made from illegal artisanal sawnwood) and high cost (furniture made from industrial sawnwood);
- The Charbonniers: The populations are grouped together on the site of forest residues of certain companies to recover the crowns and certain sawn timber to make charcoal. These coals are then resold in the localities or in Bangui;
- Households: Households benefit from the charcoal made by the charcoal burners and the furniture made by the carpenters;

  Craftsmen: They use certain species that have fallen during slaughtering and also species such as Difou, Mahogany, Padouk, Gmelina, Ebony, etc. to turn them into works of art.

4.1.2.6.6 Sources and types of forest biomass residue in Central Africa Republic

The main sources of forest biomass residue are government forests in CAR since the government is the main player. Biomass residue is generated at harvesting sites and through primary and secondary processing as shown in Table 35.

Table 35: Sources of forest biomass in Central Africa Republic

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Harvesting of trees leaving wood at harvesting sites
	- Industrialists and producers - Examples: ThanryCentrafrique, IFB, SCAD, SEFCA, SOFOCAD, VICA, Timberland ind, STBCA, SINFOCAM, RSM, SCB	
	- Wood depot managers; Carpenters; Hardware stores; Charcoal makers; Hotels; Restaurants; Households; Decoration industries; Craftsmen and artisans	Wood residues are produced during wood supplies
	- Wood saw milling companies - Examples: IFB, IndustrieForestière de Batalimo, SCAD, CENTRAFRIQUE, THANRY, SOFOKAD	
	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture) - Examples: IFB, IndustrieForestière de Batalimo, SCAD, CENTRAFRIQUE, THANRY, SOFOKAD	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites - Examples: ECOWOOD	
Consumers	- Wood depot managers; Carpenters; Hardware stores; Charcoal makers; Hotels; Restaurants; Households; Decoration industries; Craftsmen and artisans	

Availability of forest biomass residue and conclusion

In 2017 the total volume of wood production was 536,713 m^3 of which 51% was sawn and in total about 46% of residue produced, i.e about 246,887.98M^3. The country therefore has a high potential to generate forest biomass residue for bioenergy at the processing stage.

4.1.2.7. Case of the Republic of Chad

4.1.2.7.1 Forest resources in Chad

Chad is a vast country covering an area of 1,284,000 km^2. Compared to climatic zoning, from North to South, the plant formations of the Sudano-Guinean domain correspond to the humid tropical climate including 2 types of formations: clear forest with dominant legumes and combretaceae and forest tree savannah, formation whose composition vary according to the proportion of species such as *Anogeissusleiocarpus*, *Prosopisafricana, Butyrospermumparkii*; the Sudanese domain corresponding

to formations of the Sudanese savannah type more or less wooded with combretaceae; the Sahel-Sudanese area corresponding to the southern margin of the Sahelian climate characteristic of shrub savannas where Acacias dominate, the Sahelian area corresponding to the northern margin of the Sahelian climate and the desert climate and has for characteristic low, open or pseudo-steppe formations.

In Chad, the forest domain brings together the massifs under the jurisdiction of the forest regimes: classified forests, protected and defended forests, national parks, wildlife reserves, game reserves. Added to this, are reforestation areas. Several estimates have been made on the area of forests in Chad. The areas of classified forests (593,000 ha), national parks (414,000 ha) and wildlife reserves (11,080,000 ha) constitute approximately 12,087,000 hectares. The natural plant formations according to the Tropical Forest Technical Center (1989) would be around 23,000,000 hectares. Using the degradation rate estimated by FAO in 1995, which is 0.6% / year, it is estimated at about 21,000,000 ha (Haggar, 2001).

Reforestation operations in Chad were launched in 1950 with the establishment of the forest service in 1949. Early on, plantations were established as a soil protection measure. During colonial times and up to independence in 1960, plantations and plantation management were the responsibility of the forest service. Tree-planting by communities and private citizens began to be encouraged in 1961. Successive droughts have raged over most of Chad since the 1970s. The Government has been trying ever since to combat desertification by installing forest plantations and by soil conservation and rehabilitation efforts.

The main species planted are neem (Azadarichtaindica) and Khayasenegalensis, as shadetrees and for row-plantings, Eucalyptus spp. and Parkinsoniaaculeata for hedgerows and windbreaks, Acacia nilotica, Prosopisjuliflora and Acacia senegal. Forest nurseries, managed by the forest service usually with the active participation of village communities, are common. State-owned plantations are increasingly giving way to village plantations. Planting density in arid zones is about 1,100 seedlings/ha. Felling cycles for fuelwood production can be 4 to 5 years, with Eucalyptus spp. in the sudano-sahelian zone. For the production of poles, a longer cycle is required, about 6 to 7 years, at spacing of 4 x 4 m, for full planting.

Chad’s forest resource conservation policy orientation excluded public participation. In earlier times, forest management was based on strict repression, and the results were mixed if not mediocre. Mounting awareness of the issues involved led to a number of government initiatives such as the formulation and adoption of a 1989 national plan to combat desertification, a global framework for the use and management of natural resources, and the preparation of a new forest code calling for the transfer of responsibility for natural resources to local people and private citizens and a reorientation of the role of the state. The country also intends to reinforce the current arrangements for resource protection, expand its protected areas, and introduce watershed management. All these operations plan to enlist the participation of local people in line with the trend towards decentralization.

4.1.2.7.2 Forest value chain in Chad

Like all other Central African countries, Chad's forest value chain is dominated by Asian, European and African markets. This value chain goes from production to processing and sale of forest products. At each level of the link in the chain is an actor or a group of actors. They interact for the purpose of sustainable exploitation of forest resources. There are several actors such as management actors, extraction actors, processors, transporters, merchants, consumers. It should be noted that the management actors intervene at all level of the chain to ensure compliance with established forest rules and codes.

4.1.2.7.3 The players involved in Chad's forest value chain

4.1.2.7.3.1 Forest resource management and conservation actors in Chad

- The Government: The Chadian government role is to establish a comprehensive mechanism governing the status, development, exploitation and protection of its various resources through a new code (Law 36 / PR / 94 on the organization of the marketing and transport of fuelwood in large agglomerations and the taxation applicable to them and the Decree No. 107 / MTE / 97 implementing this law).. This code defines the principle of sustainability that requires rational, fair and balanced management of resources. The Chadian government manages its forest sources through its ministries and administrations (Haggar, 2001).
  - The Ministry of Environment and Water through its main branches is responsible for safeguarding the environment, combating desertification through environmental protection and the development of any action aimed at generating renewable natural resources; coordinating activities to combat desertification, initiation, coordination, regulation and monitoring of actions related to environmental clean-up and improving the living species in both rural and urban areas. It is responsible for monitoring forest and wildlife policy through the constitution, classification, conservation, management plan and management of the national forest heritage.
  - The forestry administration is represented by the Directorate of Forests and Environmental Protection (DFPE), and is responsible for the implementation and monitoring of national environmental and forest policy, enforcing national regulations of regional and international environmental, prevention and environmental conventions, designing and developing strategies to combat desertification and coordinating related programs.
  - The forest inspections at the departmental level assist the DFPE in the performance of its duties.
- The private sector is involved in forest management defined by the Plan for Fighting Desertification. The private sector is comprised of industrials who own concessions and operating permits. Forest resources are managed through an operating and management plan. These industrials are the main actors in the extraction and processing of forest resources (Haggar, 2001).
- The international and sub-regional organizations: they support the State and intervene in the development of strategies to combat desertification aimed at finding a socio-economic

balance between meeting the basic needs of the population and preserving the environment. They include:

- la Commission du Bassin du Lac Tchad (CBLT) ;
- l'Autorité du Bassin du Niger (ABN);
- The Economic Community of Livestock, Meat and Fish (CEBEVIRHA);
- The National Committee of the CILSS (CONACILSS);
- Central African Forestry Commission (COMIFAC);
- RAPAC (the Central A Protected Areas Network);
- The Central African Forest Observatory (OFAC) (GEF, n.d).

- Communities: The new forest texts define the legal and institutional framework for the participation of communities in the management of forest resources. They are involved in crop development, soil protection, streamlining of tree felling activities, etc. These communities most often act under the support of:
  - NGOs
  - Community environmental actions such as Green Village, ILOT, CVS, etc. (GEF, n.d)

4.1.2.7.3.2 Actors involved in the exploitation of forest resources

The state being the owner of all forest areas intervenes at all levels of the forest value chain. At this level:

- The state through its ministries, departments and branches establishes laws, regulations and a tax system to ensure the exploitation of sustainable forest resources. It also allocates concessions and operating permits to private and public sector companies.
- Operating companies: these are domestic and foreign. They are responsible for harvesting the various forest products for commercial purposes. These products are then transported either to processing sites or exported. Companies such as Rougier, Thanry are present in Chad.
- Communities: these actors harvest forest products mainly for commercial purposes. They supply the local market with forest products. They include coal miners, craftsmen and farmers.
- NGOs

<u>Transporters and logistic operators</u>

Transporters are usually self-employed and do not belong to any company. Wood transporters from Chad mainly use the roadway:

- the road from Kousseri (Cameroon) to N'Djamena (Chad);
- the road out of N'Djamena for Abéché;
- the road to Moundou (Chad) from the south;
- Moundou exit routes to towns in the southern area of Chad, where human density is high.

<u>Merchants and consumers</u>

Traders, craftsmen, households, carpentry, restaurants are the main marketers and consumers of sawdust imported from Cameroon and CAR (Lescuye & Tal, 2016).

In conclusion, there are several forestry activities in the different countries of Central Africa. These activities range from logging to sale, including possible transformations. Similarly, these activities vary from one country to another depending on the economic situation, access to energy, laws and regulations, etc.... As a result, there are also different types of waste produced as a function of the

activities carried out. These include sawdust, shavings, trimmings, slabs, edgings, sapwood, core defects, cuttings or spurs, etc. ... The quantities of waste produced depend on the volume of wood and the technology used. According to a study carried out in 2003 on the valuation of under sawmills, we note the production of 13% of offcuts, 25% of slabs, edging, sapwood; 10% of Heart defects, 16% of sawdust, 5% of spurs.

These residues are found in the sites where forestry activities take place: cutting, processing, deposit sites, etc ... these correspond to the action zones mentioned in the tables of the above-mentioned forestry operating units.

This waste has the potential to be exploited for self-consumption or transformation (conversion into bioenergy, for example) by individuals or companies.

The common feature of the areas housing the logging units is poor access to energy. However, through adequate financing and technology, this waste can be recovered and better exploited in order to improve the conditions of the local populations.

The production of electricity for lighting and heating, the production of biogas for cooking by modern combustion technologies of forest waste will be an asset for the development of rural areas.

4.1.2.7.3.3 Sources and types of forest biomass residue in Republic of Chad

The main sources of forest biomass residue are government forests in CAR since the government is the main player. Biomass residue is generated at harvesting sites and through primary and secondary processing as shown in Table 36.

Table 36: Sources of forest biomass in Republic of Chad

Sources of forest biomass	Main actors	Role played in the production of forest residues
Harvesting	- The government - Dealers - Local communities - NGOs	Harvesting of trees leaving wood at harvesting sites
	- Industrialists and producers	
	- Transporters	Wood residues are left at collection points
	- Wood saw milling companies	

	- Charcoal producers	
Secondary processors	- Wood products and by-product processors and workshops (e.g. furniture)	Production of wood residues (chips, sawdust, etc.) during processing
	- Wooden construction sites	
Consumers	- Wood depot managers; Carpenters; Hardware stores; Charcoal makers; Hotels; Restaurants; and Households	

Availability of forest biomass residue and conclusion

Climatic conditions and difficulties in accessing energy limit logging in Chad. The quantity of wood produced is not known and therefore the quantity of waste produced is unavailable.

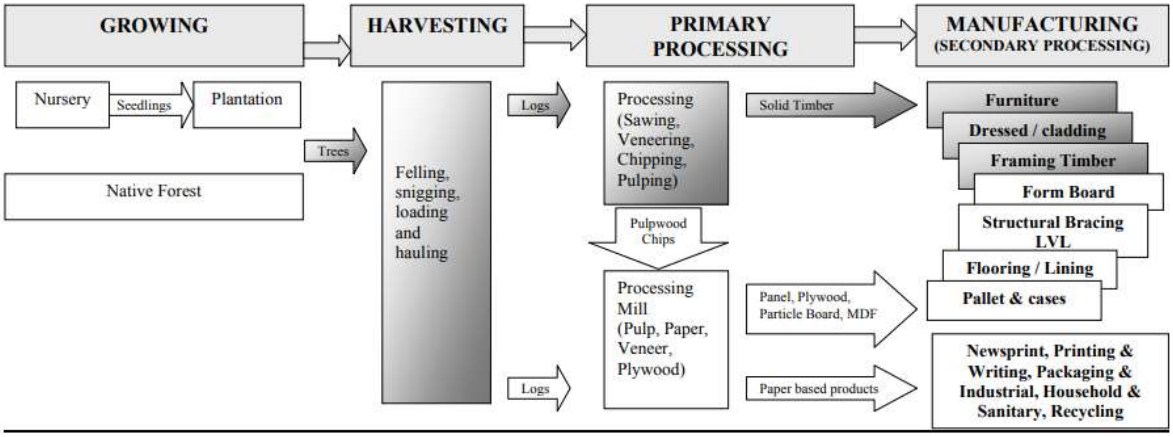
4.2 West Africa region

4.2.1 Forest value chain in West Africa

There are important value chains in West Africa, the timber value chain and the wood fuel value. Similar to the Central African sub-region, primary processing is the dominant value-adding activity in West Africa. The sub-region's sawmilling industry is well-developed especially in Nigeria, Côte d'Ivoire and Ghana. However, production of further value-added products such as panel products and pulp and paper is less developed. Plywood production is limited to Côte d'Ivoire, Ghana, Liberia and Nigeria (Asumadu, 2004)[14]. The main characteristics of the wood processing sector in the sub-region are dominance by small to medium enterprises (SMEs), most of which operate in the informal sector and dominance of obsolete equipment and low recovery rates. The key challenges facing the sector in the sub-region are diminishing resource base. Previous over-harvesting for log exports has depleted the forests of their stock of large logs forcing the industry to increasingly depend on re-growth secondary forests and plantations, which produce relatively small logs. Figure 27 shows typical value-adding and supply chains for the forest and wood products sector in developed countries which also apply to many West African countries.

Figure 27: Typical forest and wood products further processing value and supply chain

[14] Asumadu, K., 2004. Development of wood based industries in sub sahara Africa, Lessons Learnt on Sustainable Forest Management in Africa. Royal Swedish Academy of Agriculture and Forestry (KSLA), African Forest Research Network (AFORNET) at the African Academy of Sciences (AAS) and FAO.



Source: Asumadu, 2004

4.2.2 Key players involved in forest biomass management

A simple stakeholder analysis was conducted in the West African forest sector, highlighting the major actors, the possible alliances and oppositional tendencies between the stakeholder groups, their different positions with regard to policy decision center as well as the effects of the policy measures on them. These stakeholders, according to the analysis by FAO[15] include: the state/government agencies; municipalities; logging companies/private sector; village/local communities; Civil Society/environmental NGOs; forest scientists (academia and research Institutes) and development partners.

The state/government and its administrative and technical agents: The governments have the lead role in natural resource planning and policy making process in West Africa as elsewhere in Africa. From problem identification, agenda setting, policy formulation, adoption, implementation to monitoring and evaluation. Forest policies and laws have put all forests and tree resources under the control of the State, with use rights given to local people. Governments have largely treated forests and forest resources as important assets for building internally capital bases for economic development in West Africa. With the increasing loss of forests and the dwindling of forest resources in West Africa, due mainly to the rapidly growing urban demand for wood-energy and the increasing demand for agricultural land, governments are finding it extremely difficult to single-handedly arrest deforestation, land degradation, and all the associated woes (e.g., soil erosion, desertification, climate change, diminishing agricultural productivity and loss of rural livelihoods opportunities). They are therefore more and more willing to embrace pluralism and build partnerships with private sector and civil society actors in natural resource management and policy making processes (FAO, 2015).

Private sector actors: This group in West Africa is quite diverse and includes logging companies; firewood and charcoal producers and traders; non-timber forest products producers and traders; commercial tree growers; and all those involved in value-addition to forest products. The importance of these components of the private sector stakeholder group depends on the forest ecosystem they operate in. For example, in the Upper Guinean Forest Ecosystem extending from Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, to Nigeria, logging and wood processing companies seem to be highly valued and given direct access to forest benefits through forest concession allocations

[15] *FAO, 2015. A subregional strategy for enhancing the participation of the civil society in forestry planning and policy making process in West Africa.*

than the other private sector stakeholders. This is because of their capacity to finance forest exploitation and pay taxes and fees to the State. They are therefore natural associates to the government.

Forest Scientists (Academia and Research Institutes): Forest scientists have developed a science of forest exploitation and conservation; and have provided a stream of forestry professionals to both government and forest industry. Applying these forestry and wood processing technologies, forest industries generate jobs, capital and products which are highly valued in government development agenda. Therefore, a high degree of association exists between government, industry and forest scientists.

Municipalities: Municipalities, as decentralized government extension entities, are least affected by forest policy decisions but influential in making forest decisions and laws. They are also high on the list of those stakeholder groups benefiting from forest resources exploitation. They play the dual role of serving as a vector for disseminating public policy decisions and legislative measures; and also as a defender of the interests of local people and their communities.

Village/local communities: The "Village/local communities" is the stakeholder group most affected by forest policy decisions but least influential in the policy making process. The degree of association of the "Village/local communities" is naturally high with Civil Society Organizations/non-governmental organizations (NGOs) which they tend to look at as partner and trusted allied given the NGOs' reputation as non-profit organizations working for the promotion of the livelihoods of the poor rural people and communities.

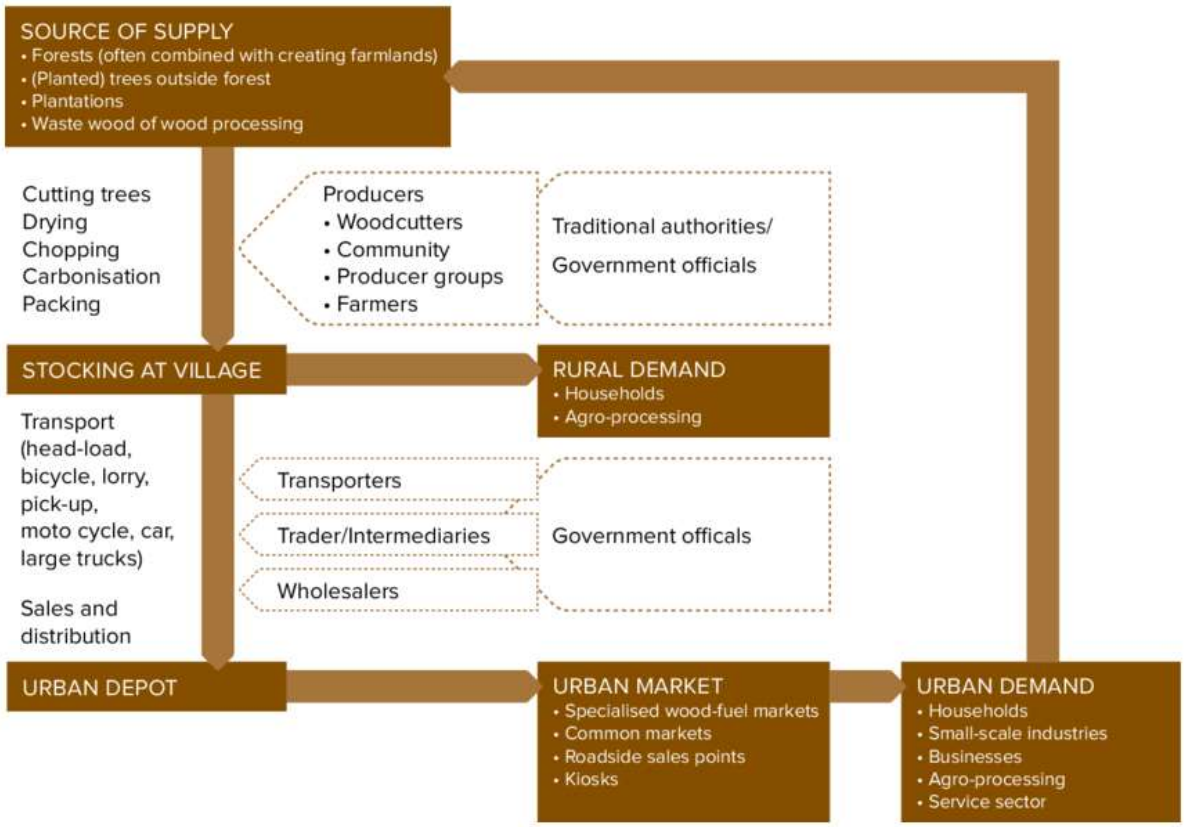
Development partners: Development partners , including international aid agencies and multilateral banks, are external key actors which have important direct and indirect impacts and interests in the forestry sector. Their interests in the forestry sector could be best looked at as that of the international community, interested in (i) the improvement of the livelihoods of the poor and marginalized people or communities in rural areas, most affected by forest planning and policy decisions and the depletion of forest resources; and (ii) the value of the forests as crucial sink for carbon sequestration for climate change regulation for the benefit of planet earth as a whole.

Civil Society Organizations (CSOs): This group of stakeholders is the most heterogeneous group in the forest sector; and their diversity makes the analysis of their relationships with other stakeholder groups complex. Nevertheless, CSOs can roughly be grouped into two categories: Community-Based Organizations (CBOs) on one hand and Non-Governmental Organizations (NGOs) on the other. Generally NGOs are the most formally organized form of CSO and are non-profit and voluntary in nature. They also generally share a common zeal for addressing developmental issues —touching the livelihoods of the poor and marginalized in rural areas— that have not been adequately addressed by other societal institutions. For their potentially important roles, CSOs in West Africa tend to have a higher degree of association with development Partners, because of their effectiveness on the ground where the actions that make a difference in the lives of local people take place.

Wood industry players: West Africa has a well-developed sawmilling industry, largely based in Nigeria, Côte d'Ivoire and Ghana, which together accounted for about 93 percent of sawnwood production in 2000.

Consumers: In the West Africa forest value chain, consumers also stand out as key players. Undoubtedly the most important product derived from forests and woodland is woodfuel, which accounts for over 85 percent of the total energy consumption of West African countries and provides most household energy needs.

4.2.3 Mapping of forest value chains in West Africa target countries



How Supply chain works and at what points the greatest amounts of wood waste is generated.

4.2.3.1. Case of Benin

4.2.3.1.1 Forest resources in Benin

In terms of vegetation, despite its apparently favourable position, Benin is not a forest country. Law 93-0009 on the forest regime distinguishes 3 categories of forests: natural forests (those in which there is no sylvicultural development action), semi-natural forests (developed natural forests) and artificial forests (land planted by hand. According to article 10 of the Law, forests are classified as follows:

- classified area : includes classified forests, reforestation areas, national parks, hunting areas;
- Protected area: the protected forests made up of the rest of forests in the State domain that have not been classified.

In general, the vegetation cover of Benin is represented by a few relics of dense semi-deciduous forests, dense dry forests and gallery forests, the whole dominated by vast expanses of savannas ranging from the Sahelian to Guinean type. The few islands of dense natural forests often constitute sacred places (sacred forests). The vegetation cover of Benin is experiencing a worrying rate of degradation due to the combined actions of the farming system (slash-and-burn agriculture) and anthropogenic actions (uncontrolled cutting). Thus, the national forest cover evaluated in 1957 at 2,700,000 hectares decreased to 1,500,000 hectares in 1980. According to a study by the FAO in 1975, and the Directorate of Energy on energy strategy in Benin in 1995, losses in plant cover reached 3781 km^2 in 20 years, or about 190 km^2 per year[16]. Sources agree that natural resources steadily declined during this period. Thus, the National Center for Remote Sensing (CENATEL) also reports that from 1978 to 1998, the main courses fell by 3 million hectares, or 1 60 000 ha per year[17].

[16] (CIMA International / DIRECTORATE OF FORESTS AND NATURAL RESOURCES, November 2005)

[17] (General Directorate of Forests and Natural Resources / National Program for Sustainable Management of Natural Resources, November 2008)

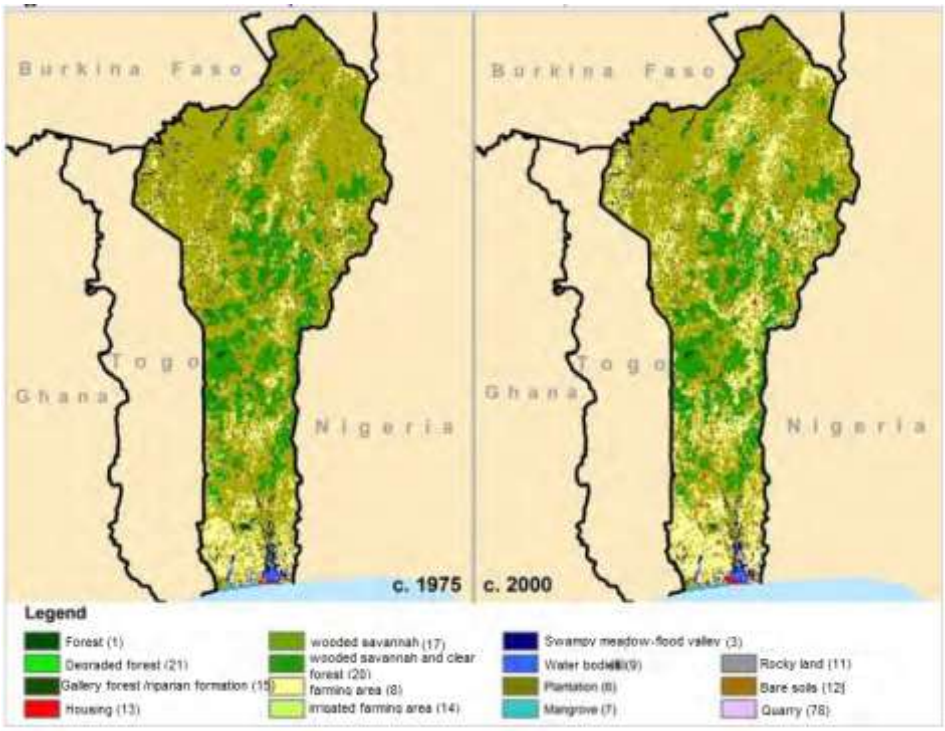


Figure 28: Land use map of Benin, years 1975 and 2000 [18]
(Source : National Center for Remote Sensing (CENATEL)

It is estimated that around 70,000 ha of forest were destroyed each year between 1990 and 2000 as a result of expansion of agriculture, livestock, uncontrolled logging and bush fires. Benin had a plant cover (forest and agricultural) estimated in 2005 of 7.67 million hectares, or 68.08 % of the surface area of Benin. The forest domain covers approximately 2.7 million hectares, or 19 % of the national territory. It includes two national parks covering 843,000 ha (the Pendjari and '' W '') essentially divided wildlife reserves and three hunting zones (420,000 ha) and protected forests and areas of reforestation (1,436 500 Ha). The protected area covers approximately 2 million hectares and includes private plantations, patches of forests protected by religious practices and natural forests.

Table 37: Forest cover in Benin[19]

Forest classification (Type of forest formation)	Area (Ha) Proportion (%)	Area (Ha) Proportion (%)
Dense forests	68,702	0.88
Gallery forests	277,038	3.55
Clear forests and wooded savannas	1,456,793	18.64
Tree and shrub savannas	5,591,891	71.57
Marshy formations (forest, savannah, meadow, mangrove, lowlands)	184 876	2.37
Plantation (forest, fruit, e.g. oil palm, coconut, cashew, orange)	234 195	3.00
Total area of forest cover	7 813 495	100.00

Source: IFN, 2007

[18] (General Directorate of Forests and Natural Resources / National Program for Sustainable Management of Natural Resources, November 2008)
[19] (Directorate General of Water, Forests and Hunting, February 2018)

In a report of the Support Project for the Promotion of Non-Timber Forest Products (NTFPs), it is estimated that during ten years (1995 to 2006), forest cover decreased by 20.92% at a rate of 60,000 ha per year.

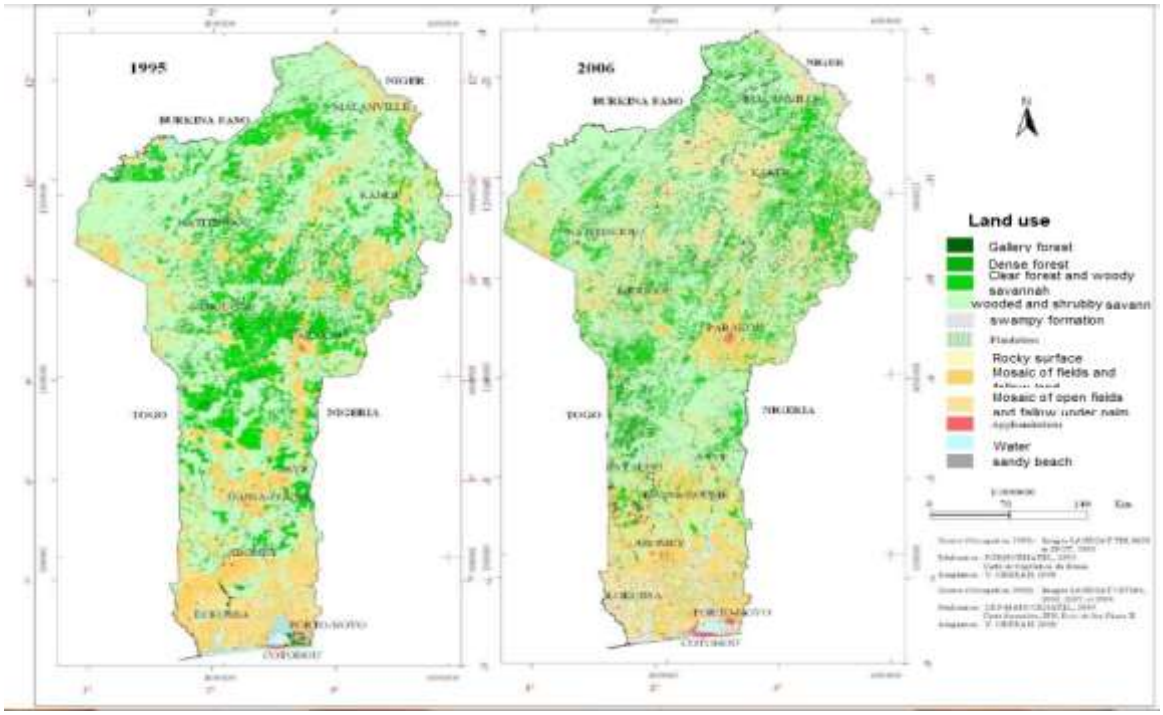


Figure 29: Land use map of Benin from 1995-2006[20]

4.2.3.1.1.1 Wood energy supply and demand

Within the framework of the Fuelwood Project Phase II, a mission was carried out to determine the fuelwood supply basins of the eight main urban centres of Benin, namely: Cotonou, Porto Novo, Lokossa, Abomey, Bohicon, Djougou, Natitingou and Parakou[21]. The report of this mission assessed the wood resource and the potentialities, based on the results of the National Forest Inventory of 2007 and evaluated the annual production. Thus, it appears from this report that the total volume of standing timber was estimated at 232,220,111 m^3 in 2007 for all forest and agricultural formations.

Table 38: Wood energy supply in Benin

Stratum	Number trees / ha	Total volume M^3 / ha	Total volume M^3
Dense forest	245	67	4,599,693
Forest gallery	189	44	12 690 611
Clear forest / Wooded savannah	192	35	52 700 785
Tree and shrub savannah	126	21	122 023 471

[20](General Directorate of Forests and Natural Resources / Support Project for the Promotion of Non-Wood Forest Products, May 2014)
[21]Claudine SERRE DUHEM-FUELWOOD PROJECT PHASE II, 2007

Planting	143	21	5,507,205
Mosaic of cultivation and fallow	79	11.5	32 032 028
Mosaic of cultivation and fallow under palm trees	134	5.4	2,666,320
TOTAL			232,220,111

From the productivity assumptions of natural formations and agricultural land, an assessment of forest productivity was established.

Table 39: Forest productivity assumptions for Benin

Stratum	Productivity assumptions	Annual wood production by stratum	
	m ³ / ha / year	m ³ / year	T / year
Dense forest	2	137,304	96,113
Forest gallery	2	576,846	403 792
Clear forest / Wooded savannah	1.2	1,806,884	1,264,819
Tree and shrub savannah	0 , 8	4,648,513	3,253,959
Mosaic of crops and fallow land	0.6	1,671,236	1,169,865
Mosaic of crops and fallow under palm trees	0.4	197,505	138,254
TOTAL		9 038 289	6 326 802

Source: IFN 2007, Hubert Forster estimates

Annual wood production was therefore estimated at 9,038,289 m^3. This production, as can be seen, does not take into account that of plantations, which cover very heterogeneous realities such as timber plantations, orchards, cashew tree plantations and fuelwood plantations. The mission considered in its report that 90% of the production (excluding plantations) is potentially usable as fuelwood. So to speak, from the above estimated value, the annual production of wood energy can be estimated at around 5,700,000 tonnes (8,134,460 m^3) in 2007. This value is not very far from that of the EIS 2015 report of the Directorate General for Energy. Indeed, in this report, it is estimated that the total quantity of fuelwood taken from the forest amounts to 7,125,996.4 tonnes. This productivity is established on the basis of values of 5 tons/ha for dense forests, 1.2 tons/ha for open forests and wooded savannahs and 0.6 tons/ha for wooded savannahs, weighted with the percentage represented by each type of forest formation[22].

In Benin, as in most sub-Saharan countries, fuelwood is consumed mainly by households, accounting for 93% (75% for fuelwood and 18% for charcoal) of final energy consumption in 2015 (3,566,734 tonnes of fuelwood and 399,431 tonnes of charcoal). Next come the production and service units (bakeries, small food processing units, fish smoking, traditional hotels and restaurants, etc.) whose consumption was 80,279 tonnes of firewood and 79,750 tonnes of charcoal in 2015[23].

However, a study carried out in 2007 on the wood energy needs of the major consumption centers for the benefit of the PGFTR reveals that the global annual demand for wood energy for the year 2006 can be estimated at 9,110,821.5 tonnes of wood energy. This study estimates the national household demand for wood energy at 7,896,916.9 tons of wood equivalent for 2006 and the total annual consumption of wood energy by production and service units at 1,213,904 tons of wood equivalent.

[22](SIE 2015/General Directorate of Energy, JUIN 2017)
[23](SIE 2015/General Directorate of Energy, JUIN 2017)

In addition, this study states that the total annual national consumption of firewood is estimated at 4,242,128.4 tons while the total annual national consumption of charcoal is estimated at 548,218.3 tons[24].

Based solely on 2007 data (annual supply and demand), it can be said that Benin had a theoretical fuelwood deficit of 3,410,821 tonnes, a factor of 1.6.

4.2.3.1.1.2 Wood energy supply basins

A mission carried out in 2007 within the framework of the Fuelwood Project Phase II identified the fuelwood supply basins of Benin's eight main urban centers, namely: Cotonou, Porto-Novo, Lokossa, Abomey, Bohicon, Djougou, Natitingou and Parakou. These basins are presented by urban centre in the figures[25].

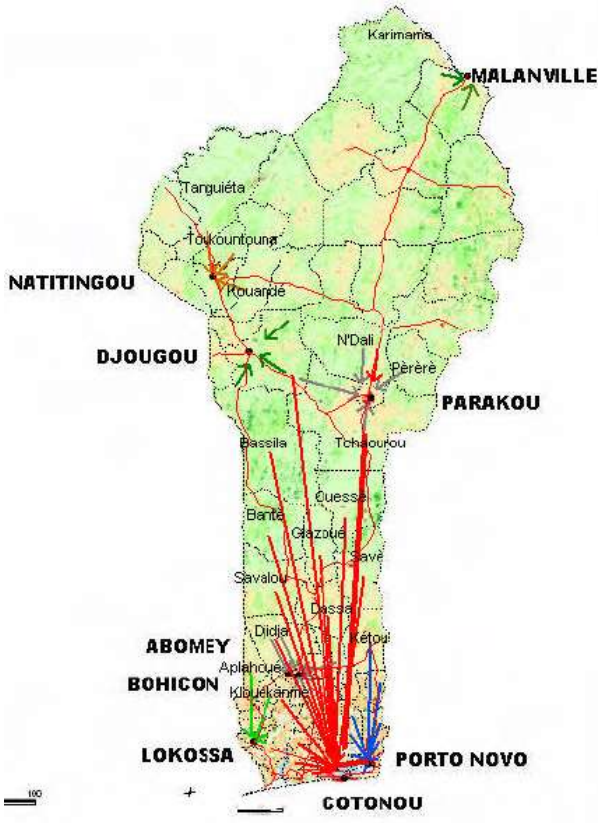


Figure 30: Flow of wood fuel to urban centres of Benin

NB Agglomerations appear in red on all basin maps .

The main local supply roads are Djidja and Zagnanando .

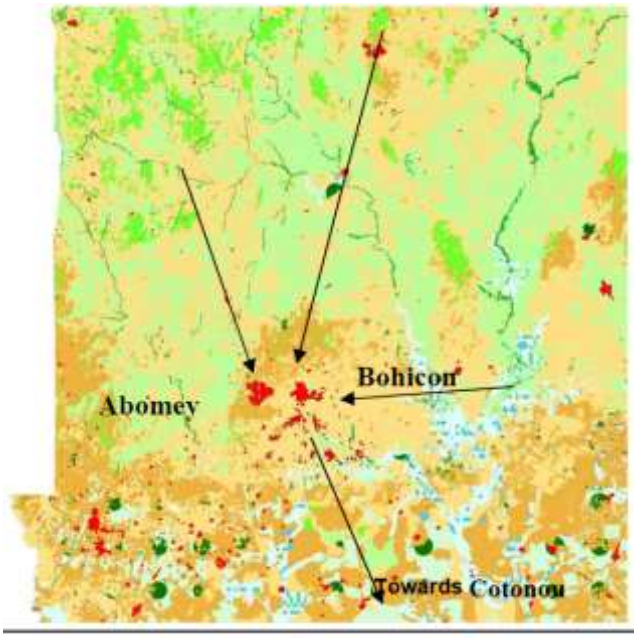
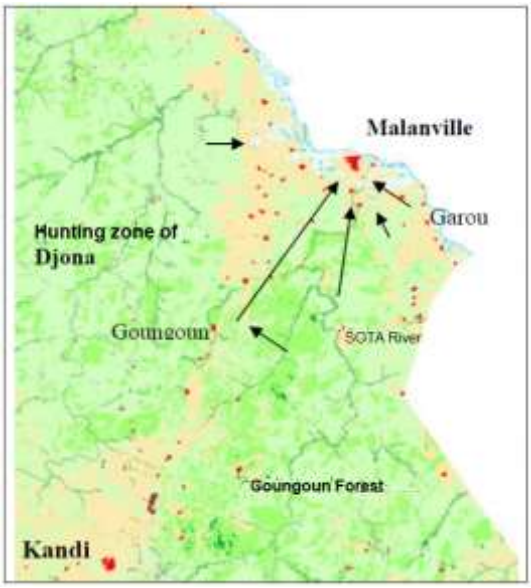


Figure 31: Abomey-Bohicon supply basin

[24]Ogoudedji Georges, 2007

[25](Claudine SERRE DUHEM-FIREWOOD PROJECT PHASE II, 2007

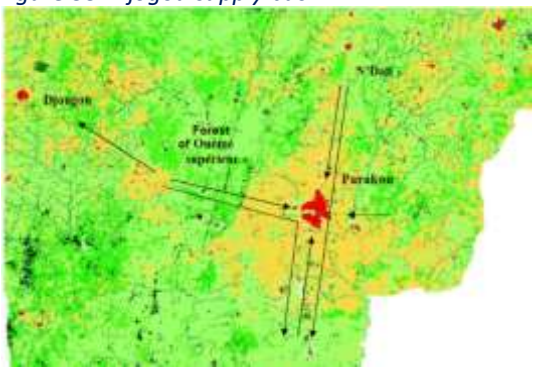


The municipality of Malanville has relatively large forest resources, but these are mainly classified forests or hunting reserves. Harvesting of fuelwood for its supply is concentrated in the south-east, which can lead to local phenomena of overexploitation, along the road from Kandi to the village of Goungoun

Figure 32: Malanville supply basin

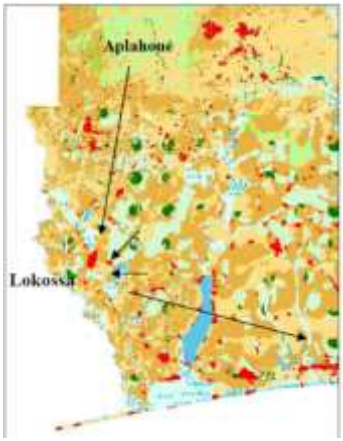
The charcoal comes from the exploitation of classified forests, in principle by recovery of the by-products of the exploitation of timber (Upper Ouémé Forest near Baku).

Figure 33: Djogou supply basin



Part of the charcoal supply comes from the classified forest of the Ouémé. Wood and charcoal are also supplied from agricultural clearing along the Tchaourou and N'Dali axis.

Figure 34: Parakou supply basin

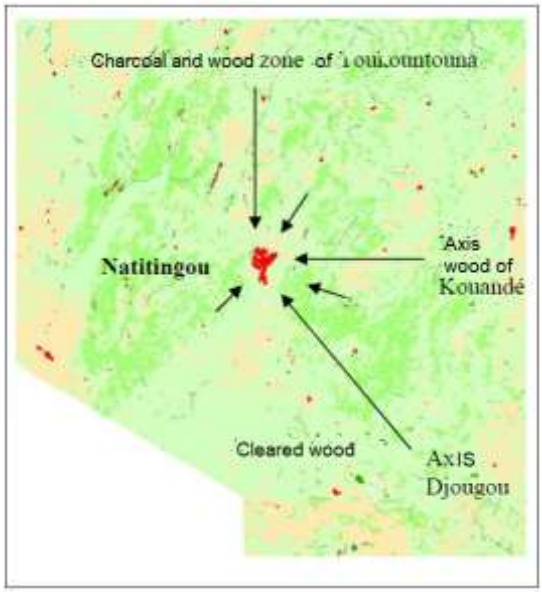


Most of the coal comes from the department of Couffo (Aplahouè, Klouékanmè) in the North.

The local traffic, by transporting basins of

coal or bundles, provides more than 30% of supplies. In addition, there is also sawmill waste.

Figure 35: Lokossa supply basin



About half of Natitingou's supplies come from the surrounding villages. It is provided by women who carry bundles or basins of charcoal on their heads. Vans also criss-cross the markets in the Toukountouna area, sometimes Tanguiéta, and supply Natitingou with coal. Most households use firewood.

Figure 36: Natitingou supply basin

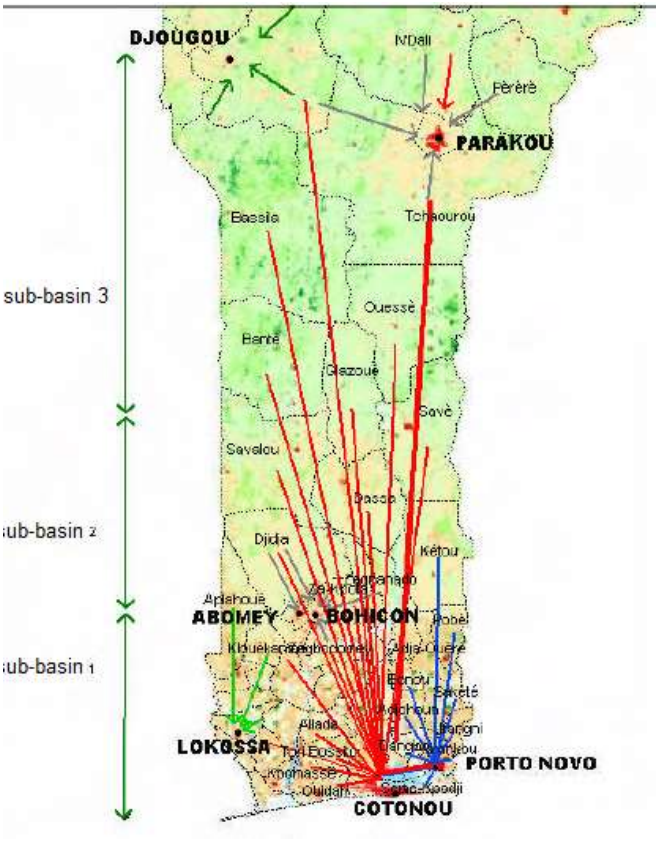


Figure 37: Cotonou-Porto-Novo supply basin

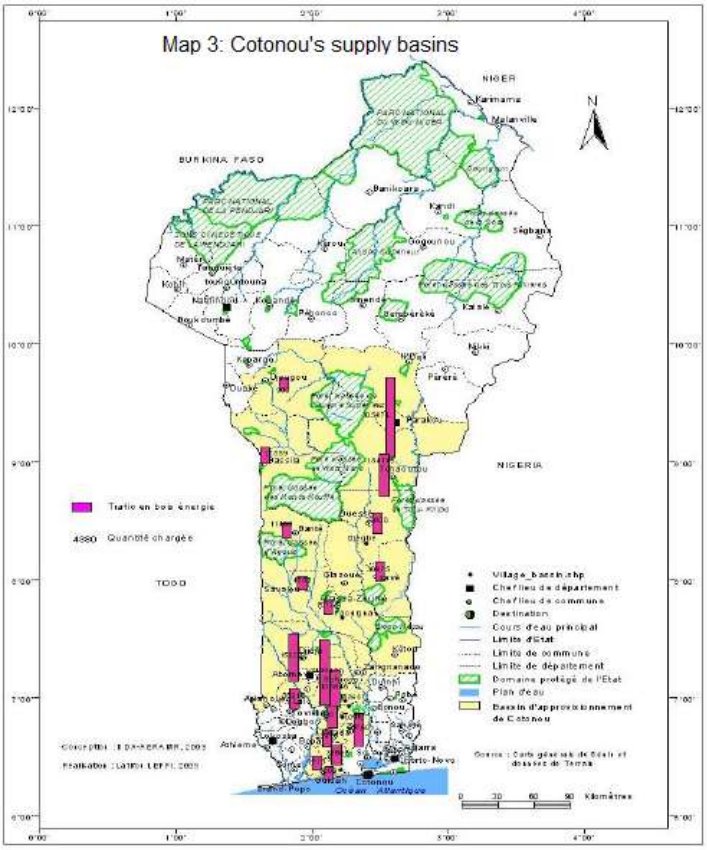


Figure 38: Cotonou supply basins[26]

4.2.3.1.2 Players involved in Benin forest value chain

4.2.3.1.2.1 Forest management and conservation

There are two main actors involved in the production of wood: the State; and individuals and cooperatives. Benin, as mentioned above, is not a forest country. There is no ministry exclusively in charge of forestry, as in some countries with high forestry potential. In fact, the department devoted to forest resources is also responsible for other areas such as water and hunting. Nevertheless, the management and exploitation of forest resources are important.

The wood-energy sector is the most important in Benin. It represents the main source of energy for the population. Although the sector provides a living for many people, it is not organized. Most of the actors operate informally and sometimes illegally. The volumes of wood generated by the sector are significant and only a tiny part is recorded by the Forestry Administration. They affect all types of forest (natural or artificial) and savannah. The sector generates waste. First at the cutting sites (small branches, foliage), then at the carbonization level (for charcoal: dust and poorly carbonized wood) and finally at the retail level (small wood remaining after the wood has been put into bundles or heaps and dust after the charcoal has been bagged).

[26](AKOUEHOU, 2009)

The timber sector is better organised and better controlled by the Forest Administration, certainly because part of the timber exploited is exported. The non-exported part is mainly transformed into furniture, thus generating waste (bark, sawdust, shavings) that is used in livestock (chips) or in households (for cooking).

However, the artisanal sector, whose products (wood carvings, tam-tams, mortars, dugout canoes, masks, etc.) have not only a commercial character but also a socio-cultural (or even cultural) meaning, escapes this control. And yet, this artisanal sector generates a lot of waste (bark, pieces after wood cutting, etc.) but these are used by households.

As for the service wood sector, it only concerns plantations (ONAB state-owned or private). Teak is the most commonly used wood in this sector. The quantity of wood produced by the sector is less compared to previous sectors and the exploitable waste generated by the sector is negligible.

4.2.3.1.2.2 Wood production and management

In Benin, the General Directorate of Water, Forests and Hunting (DGEFC) of the Ministry of the Living Environment and Sustainable Development (MCVDD) has the mission to ensure the development and rational management of natural resources throughout the country. At the departmental level, the DGEFC is represented by the Forest Inspections (IFs) which are responsible of implementing the national forest policy[27]. Law 93-0009 on the forest regime[28] did not specify the role of local communities in the management of forest resources. Forests were placed under the exclusive authority of the Forest Administration and its agents with the essential mission of guaranteeing the development of the State's forest estate. Nevertheless, Law No. 97-029 on the organization of municipalities in the Republic of Benin grants roles and responsibilities to local authorities in various fields including the management of forests, wildlife and natural resources in the non-permanent State forest estate. Indeed, article 94 of Law No. 97-029 stipulates that "The municipality is responsible for the creation and maintenance of plantations, green spaces and any public development aimed at improving the living environment. It shall ensure the protection of natural resources, particularly forests, (...) and contribute to their better use"[29].

The Act respecting the forestry regime considers "as part of the forest estate of individuals and cooperatives, the areas forested or reforested by such individuals and cooperatives for economic or non-economic purposes". (Art. 60). Timber production/management in Benin is therefore by the State through the Forest Administration and to some extent local communities or by individuals and cooperatives.

4.2.3.1.3 Actors involved in exploitation and harvesting

Timber exploitation in Benin has a legal basis in the Forest Regime Act. Indeed, "the exploitation of the State forest estate by public services or by private individuals may be carried out either under management (exploitation carried out by the Forest Administration in classified or protected forests), or by sale of cuttings (the cut being a well-delimited portion of forest on which wood products are harvested), or by a permit for the cutting of a limited number of trees, pieces or cubic meters .

[27](General Directorate of Water Forest and Hunting, February 2018)
[28] (Law n°93-009 of the 2 july 1993 forest regime, 1993)
[29](Law No. 97-029 on the organization of municipalities in the Republic of Benin, 15 January 1999)

Exploitation in the State protected area is carried out by means of a cutting permit that takes into account the available forest resources. This exploitation is organized according to a cutting plan specifying the intervention zone on a map, the species by diameter class and the species not to be cut.

Any natural or legal person wishing to practise in the Republic of Benin the profession of forest manager, trader in forest products or industrialist of forest products must be approved by the State. The conditions for obtaining such approval are laid down in a decree issued by the Council of Ministers[30](Art. 51). The exercise of the professions of forest logger, trader of forest products and wood industrialist is subject to obtaining an approval issued annually by the DGEFC (ex- Directorate General of Forests and Forest Resources).

However, approval is not mandatory in the case of non-commercial operations, except in the context of implementing a development plan. Article 41 of the implementing decree thus considers as a forest operator "any natural or legal person, approved by the Forest Administration to harvest timber products for profit".

The exploitation of forest resources is tgranted to the approved operators who must obtain an authorization from the Forest Administration before any exploitation within the limits of available resources[31]. Exploited forest products come from different sources of supply, namely:

- natural forests of the State's protected area ;
- private plantations ;
- State-owned plantations of the National Wood Office (ONAB);
- Classified forests with a development plan.

The Forest Administration considers private operators in the three main categories of activities (logging, trade in forest products and the timber industry) as users of wood.

The following table shows the number of cards (approvals) issued and the number of users in 2014, 2015 and 2017.

Table 3: Statistics on the issuance of licences in 2014, 2015 and 2017

Table 40: Statistics on the issuance of licences in 2014, 2015 and 2017[32]

Categories of maps	2014		2015		2017	
	Number of cards	Number of users	Number of cards	Number of users	Number of cards	Number of users
Operators	487		297		304	
Retailers	876		199		398	
Industrialists	357	1020	154	322	201	445
Total	1720		650		903	

NB:*The delivery of approvals to users (timber operators, traders and industrialists) was temporarily suspended in 2016 by decision of the Council of Ministers on 13 April 2016. These operations for issuing and renewing approvals resumed in 2017.*

[30](Law n°93-009 of the 2 july 1993 forest regime, 1993)
[31]General Directorate of Forest Waters and Hunting,February 2018
[32]General Directorate of Forest Waters and Hunting, February 2018

In 2012, the associations of wood operators wished to create a Union bringing together their various associations. This union, called the National Federation of Associations of Timber Professionals and Users (FENAPUB-Benin), was supposed to bring together associations such as Anub (National Association of Timber Users), Upb-Benin (Union of Timber Professionals of Benin), Acoprof, Adcppf, Udaebo and Anebr-Pr[33]

4.2.3.1.4 Actors in wood energy harvesting and processing

The General Directorate of Forestry and Natural Resources (DGFRN) estimated in its report of activities in 2015, the volume of operations of timber to 72,982 m^3 from the North essentially (Atakora / Dong has , 28514 m^3 and Borgou / Alibori, 26,266 m^3). In 2017, in its activity report, the Directorate General of Water, Forests and Hunting (formerly DGFRN) estimated the volume of timber harvested at 122,073 m^3 without specifying the origins by department. However, the two activity reports indicate that the most exploited species is *Tectona grandis* (called Teck) both in terms of number of plants and volume.

Regarding timber processing, very little is mentioned in the documentation. However, the 2015 and 2017 activity reports mentioned above reveal that 357 cards in 2014, 154 cards in 2015 and 201 cards in 2017 (i.e. 712 cards) were issued to wood industry (wood machining).

The implementing decree considers "as a forest industry, the transformation of all forest products into semi-finished or finished products"[34]. The industries covered by this decree are: fixed or semi-mobile sawmills, industrial charcoal factories, match factories, plywood, panel, fibre, particle and post, glulam industries , wood pulp and paper pulp industries, joinery and cabinet work. (Art.56. implementing decree). There are very few large wood processing units in Benin as cited in Article 56. In the early 2000s, a study of the timber sector in Benin revealed that 11 sawmills would be officially approved and registered with the Directorate of Forests and Natural Resources[35]. However, this study specified that there would be at most five so-called modern sawmills whose characteristic is the processing of teak wood, which they export exclusively. These mills are: the Beninese Wood Industry (IBB) (Industry Branch of ONAB), the Compagnie du Golfe, Bentect S.A., SOPACOB and the Justin Company. The products manufactured by these factories are sawing, squared timber, parquet, parquet frieze, pallets, furniture. The ONAB sawmill had, according to this study, the largest production capacity and by far the most sophisticated. Another processing unit called ATC-Industrie de bois (ATC-IB) located in Sékou (commune of Allada) stands out nevertheless. Erected on an area of eight hectares, ATC-IB is dedicated to the transformation of wood and the manufacture of furniture of all ranges. It includes various sections including the sawmill, machining, assembly, sharpening, parquet flooring, paint finishing, and upholstery.[36]

On the other hand, there is a multitude of wood processing stores (joinery or cabinet making) using only rudimentary tools such as saws, planes, chisels, bits, etc. These stores are exempted from approval according to article 57 of the implementing decree. Moreover, in Benin, as in some sub-Saharan countries, there are "manual" wood processing industries. The products of these processes include mortars, tam-tams, sculptures and canoes.

[33]Jean-Claude D. DOSSA/specificevent log, 2012
[34](Benin/Forestry Regime Application Decree, 1996)
[35](TCHIWANOU, OctobER 2000)
[36]Maryse ASSOGBADJO, 2015

4.2.3.1.5 Actors involved in timber harvesting and processing

Service wood in Benin is essentially made up of poles and posts of small diameters (6 to 20 cm in diameter) for 5 to 12 m in length all species combined[37]. These are generally plantation woods. In this sector, the operators are mainly individuals who have an approval (for ONAB state plantations) or an authorization from the owner (for private plantations). According to the General Directorate of Forests and Natural Resources (DGFRN), a total of 101 permits have been granted for the exploitation of approximately 159,157 feet (essentially in the departments of Mono/Couffo, 77,464 feet and Ouemé-Plateau, 63,901 feet), the majority of which is teak. In its 2017 activity report, the Directorate General of Waters, Forestry and Hunting formerly the Directorate General of Waters, Forestry and Hunting (DGFRN)) indicates that 224 cutting permits were issued for the exploitation of 857,139 feet in both ONAB's state-owned and private plantations. The departments of the Atlantic and Coastal regions lead the way in the exploitation of service timber (471,886 feet granted). A priori, there are no processing units for service wood in Benin.

4.2.3.1.6 Actors involved in transport of wood energy and timber

The main means of transport for wood energy are[38]:

- Non-motorized short: mainly small towns involving pedestrians (mostly women) carrying bundles (of wood) or basins (of coal) on their heads or two-wheelers or carts ;
- Medium "vans or tarpaulin-covered": circuits that are often "informal", little controlled by the forest services, active within a radius of less than 100 km, particularly when the supply of wood energy is scattered;
- Medium "trucks": characteristic of a rather important demand for wood and an impoverishment of the soils closest to the city;
- Medium "Titan trucks": more formal, involving approved operators, mainly supplies Cotonou and over long distances (more than 200 km).

This sector is regulated by article 84 of the implementing decree[39]. Indeed, "Any person transporting wood, charcoal for commercial purposes by pirogue, boat, cart, car, truck, wagon, bicycle, animals or any other means is required to submit to controls of his load by Forest Administration agents.

The transportation of timber is mainly done with trailers or semi-trailers from logging sources. The same is true for service timber when the distance is long.

4.2.3.1.7 Actors involved in marketing of wood products

The decree implementing the forestry regime defines as trade in forest products any activity carried out for profit and relating to the purchase, sale, import and export of forest products (art. 13). Forest products are essentially defined as :

- wood for heating, charcoal and sawing ;

[37]TCHIWANOU, October 2000)
[38]Claudine SERRE DUHEM-FIREWOOD PROJECT PHASE II, 2007
[39](Benin/Forestry Regime Implementation Decree, 1996)

- wood intended for the manufacture of canoes, drumsticks, mortars, handles, bowls, stools and other carved or commonly used objects, made from protected or unprotected species.

The activity of marketing firewood or charcoal is normally subject to obtaining an approval. However, many actors operate in the most irregular manner, exposing themselves to sanctions.

The wood energy commercialization pathway can be described as follows.

Rural traders collect the products from the forests of the PGFTR (Forest and Riparian Land Management Project), ONAB (National Timber Office) and farms and transport them to wholesale traders. The latter (often with lorries), who therefore mainly obtain their supplies from production sources or on the roads, supply the semi-wholesale traders who ensure distribution to retailers. The retailers (mainly women), in turn, sell the products to households and other consumer actors (commercial and industrial production and service establishments)[40].

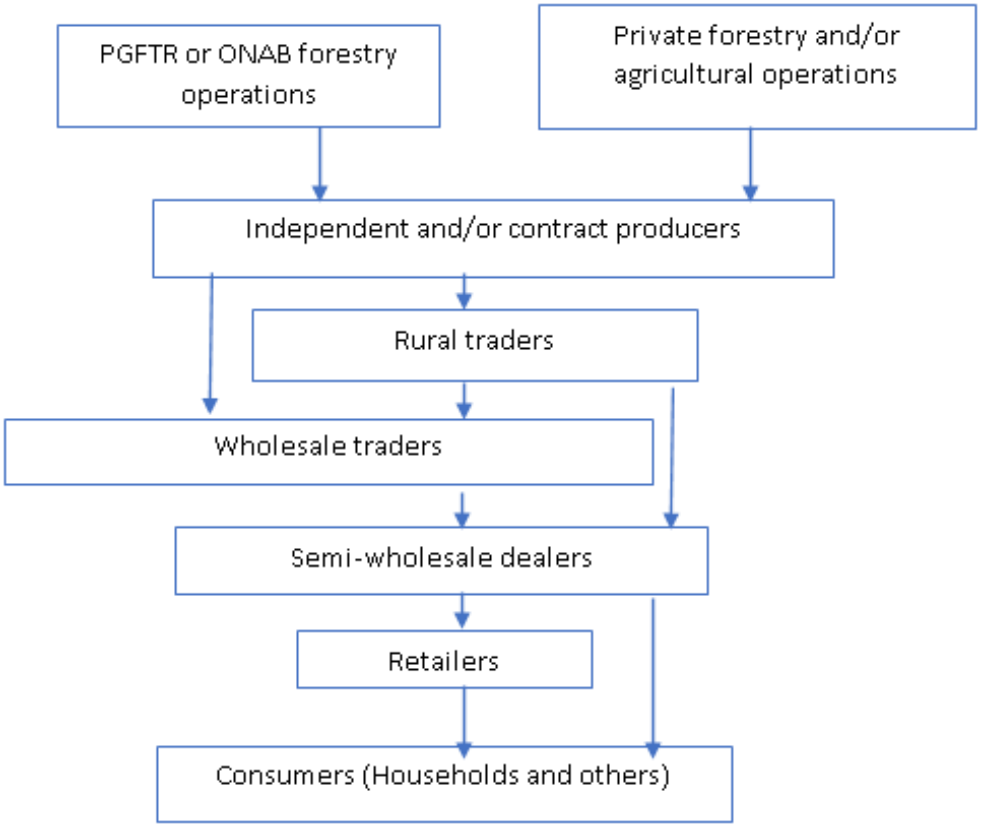


Figure 39: Diagram of stakeholders in the wood energy sector

The marketing of timber is mainly by export or import. In Benin, the General Directorate of Water, Forests and Hunting issues an opinion on the conformity of wood forest products to be exported, with the legal and technical prescriptions in force. The Autonomous Port of Cotonou (PAC) is the main exit point for timber outside the country.

In 2017, 88,373.5m^3 of wood were exported while in 2015, the volume of wood exports was 83,072m^3. The species *Tectonagrandis* is the most exported (50,436.2 m^3 in2017 against 54,046m^3 in 2015). Products were exported mainly in raw form (logs, logs and squared timber) in 2017, while in 2015,

[40](Ogoudedji Georges, 2007)

products processed to the second degree (parquet and friezes) accounted for more than 50% of exports[41].

With regard to the import of timber, it should be pointed out that until 2015, the issuance of special import permits for forest products was suspended. Consequently, there were no formally registered cases of timber imports in the year 2015[42]. However, it would appear that this suspension was to be lifted in 2017. However, this activity is subject to conditions (supporting documents, marking of the country of origin) that are difficult for wood users to comply with. As a result, cases of irregular wood imports were recorded (3,138.48m^3 of wood imported from Nigeria via the Kétou, Savè, Tchaourou, Nikki, Kalalé entry points) and were the subject of forest litigation[43].

Moreover, in Benin, timber is also processed into other local finished products such as mortars, canoes, tam-tams, stools, carved objects, etc., which are often marketed along the tracks. In this chain, the products are sold directly, usually by the manufacturers themselves.

[41](Directorate General of Water Forest and Hunting, February 2018).
[42](Directorate General of Forests and Natural Resources, December 2016).
[43](Directorate General of Water Forest and Hunting, February 2018).

Figure 40: Sale of tam-tams in Bohicon (Benin)[44]

Figure 41: Woodcarved armchairs by DanielliaOliveri in the Commune of Zagnando in Central Benin[45]

Figure 42: Mortar and pestle seller in Benin

As stated above, service wood is generally plantation wood. It is marketed either directly in plantations (wood cut on demand) or at sales points scattered throughout the cities.

4.2.3.1.8 Actors involved in wood consumption

Wood energy is consumed mainly by households and production and service units (bakeries, small food processing units, fish smoking, traditional hotels and restaurants, etc.).

If it is not exported, timber is processed on site into finished products such as chairs, armchairs, tables, cabinets, etc., which are sold on the streets. Other major industries such as ATC have showrooms for the display of their products. This furniture is consumed by households and services. Home-made products such as mortars, tam-tams and others are mainly consumed by nationals (family).

In Benin, service wood is used as poles in construction, frames, props for the construction of ceilings, scaffolding, to support electric wires "spider's web" supplying the neighbourhood with electricity, etc. or as electric poles for the Benin Electric Energy Company (SBEE).

4.2.3.1.9 Summary of key actors

Table 41: Main actors in the forest residue value chain

Category / component of the value chain	Key actors	Names of key actors	Location	Role played in the production of forest residues
Forest biomass sources	Forest owners, managers, etc.	Ministry of the Living Environment and Sustainable Development	National (especially in the Centre and North)	*Not known*

[44](Benin24TV/Benin 24TV/Valorization of Bohicon crafts: discovering Louis Lihui, 2020)

[45](Rémy HOUEHOUNHA/University of Abomey-Calavi (Benin) - Single Doctorate 2009, 2009)

(government, etc. private) Production/Management		(General Directorate of Water, Forests and Hunting) Local authorities (Municipalities) Individuals in cooperatives		
Harvest (Logging)	Forest Owners	National Wood Office (ONAB) Private plantation owners	National (especially in the Centre and North).	Harvesting of trees leaving wood residue on the harvest sites
	Forestry contractors	Forest operators Existing associations: Anub (National Association of Timber Users), Upb-Benin (Union of Timber Professionals of Benin), Acoprof, Adcppf, Udaebo and Anebr-Pr	*Not known*	Harvesting of trees leaving wood residue on the harvest sites
	Carriers	*Not known*	*Not known*	*Not known*
	Merchants, farms, wood/coal merchants	*Not known*	*Not known*	*Not known*
Primary Processes	e.g. Pulp mill owners	*Not known*	*Not known*	*Not known*
	Wood sawmillingcompanies	Beninese Wood Industry (BBI) (industry branch of ONAB)	Cotonou	Wood debarking
	Charcoalproducers	*Not known*	Zou(Djidja) Collines (Dassa, Savalou,Glazoué) -Donga (Djougou, Bassila)	Carbonization of wood generating waste such as dust or badly carbonised wood
Secondary Processes	Wood products and by-product processors and stores (e.g. furniture)	ATC Timber Industry Corporation (ATC-IB) Beninese Wood Industry (BWI)	-Sekou (Allada) -Cotonou	Transformation of wood into furniture generating Chips and Sawdust
	Local craftsmen	Sculptors, manufacturers of percussion instruments, mortars and canoes	Zou Department	Size of the wood resulting in small pieces of wood
End Consumers	Households Food processing units, Production units Services	HouseholdsProducers of "gari", peanut oil, red palm oil, etc. Street sellers	Department of Zou and the collines In all regions	Use of wood for cooking Coal ashes

4.2.3.1.10 Sources and types of forest biomass residue in Benin

In Benin, the main sources and types of forest biomass residues for the charcoal sector is comprised of dust, poorly charred wood, dust available after sorting before retail sale and dust available after sorting before charcoal consumption. For the fuelwood sector, biomass is derived from small branchs, small woods and sheets;

while for timber it comes from branches, twigs, bark, sheets, sawdust, shavings, bark, chips, used pallets and furniture bi-products at the end of the cycle. These main sources, where they are generated from and current use are presented in Tables 42,43 and 44 below

Table 42: Sources of forest biomass residues related to the charcoal sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	Charcoal residue (dust) Poorly charred wood	Charcoal production sites	Self-employed or contract coal miners	*Not known*
Distribution	Dust available after sorting before retail sale	Retailoutlets	Retailers	Sales to forges and vulcanizers ("gluers") Filling of holes to prevent water stagnation Rejection
Consumption	Dust available after sorting before coal consumption	Private homes Restaurants Seller on the street	Households and professional users such as restaurants	Disposal in the garbage Filling of holes to prevent water stagnation

Table 43: Sources of forest biomass residues related to the fuelwood sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Small branchs Sheets	Cutting sites	Lumberjacks	*Not known*
Distribution	Small woods	Retailoutlets	Retailers	Rejection
Consumption	Charcoal	Private homes School Restaurants and Canteens Artisanal bakeries Smoking of poisons Local breweries (''tchoucoutou'') Gari producers in the Zou, the Couffo, Collines Red palm oil or peanut oil producers	Households, food production and processing units	Reuse of coal produced Discharge of ashes

Table 44: Sources of forest biomass residues relative to the timber sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	branches twigs Bark Sheets	Cutting sites	Timber jacks	*Not known*
Secondary exploitation (woodprocessing)	Sawdust, shavings, bark	Sawmills	Furniture production units IBB-ONAB and ATC-IB	Chips used in animal husbandry Sawdust sold to housewives for combustion
	Chips	Joineries	Carpenters, Cabinet makers	Chips used in animal husbandry
	Bark, shavings	Craft stores	Sculptors of objects, manufacturers of tam-tams, mortar, dugout canoes, etc.	
Consumption	Used pallets	Warehouses, stores	Supermarkets	Sale with energy recovery
	Furniture at the end of the cycle	Houses, services	Households, service units	Disposal in the garbage Use as fuel

Benin is certainly not a "forestry" country, but it does have some forestry assets, mainly in the Center (Zou, Colines) and North (Borgou, Donga). Even if there is some waste produced both at farm level and in the large sawmills (IBB and ATC), it remains relatively low and is used for self-consumption by the populations or by the processing units themselves, according to local sources.

As regards wood energy, dust seems to be the only category of wood residues that is very little used and can be recovered for energy purposes. Mainly found in sale points and certain end consumers of charcoal, and constituting 15% to 20% of the mass of charcoal contained in a bag (own studies), this waste can indeed constitute important deposits, although rather scattered but concentrated in large cities such as Cotonou or Porto Novo. An initial approach recently carried out by the GIZ to consider the recovery of this waste in an organized manner, in the form of mixed waste briquettes, had concluded that it was not economically feasible to recover these materials, as they are fairly scattered geographically and in small quantities; moreover, in some cases they have a market value. Given the rather limited data available, the quantitative, qualitative and logistical aspects should be studied more closely to better assess the profitability of the operation.

For timber, the second largest exporter behind Côte d'Ivoire among the six countries in the study (see Image 45 in the West African Context report), Benin is reportedly the second largest exporter of timber, according to the sources: (i) in 2000, five large industrial wood processing units approved, especially for teak, which they export exclusively, the most sophisticated of which is the BWI-ONAB; and (ii) in 2015, only two large industrial units, including those of BWI-ONAB and ATC-IB. In fact, the volumes of wood exported by Benin are in clear decline, as can be interpreted in Table 45 below. It should also be noted that Benin's export statistics are influenced by products coming from neighbouring Nigeria, which choose the port of Cotonou as an exit route for exports. The weight of this component, which should be removed from the export balance sheet of national sawmills, could not be determined. In any case, Benin's sawmills certainly produce large volumes of waste products, such as

sawdust and wood chips, which would deserve to be quantified with a view to studying their potential for energy recovery. However, it has been reported that the volumes currently not recovered are very small or even non-existent, as the populations have already established recovery channels (in animal litter and biomass energy). The same would be true for sawmills and artisanal carpentry stores. Until now, it has not been possible to contact these industrial actors to confirm these, despite the intermediation of our partner the Designated National Entity.

Table 45: Timber exports to Benin (in tonnes)

Type	HS Code	2015	2016	2017	2018	% weight of AO6 (2018)
Raw wood (logs)	4403	189 614	196 555	63 872	48 668	35,0%
Planksth>6mm	4407	80 039	27 516	53 526	25 255	13,2%
Firewood	4401	59	1	-	26	3,0%
Vegetable coal	4402	1 701	274	638	452	5,1%
Profiled wood	4409	781	493	963	313	9,8%
Plywood, densified wood and veneer sheets	4408, 4411, 4412 and 4413	18	319	253	42	0,0%
Others	4404, 4405, 4406, 4410	-	4	20	44	12,2%
Total		272 212	225 162	119 271	74 799	14,9%

Source: (UN Comtrade)

For service wood, most of *the* exploitation is based on teak plantations, whether state-owned by ONAB or privately owned, but there are reportedly no processing units in the country. It is therefore difficult to envisage the recovery of residues within this sector, as any waste from logging remains very scattered.

Finally, given that (i) a teak plantation can produce, depending on the area of production, from 05 to 16 m^3/ha/year of wood from thinnings and (ii) that it will generally have three to six thinnings spaced three to 12 years apart, an energy exploitation of this deposit could have been studied according to the national potential; however, it is very likely that it is already used as service wood: poles or posts. It would be necessary to establish fluid contact with ONAB to confirm or disprove this theory.

However, it is useful to look at other resources that are abundant in Benin without straying far from the forest that forms the basis of the study. For example, we can consider the cashew nut and shea nut commodity chains, whose products can benefit from special attention for the following reasons: (i) they are products of tree massifs similar to planted forests, even if the main product of interest is not woody, (ii) Benin is a major producer for these two chains, (iii) the waste from these products (cashew and shea nut shells, shea cake) could be recovered.

Cashew nutchain[46]

In Benin, cashew nuts are the2nd export product after cotton (the country's flagship crop). It contributes 3% of GDP, is one of the three high value-added sectors selected by the Government's Action Programme (GAP), and as such benefits from massive State investment. The areas or zones favourable for cashew nut production cover an area of about 9,763,836 ha in Benin. Nevertheless, the area sown in 2018 was 285,000 hectares with an average yield of between 300 and 400 kg/ha. Its production employs 200,000 people. In Benin, the production areas are grouped into four groups as shown in the figure below.

[46](Dr. Kassimou ISSAKA/CASHEW DEVELOPMENT AGENCY/BENIN REPUBLIC, January 2019)

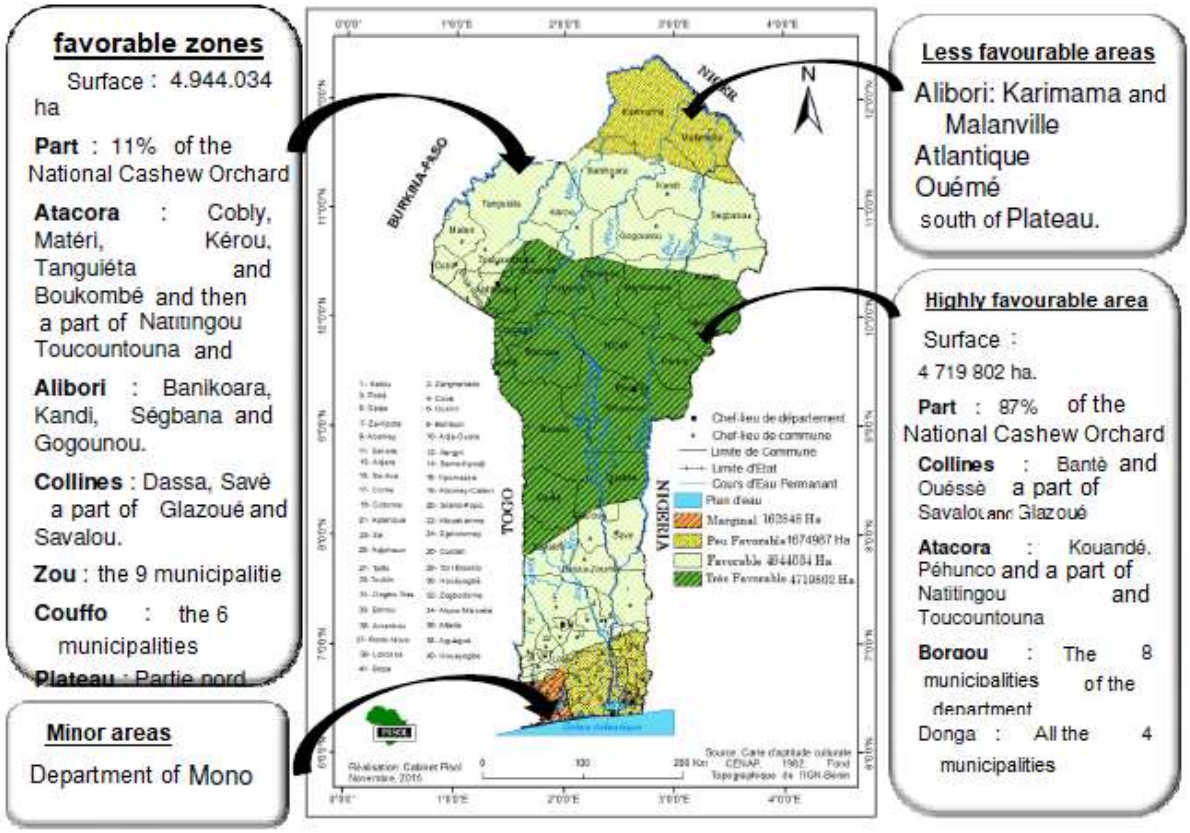


Figure 43: Cashew nut production areas in Benin[47]

Benin's cashew production was 140,000 tonnes in 2018 with a target of 171,000 tonnes in 2019. There are about ten (eight according to sources) processing units installed with a total capacity of 31,500 tonnes in 2018. The two largest plants are those of TOLARO SA in Parakou (Borgou department) and FLUDOR S. A in Bohicon (department of Zou).

4.2.3.1.11 Estimated amount of cashew waste available in Benin

It is possible to determine the quantity of cashew nut shells available and eligible for a recovery project from the total quantity of nuts processed in the country. For this purpose, the following elements will be considered:

- the year 2018, during which 31 500 tonnes were processed;
- the percentage by mass of the hull being 70%, i.e. 22 050 tonnes of hulls;
- units using on average only 20% of the hulls for their energy needs (XXXXXX); consequently, 80% will remain unrecovered by these units.

Thus, the quantity of hulls available and recoverable is estimated at approximately 17,640 tonnes of hulls based on the year 2018. According to forecasts, 300,000 tonnes would be expected by 2021 by the Government, with 50% local processing. This bodes well for the future of the cashew sector in Benin and, consequently, for the sustainability of cashew shell development projects in the country.

[47](Dr. Kassimou ISSAKA/CASHEW DEVELOPMENT AGENCY/BENIN REPUBLIC, January 2019)

4.2.3.1.12 Shea butter chain

It is very difficult to find documentation on the shea industry in Benin, even though the country is a major producer. This could be explained by the non-organization of the sector and its quasi-informal nature. There would be small processing units but no mention of large processing industries. There is, however, a recently created umbrella organization, AKBEN (Association karitéBénin).

The shea tree (*vitellaria paradoxa*) grows wild in the dry forests and fallow lands of the northern half of the country, stopping approximately at Parakou. It is not cultivated but is a species preserved by the populations because of the interest of the products it provides, in particular nuts containing a fatty substance, which can be used in food and cosmetics, called shea butter.

The following information has been taken from the sites of public bodies, but it is to be taken with caution. Unlike cashew nuts or even pineapple, shea is not included among the priority sectors of the Government's Action Programme. But it remains an important agricultural product, given the number of people it employs and its increasingly important share in Benin's trade balance (Presidency of the Republic of Benin, 2013). Shea is the country's third largest export product after cotton and cashew nuts. It grows in three large basins, one in the centre of the country and two in the northern part of the country (the area with the highest shea potential is the Alibori). Its contribution to the GDP is 1.23%.

It is estimated that more than 500,000 rural women live directly off the shea tree. The production of shea encompasses more than 20 municipalities whose populations are involved in the marketing of shea kernels and the processing of the kernels into butter. Benin is currently the third largest producer of shea kernels in West Africa after Mali, Burkina Faso and Nigeria, with average annual export volumes of about 30,000 tonnes of dry almonds. As for what remains to be processed in the country, around 13,108 tonnes of shea kernels are marketed locally and generate a total added value of about 3.4 billion CFA (Prudencio, 2018) francs in the Beninese economy.

According to the N'Kalô service in Nitidæ, between 2014 and 2019, approximately 110,435 tonnes of shea kernels, processed or not, were exported from Benin (of which 101 558 tonnes were exported as whole kernels and 8,877 tonnes were processed into butter representing 3,551 tonnes of butter).

Knowing that a given quantity of almonds processed into butter produces up to 50% cake, it can be estimated that over this period the production of butter for export generated a theoretical cumulative total of approximately 4,450 tonnes of cake. Assuming that the processing units use up to 30% of this cake (1,330 tonnes), we can estimate that 3,100 tonnes of cake waste can be potentially recovered over the five-year period from 2015 to 2019. However, a major difficulty in envisaging the recovery of these residues is their real accessibility because the processing centers remain very artisanal and therefore scattered in addition to the poorly counted. In this context, all these estimates remain speculation and therefore need to be confirmed.

To sum up, Benin is a country, which by its geographical position should be a wood-producing country. This is not the case. It is true that there are some exploited forest resources, but this is still much lower than in Central African countries. However, the exploitation of these forest resources (production, processing & marketing) generates residues but these are already valued either by the processing units themselves (ATC and IBB) or by the populations for their own consumption. As a result, the potentially valuable forest residues remain very small or even insignificant. That said, by looking at other forest-related pathways, it is possible to find recoverable residues.

Thus, the cashew and shea butter sectors have attracted our attention in Benin. Even though these two chains represent important export products in the country, the first seems to be better organized, especially since it benefits from state investment. Analyses have shown that the sector generates a significant amount of recoverable waste, particularly cashew nut shells, estimated at more than 17,000 tonnes in 2018. It is therefore possible to envisage the feasibility of recovering energy from these shells at the present time. However, it should

be pointed out that this waste is currently the subject of attention and, consequently, it is not impossible that there will be projects for its recovery in the coming years. One example is the project that Fludor Benin is announcing for the recovery of its cashew hull meal (Prudencio, 2018), or the project for the energy recovery of the hull for the benefit of Tolaro (Kerekou, 2020). Concerning the shea industry, information is difficult to find and remains very speculative. It would therefore be complicated to guarantee the reliability of this data. In addition, the majority of processing units are artisanal. Due to the low availability of accurate data, it is difficult to recommend the feasibility of recovering waste (cake) from shea processing units in Benin.

4.2.3.1.13 General Conclusion

Benin is characterized by a climate of the Sudano-Guinean type that is contrasted from north to south and is oriented towards the Atlantic Ocean in the south. It includes modified natural or semi-natural forests as well as forest plantations according to FAO definitions. Representing a total area of about 7.8 million hectares in 2007, i.e. 68% of the national territory, Benin's forest cover is mainly composed of wooded savannah with shrubs, less open forests and wooded savannah and, to a lesser extent, gallery or dense forests and plantations for forestry or agriculture.

Very heavily used by the Beninese population, wood energy accounted for 93% of final household energy consumption in 2015. The country would theoretically have a deficit in wood energy, i.e. 3.4 million tonnes of wood equivalent in 2007, taking into account (i) the forest productivity of all forest areas, excluding plantations, but including fallow land and (ii) the national demand for firewood and charcoal for domestic and professional use.

With a view to increasing the country's energy supply, one of the most appropriate solutions could be the use of forest biomass residues generated by the wood energy, timber/service wood and non-timber forest products sectors.

As regards the wood energy value chain, a valorisation of charcoal dust could possibly be envisaged. However, availability has been limited and at present further studies are needed to assess the resource in a comprehensive way.

Although Benin ranks second among the six West African countries under study in terms of volume of timber exported, its size relative to Côte d'Ivoire remains very modest (about one-fifth of timber exports relative to Côte d'Ivoire in 2018). Roundwood and service wood sector actors have seen their numbers and volumes of wood exported gradually decrease; it will therefore be crucial to obtain more first-hand data from existing industrial actors (IBB-ONAB and ATC-IB), which has not been possible for the moment. Teak wood from plantation thinnings would also be an interesting source, but no information could be extracted at this level; and it would not be uncommon to find that these trunks are already being used for service wood.

As far as NTFPs are concerned, the cashew nut sector, the country's second most promising export product after cotton, seems to be the most promising with a relatively developed industrialization with a dozen cashew nut processing units for a total capacity of 31,500 tons in 2018. The total potential of recoverable waste in these plants can indeed be estimated at more than 17,500 tonnes for this year.

Despite shea is Benin's third largest export product, this sector is not very recommendable in terms of waste recovery. Indeed, the processing of almonds into shea butter would only take place in small, mostly informal artisanal units, whose cakes would be difficult to collect because of the wide geographical dispersion of these units, not to mention the fact that local use as fuel cannot be ruled out. Also, although the quantity of shea nut shells generated should be much greater than that of the cake, the context for collecting these residues seems even more unfavourable, since the nut producers operating the shelling process are even more scattered than the processors.

In such a situation that the shea tree is the oil palm sector. In fact, no centralized activity of pressing and transformation of the fruits of the palm tree was reported to us, which makes the collection of waste very complicated.

Finally, although it is not a "forestry" sector, it should be noted that cotton stalks could be considered as a source of biomass energy, given the country's specialization in this agricultural value chain.

4.2.3.2. Case of Burkina Faso

4.2.3.2.1 Forest resources in Burkina Faso

Burkina Faso is essentially covered by shrubby savannah (37% of the territory). In 2002, all forest formations (open forest, gallery forest, shrubby savannah, steppes) occupied 16,647,000 ha, i.e. 61.75% of the national territory (FAO, 2020). These areas, classified by the FAO system as forests and other wooded land, are divided into 6,216,400 ha of forest (mainly dense wooded savannah, forest plantations and orchards and gallery forest); and 10,430,600 ha of other wooded land (open wooded savannah, shrubby savannah and steppes).

Burkina Faso's Forest Code[48] categorizes the forest estate. Indeed, under Article 9, "the forest estate includes public forests and private forests". Within the meaning of the Code (article 10), forests are land covered by plant formations of trees or shrubs and grasses, excluding those resulting from agricultural activities. Public forests are divided between the State and the territorial collectivities (Art. 15) while private forests are the property of natural persons or legal entities under private law who are owners when they have legally acquired them or have legally planted them (Art. 31). Public forests are therefore those belonging to legal persons governed by public law; they may be classified or protected.

23% of the national territory is made up of forests (Table 46), and these include productive tree plantations, otherwise known as production forests (wood, fruit and other NTFPs). Although the area of planted forest is very small (0.5% of the total national territory), it has increased by 44% in ten years, mainly through the planting of productive trees (mango, cashew tree) and is the only category of forest that is increasing, with naturally regenerated forest having decreased by 8% in ten years (through conversion of these forests into wooded savannahs and farms) - see Table 46. Indeed, according to the FRA 2020 country report, "The increase in area in this class reflects the enthusiasm of stakeholders for reforestation following numerous awareness campaigns. To this end, various programmes aimed to promote planting and enhancing the value of cashew tree fruits have made it possible to increase the areas planted".

According to the Directorate General of Nature Conservation (Direction of Forests, 2007), between 1990 and 2010, Burkina Faso lost an average of 59,900 ha of forest formations, or 0.87% per year. In total, between 1990 and 2010, Burkina Faso lost 17.5% of its forest cover, i.e. about 1,198,000 ha.

Table 46: Evolution of forest area from 1992 to 2020 in Burkina Faso

Forest Type	LUD 1992	LUD 2012	FAO 2015	FAO 2020	% surface 2020
Forest	7 616 585	6 616 456	6 466 400	6 216 400	23%
Other wooded land	7 982 886	9 714 100	9 982 800	10 430 600	38%
Total wooded areas	**15 599 471**	**16 330 556**	**16 449 200**	**16 647 000**	**61%**

Source: FAO, 2020

Source: Adapted from (FAO, 2020)

[48] (National REDD+ Technical Secretariat, May 2019)

Table 47: Evolution of natural and planted forests in Burkina Faso

	2000	2010	2015	2020	5-year evolution (2015-2020)	10-year evolution (2010-2020)
Naturally regenerated forest	7 148 200	6 593 800	6 316 600	6 039 300	-4%	-8%
Planted Forest	68 300	122 600	149 900	177 100	18%	44%
• of which plantation forest	3 400	6 100	7 500	8 900	19%	46%
• of which other planted forest	64 900	116 500	142 400	168 200	18%	44%

Source: FAO, 2020

In terms of the spatial distribution of forest areas, the Center and North of the country are characterized by a low level of vegetation cover; the most forested areas are in the West, Center - West and East of the country (Figure 43).

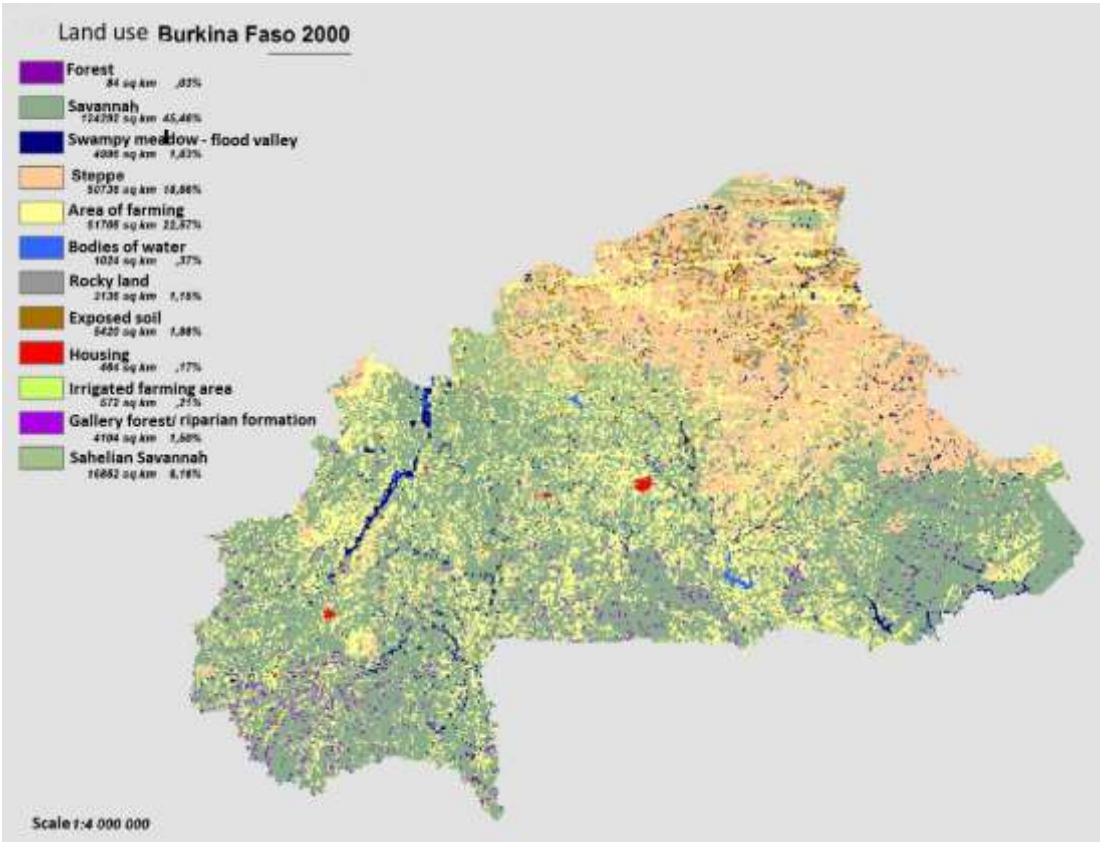


Figure 44: Land use in 2000
Source: ICDCS, 2015

4.2.3.2.2 Wood energy supply/demand

In its study aimed to identify the main drivers of deforestation and forest degradation in Burkina Faso[49], REDD+ assessed the supply and demand for wood energy. This study reveals that the demand for wood energy is mainly met by natural forest formations, whether developed or not, and that the contribution of plantations is marginal (0.5% of wood production in Burkina Faso in 1999). This study, based on the second National Forest Inventory

[49] (National REDD+ Technical Secretariat, May 2019)

(NFI 2 - 2017), indicates that the total volume of live trees with a diameter greater than or equal to 5 cm (D1, 30 m ≥ 5 cm), is estimated at a national level at 467.9 million m^3 , or 374.32 million tons. The volume of potentially exploitable firewood is estimated at 207 million m or 165.6 million tons.

The demand for wood energy is estimated at 8.3 million tonnes in 2018, equivalent to 10.375 million m3. It is broken down as follows: 3.4 million tonnes (4.25 million m^3) for urban areas and 4.9 million tonnes (6.125 million m^3) for rural areas. The report points out that in 2012, Burkina Faso's demand for wood energy was estimated at 6.880 million tonnes of wood (FAO, 2012).

In 2018, the balance between supply (165.6 million tonnes) and demand (8.3 million tonnes) for wood energy was therefore largely positive, with standing dead wood alone covering about 88% of wood energy needs. In fact, the total volume of dead wood at the national level was estimated at 9.1 million m^3, i.e. about 7.28 million tonnes, mainly located in the following regions: East, Boucle du Mouhoun, Hauts-Bassins, Cascades and South-West.

However, the study points out that in reality, the supply-demand balance for wood energy indicated above is very mixed, as corrective factors, including accessibility, local use and the size of the wood, can considerably reduce the quantities available. So the actual availability or possible drawdown can tip the balance in the other direction.

4.2.3.2.3 Forest value chain in Burkina Faso

4.2.3.2.3.1 Forest management and conservation value chain

The State forest estate is managed by the State forest services. The State's forest services are thus the guarantors of the preservation of forest resources considered to be part of the national heritage. One of these services is the General Directorate of Water and Forestry of the Ministry of the Environment, Green Economy and Climate Change. This directorate is in charge, among other things, of the protection of forest resources, the organization and control of exploitation and the marketing of forest products of plant origin. As for the management of local government forests, it is carried out by the latter through management structures based on partnership (Art.38). Lastly, private forests are managed freely by their owners, subject to declarations of exploitation and any restrictions imposed for the preservation of the natural environment (Art. 32).

4.2.3.2.3.2 Forest exploitation /harvesting actors

Article 52 of the Code states that logging may be carried out for domestic, commercial, industrial, scientific, educational and cultural purposes. With regard to domestic logging, the Code specifies that it is carried out in the form of traditional use rights to gather (ripe fruit), collect (dead wood lying on the ground), take or extract (Art. 53). This right is recognized in classified and protected forests to the riparian populations. It is therefore a question here of self-consumption limited to the satisfaction of the personal, individual or family needs of the users. This right is granted free of charge and without permit.

4.2.3.2.3.3 Exploitation and processing of wood energy

Exploitation of wood energy

The main product exploited in classified developed forests is fuelwood. The wood energy sector employs hundreds of thousands of private actors in the following links: debtors/producers, wholesalers/transporters and retail traders. There were 1,117 fuelwood wholesaler-transporters and 2,210 fuelwood retailers in 2011[50].

[50] (Forest Investment Program) (PIF)/Ministry of the Environment and Sustainable Development, 15 May 2011)

Wood energy processing[51]

The REDD+ report reveals that the current situation of the charcoal "sector" is more worrying than it was in 2005. At that time, there were 128 charcoal sites identified. At that time, the government had to take a series of measures to reorganize and better control the sector. Among these measures was the designation of charcoal production sites. Thus, 54 production sites had been authorized in 2006 in nine (9) regions: South-West, Cascades, Hauts-Bassins, Boucle du Mouhoun, Center-West, Center-South, Center-East, Central Plateau and East. In 2008, the number of authorized sites was revised downwards (38) and the Central Plateau region was excluded from the production zones. The carbonization zones in 2018 are shown in the following figure.

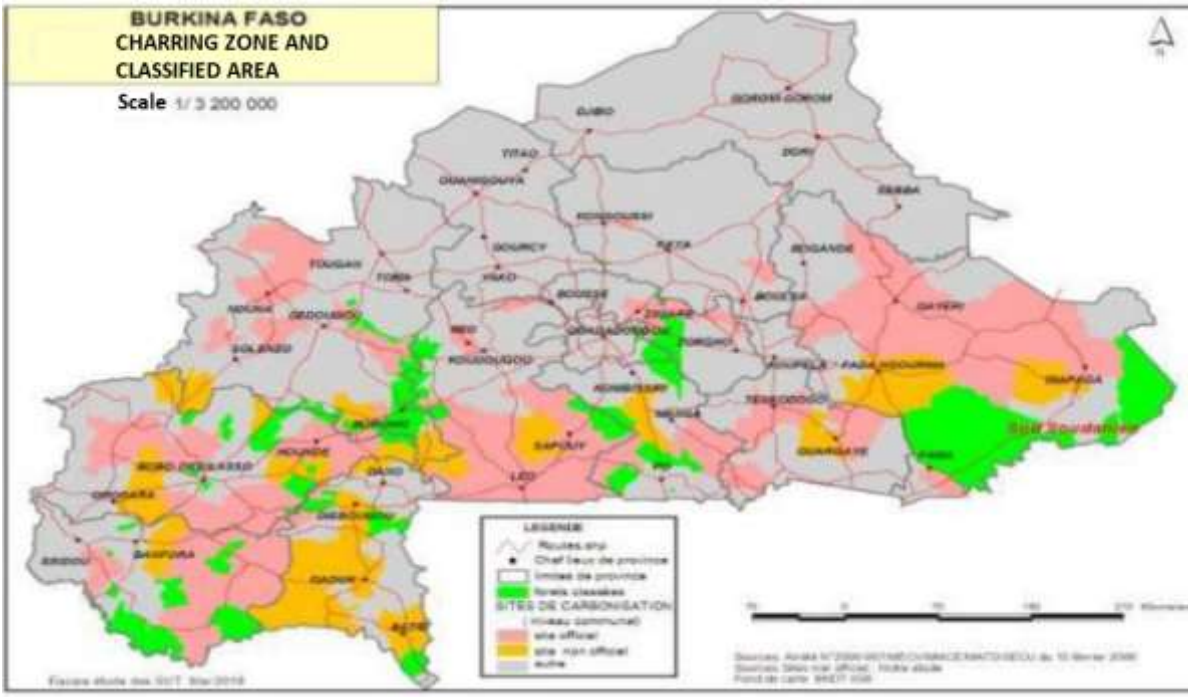


Figure 45: Location of carbonization sites[52]

According to the figure, it can be seen that the carbonization activity takes place in an official way (pink zone) mainly in the regions of the Waterfalls, the Upper Basins, the Center-West and the East. This activity is carried out by professional and occasional charcoal burners. However, a multitude of unofficial sites (in orange) can be seen.

4.2.3.2.3.4 Exploitation and timber processing

A total of 11,107 forest operators (developed forests) had been identified in Burkina Faso, including timber operators in 2011[53]. Burkina Faso is not a major timber producer. However, two small sawmills, notably the industrial wood enterprise of Faso -Faso Yiiri and the Coulibaly sawmill, established in 1965 and 1984 respectively in Banfora, Comoé Province, mainly exploit Khaya senegalensis (cauliflower) species, *Afzelia africana (lingual), Pterocarpus erinaceus, Diospyros mespiliformis, Dianiellia oliveri, Isoberlinia doka, Anogeissusleiocarpus, Milicia excelsa (Iroko)* with a diameter of at least 50 cm (World Bank, 2011).

[51] (National REDD+ Technical Secretariat, May 2019)
[52] (National REDD+ Technical Secretariat, May 2019)
[53] (Forest Investment Program) (PIF)/Ministry of the Environment and Sustainable Development, 15 May 2011)

The Coulibaly Sawmill employs 30 people while the Faso Yiiri Company employs 70 (World Bank, 2010). The production of these units had reached 8,347 m^3 in 1997. However, this production dropped to 3,994 m^3 in 2003 due to the progressive rarefaction of trees that have reached the minimum size required by the laws in force. Nevertheless, this deficit had been compensated by the importation of raw material and finished seed products from neighbouring countries (World Bank, 2010). The sawmill is still in operation in 2020, despite having recently been forced to close down by the Water and Forestry authorities, due to non-compliance with the levy quotas.

4.2.3.2.3.5 Logging and processing of service wood

The supply of service wood to cities comes from natural formations in developed and undeveloped areas. More and more they come from the reforestation sites of Gonsé, Wayen, Dagouma, Dindéresso, Maro (World Bank, 2010). Plantation eucalyptus is one of the species mainly used as service wood for construction sites.

Figure 46: Different service woods in a construction site in Bobo-Dioulasso

4.2.3.2.3.6 Transportation / logging operators

In Burkina, there are several means of transporting firewood and charcoal. According to a study on the pricing of fuelwood in Burkina Faso, the means of transport of fuelwood are marked. This consists of painting all means of transport for fuelwood in green-white to specify them and thus identify them more easily. Consequently, any unmarked means of transport is excluded from the transport of wood energy (Ouedraogo, Tarification du bois-énergie au Burkina Faso : la problématique de l'internalisation des coûts sociaux liés à l'exploitation de l'énergie ligneuse., 2015).

Figure 47: Loading a truck with firewood at the village of Nimnilaye, in the Silly-Pouni-Zawara logging site

Source: (Ouedraogo, Filière bois d'énergie burkinabé : structuration des prix et analyse de la répartition des bénéfices, 2007)

Figure 48: A truck loaded with 30 steres of wood in the Silly-Pouni-Zawara logging yared in Nimnilaye

Source: (Ouedraogo, Filière bois d'énergie burkinabé : structuration des prix et analyse de la répartition des bénéfices, 2007)

However, there are means of transport that do not comply with this marking and transport wood energy. These include: two-wheeled vehicles, private vehicles, fuel tanks, public transport, carts (pulled by donkey(s)), tricycles and even pedestrians.

Figure 49: A tricycle carrying wood towards Bobo

Source: Author

Figure 50: A wholesale carrier from the Silly-Pouni-Zawara yard

Source: (Ouedraogo, Filière bois d'énergie burkinabé : structuration des prix et analyse de la répartition des bénéfices, 2007)

The transportation of timber is mainly done with trailers or semi-trailers from logging sources. The same applies to service timber when the distance is long.

4.2.3.2.3.7 Merchants and consumers

Traders: Traders-wholesalers and traders-retailers of wood energy (firewood and charcoal) have organised themselves into socio-professional associations. The most important are located in :

- Ouagadougou: The "Tiis la Viim" and "Kogl-Wéogo" Associations operate with more than 2000 members;
- Bobo-Dioulasso: The Union of Wood and Charcoal Operators (UNIBOC) has more than 1000 members;

- Koudougou: The Association of Wood Wholesalers-Transporters and Retailers has about 100 members;
- Kaya: The Association of Wholesalers-Transporters and Traders-Retailers of Wood of Kaya has about twenty members (World Bank, 2010).

Consumers: Households remain by far the biggest consumers of biomass energy: they use 83% of the biomass energy consumed in Burkina Faso for cooking meals and medicines, heating water and houses and ironing. After households come:

- Economic units such as traditional breweries (dolo), restaurants, meat and fish grillers and smokers, craftsmen (blacksmiths, bronze and aluminium smelters, pottery, ironing, etc.), bakeries, butter and soumbala preparation, etc. The study on energy in Burkina Faso in 2009 estimated the consumption of economic units at 17%. In 2016, this consumption represented 4.6% for firewood and 3.5% for charcoal;
- Collective or community households or institutional households or special households such as boarding schools, barracks, prisons, health centers, school canteens, etc. These types of biomass energy consumers are rarely included in consumption surveys. Their consumption is estimated at between 0.8% and 0.1% respectively for firewood and charcoal according to one study.

The annual consumption of timber in 2011 was around 25,000 m^3, 93% of which is imported from neighbouring countries, and only 7% available locally[54]. This wood (mainly from secondary processing) is consumed by carpenters and cabinetmakers for the production of furniture (tables, chairs, armchairs, etc.) for the local market. As for the service wood is made up of stakes, poles, posts used in construction (World Bank, 2010).

4.2.3.2.3.8 Summary of key actors

Table 48: Main actors in the forest residue value chain

Category/component of the value chain	Key actors	Names of key actors (provide specific names of the actors as far as possible)	Location (please provide locations where they operate and generate waste)	Role played in the production of forest residues
Forest biomass sources (government, etc. private) Production/Management	Forest owners, managers, etc.	- The State Forestry Services (General Directorate of Water and Forestry of the Ministry of Environment, Green Economy and Climate Change), - Local authorities, - Private forest owners.		U/D
Harvest (Logging)	e.g. Forest owners (specify for big owners)	- Private plantation owners		Harvesting of trees leaving wood residue on harvesting sites
	Forestry contractors	timber growers	U/D	Harvesting of trees leaving wood residue on harvesting sites
	transporters	U/D	U/D	U/D
	Merchants, farms, wood/coal merchants	U/D	U/D	U/D
Primary Processes	e.g. Pulp mill owners	N/C	N/C	U/D
	Wood saw milling companies	U/D	U/D	Ecorçage du bois

[54] (Forest Investment Program) (PIF)/Ministry of the Environment and Sustainable Development, 15 May 2011)

	Wood and charcoal producers	- Association "Tiis la Viim" and "Kogl-Wéogo" in Ouaga. -UNIBOC in Bobo. -Association of Wood Wholesalers-Transporters and Retailers in Koudougou. -Association of Wholesalers-Transporters and Retailers of Timber in Koudougou. –Détaillants de bois de Kaya	- Southwest, - Waterfalls, -High Basins, -Boucle du Mouhoun, - Center West, -South-central, -Center-East	Carbonization of wood generating waste such as dust or badly carbonised wood
Secondary Processes	Wood products and by-product processors and factories (e.g. furniture)	- Industrial wood enterprise of Faso (Faso Yiiri) - Coulibaly Sawmill	-Banfora	Transformation of wood into furniture generating Chips and Sawdust
	Local craftsmen	Sculptors, manufacturers of tam-tams, mortars, dugout canoes, etc.	U/D	Wood cutting resulting in small pieces of wood
Consumer	- Households -Food processing units, - Production units - Services	- Traditional breweries (dolo), restaurants, meat and fish grills and smokers, etc.	In all regions	Use of wood for cooking Coal Ashes

***U/D : Unknown Data**

4.2.3.2.3.9 Sources and types of forest biomass residues in Burkina Faso

Table 49: Sources of forest biomass residues related to the "Charcoal" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	- Charcoal residue (dust) - Poorly charred wood	Charcoal production sites	Self-employed or contract coal miners	NC
Distribution	Dust available after sorting before retail sale	Retail outlets	Retailers	- Sale to blacksmiths - Filling of holes to prevent water stagnation - Rejection
Consumption	Dust available after sorting before coal consumption	- Private homes -Restaurants -Seller on the street…	Households and professional users such as restaurants	- Disposal in the garbage - Filling of holes to prevent water stagnation

Table 50: Source of forest biomass residues related to the "fuelwood" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	- twigs - leaves	Cutting sites	Lumberjacks	U/D
Distribution	- Small woods	Retail outlets	Retailers	- Reject

Consumption	- Charcoal - Ashes	- Private homes - School Restaurants and Canteens - craft bakeries - Smoking of poisons - Local breweries (''dolo'') - Etc.	Households, food production and processing units	- Reuse of coal produced - Discharge of ashes

Table 51: Sources of forest biomass residues related to the "Timber and service" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	- Branchs - Twigs - Bark - Leaves	Cutting sites	Lumberjacks	UD
Secondary exploitation (wood processing)	Sawdust, shavings, bark	Sawmills	Furniture production units	- Chips used in breeding - Sawdust sold to housewives for combustion
	Chips	Millwork	Carpenters, Cabinet Makers	- Chips used in breeding
	Bark, shavings	Craft Stores	Sculptors of objects, manufacturers of tam-tams, mortar, dugout canoes, etc.	
Consumption	Used pallets	Warehouses, stores	Supermarket,	Sale at retrieval
	End-of-cycle furniture	Houses, services	Households, service units	- Disposal in the garbage -Use as fuel

In conclusion Burkina Faso is a Sahelian country with fairly limited forest resources. On the other hand, biomass (wood, charcoal and agricultural residues) plays a central role in the life of the population, as it represents the largest part (77% in 2017) of energy consumption (19% oil products, 4% electricity) (WAEMU, 2018). The marketing of wood products is dominated by the wood-energy sector, mainly firewood, which accounts for 85% of the total GDP of all marketed wood products. This sector is followed by service wood (12%) and timber (3%)[55].

Wood energy is also the main source of energy for the population, especially households. Most of this wood consumption takes place in rural areas; and with a population of about 70% rural, this gives an idea of the importance of this resource for this country and in particular for its population. It is moreover this predominance of traditional energy sources, consisting mainly of wood fuels, that has led to the development of forests. Thus, one of the objectives of the “Chantiers d'Aménagement Forestier (CAF)” is the sustained production of wood (especially wood energy) and other forest products. Today, about 600,000 ha of natural, classified or protected forests are being developed and managed in a participatory manner by the State, local authorities and riparian communities organized in Forest Management Groups (GGF) with their APEX organizations. These CAFs are intended to supply large cities such as Ouagadougou, Bobo Dioulasso, Koudougou with firewood[56].

[55](Forest Investment Program) (PIF)/Ministry of the Environment and Sustainable Development, 15 May 2011)
[56](National REDD+ Technical Secretariat, May 2019)

Fuelwood sector in Burkina Faso is managed by five categories of actors --the State, producers, traders (who are responsible for supplying urban centers with fuelwood), debtors (who put the wood brought from logging sites into a form that can be used by households at home) and consumers.

The charcoal sector is similarly organized. State-accredited producers and wholesale traders are responsible for transporting charcoal from production sites to consumption centers. While the CAFs should make it possible to obtain or even quantify logging residues after the felling of fuelwood, this remains problematic for various reasons. While it is true that the CAFs should make it possible to obtain or even quantify logging residues after the cut for fuelwood, this remains problematic for various reasons.

The first is related to the current management of these CAFs. In fact, since the early 2000s, the Ministry in charge of the environment has granted the management of CAFs to the Unions of Forest Management Groups (UGGF) considered as concessionaires. However, today, this management is based on essential bases that have become obsolete: expired development plans, obsolete concession contracts, etc. Also, in some cases, such as in the Tiogo or Maro CAF, management under the responsibility of the forest administration through the PDEEVC [57] of Sanguié or the National Office of Protected Areas has alienated the members of the GGFs who do not feel responsible for the proper functioning of the CAFs, resulting in poor exploitation of the resource. In other cases, however, such as the CAFs of Cassou and Bougnounou-Nébielianayou, current management by the GGFs has shown technical and organizational shortcomings, including the weak capacity of the GGFs in the management of the forest massifs and the lack of support, particularly financial support from the forest administration to the GGFs[58].

The second reason is a question of community survival. Indeed, the creation of CAFs has probably led to the settlement of rural populations in the surrounding area in addition to those already present. With these populations for whom the use of wood residues for self-consumption remains a necessity, it would be almost impossible to find ways to valorise such residues. As far as the timber industry is concerned, the situation is not much better. Annual timber consumption is around 25,000 m^3, 93% of which is imported from neighbouring countries and only 7% available locally[59]. In addition, there are only two formally approved wood processing units. The sources we consulted report that their residues are already valued by the populations. It would therefore also be difficult to find residues available in this sector.

The service wood sector mainly generates waste at the production sites. However, these residues are used by the population for their own consumption. Consequently, and considering all of the above, we can say that potentially valuable forest residues in the wood value chain remain very low, if not insignificant, in Burkina Faso.

However, the country does exploit the fruits of trees that were originally introduced as reforestation trees. These include cashew trees and shea butter, for example. Even if it is not possible to look into the potential recovery of wood from these trees because they are already exploited by the population, there is still waste that can be recovered from the fruits. These two sectors will therefore be the subject of particular attention in the rest of this study.

4.2.3.2.3.10 The cashew nut industry in Burkina Faso

The cashew tree was introduced to Burkina Faso in 1950 as a reforestation tree but started to be considered as an interesting fruit plant in 1980. Since then, it has come a long way to be the third most important agricultural export product today, after cotton and sesame.

[57] PDEEVC: Provincial Directorate of the Environment, Green Economy and Climate Change
[58] (National REDD+ Technical Secretariat, May 2019)
[59] (Forest Investment Program) (PIF)/Ministry of the Environment and Sustainable Development, 15 May 2011)

The sector is organized around three actors: the National Union of Cashew Producers of Burkina Faso (UNPA-BF) created in 2013, the National Association of Cashew Processors of Burkina Faso (ANTA-BF) created in 2012, the National Union of Cashew Traders and Exporters of Burkina Faso (UNCEA-BF) created in 2016 and an inter-professional body (the Inter-professional Committee of Cashew in Burkina (CIA-B) created in 2015).

The area sown in (2015) was 255,000 hectares with an average yield of between 400 and 500 kg/ha[60]. The average size of orchards remains modest, with most producers being smallholders, although a part is organized in cooperatives. The production areas are: the Cascades (40%), the South-West (30%), the hauts- Basins (20%), the Center-West (10%) (Sanfo, 2020). Production is undergoing a significant evolution thanks to the involvement of all stakeholders. Thus, from 55,000 t in 2012, it will reach 120,000 t in 2020, i.e. an increase of 117% in less than a decade. The objective is to reach 200,000 t by 2030.

Figure 51: Cashew Production regions

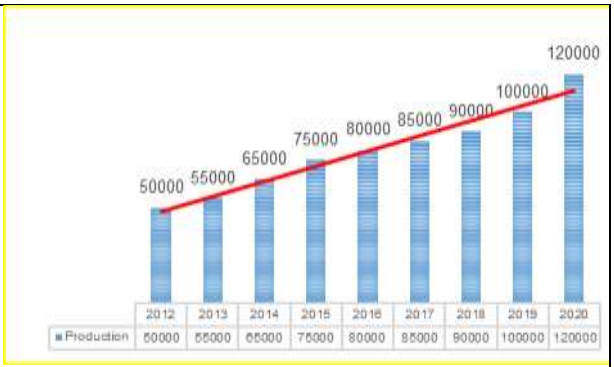


Figure 52: Annual cashew production (in tonnes) between 2012 and 2020

Source: (Sanfo, 2020)

The cashew processing link in Burkina Faso also seems to be doing well. The majority of processors are members of the National Cashew Processors Association of Burkina Faso (ANTA-BF). The number of units in 2019 was 16 and 05 new units are expected in 2020. There are also craft groups processors.

In 2018, according to ANTA-BF, there were: 03 semi-industrial units (automatic grading and shelling of nuts), 09 semi-craft units and 15 craft groups processors[61]. The units are distributed in the production areas. Thus, among the units currently in activity[62] are the following:

- In the High Basins: ANATRANS (created in 2009), GEBANA (created in 2011) and UNION YANTA (created in 2006) in Bobo-Dioulasso; UTAK (created in 2010) and COOPAKE in Orodara; ECLA in Toussiana.
- In the Cascades: SOTRIA/B (created in 2003) in Banfora; UTAB (created in 2001) in Bérégadougou.
- In the South - West: UTASO in Kampti.

In 2019, at the beginning of the campaign, the expressed needs of ANTA member units were 20,400 t. But the quantity processed locally in 2019 was 17 200 t (until October 2019). It is also reported that the processing capacity in 2018 was 20,000 t/year, i.e. 26.6% of national production. The perspective for 2030 being a production of 200 000 t, the objective is to reach a processing of 50% of the national production, i.e. 100 000 tonnes[63].

From the point of view of waste generation in the value chain, there are two main types of waste: the false fruit or cashew apple, which grows next to the nut and is in most cases abandoned in orchards; and the shell after shelling the nut in processing units. While the apple has an interesting potential for energy recovery, the

[60] Interprofessional Committee of Burkina Faso cashew nut, 2018
[61] (cashew Interprofessional Committee of Burkina Faso, 2018)
[62] (KABORE, november, 2015)
[63] (cashew Interprofessional Committee of Burkina Faso, 2018)

significant quantities of cashew nut shells, which are highly energetic, accumulated in the few processing centers and which are not fully recovered at present, make us prefer to analyze their energy potential.

4.2.3.2.3.11 Estimated amount of cashew waste available in Burkina Faso

It is possible to determine the quantity of cashew nut shells available and eligible for a recovery project from the total quantity of nuts processed in the country.

Considering the needs expressed in 2019:

- i.e. approximately 20,000 tones? to be processed,
- the percentage by mass of the hull being 70 %, i.e. 14 000 t of hulls
- units using on average only 20% of the hulls for their needs; consequently, 80% will remain unvalued by these units.

Thus, the quantity of available and recoverable hulls is estimated in 2019 to be around 11,200 tones of hulls. Assuming a production of 200,000 t and a processing of 50% of the national production, 56,000 t of hulls could be available for valorisation.

4.2.3.2.3.12 The shea industry in Burkina Faso

Burkina Faso is one of Africa's largest shea producers. The country is even the 1st exporter if we consider the volumes of almonds. The sector ranks 7th in exports after gold, cotton, sesame, cashew nuts, zinc and the livestock/meat sector and contributes 0.6% of GDP. However, in the 1960s, shea was the leading export product with a contribution of up to 33% of GDP[64].

According to a study on the socio-economic aspects of the priority non-timber forest product commodity chains and reported in a monograph on the shea commodity chain written by APEX, the shea tree stand has increased from 190 million trees to 280,802,860 trees. It is stated that the production potential of shea almonds has increased from 850,000 tons of almonds per year to 1,247,295 tons per year. Unfortunately, however, only 32 per cent of the current potential of 404,412 tonnes is being exploited. So about 68% of this current potential, or 842,883 tonnes, remains unexploited.

The production areas in 2013 are shown on the map in the figure below

[64] Promotion Agency of Exports of Burkina Faso (APEX), 2019

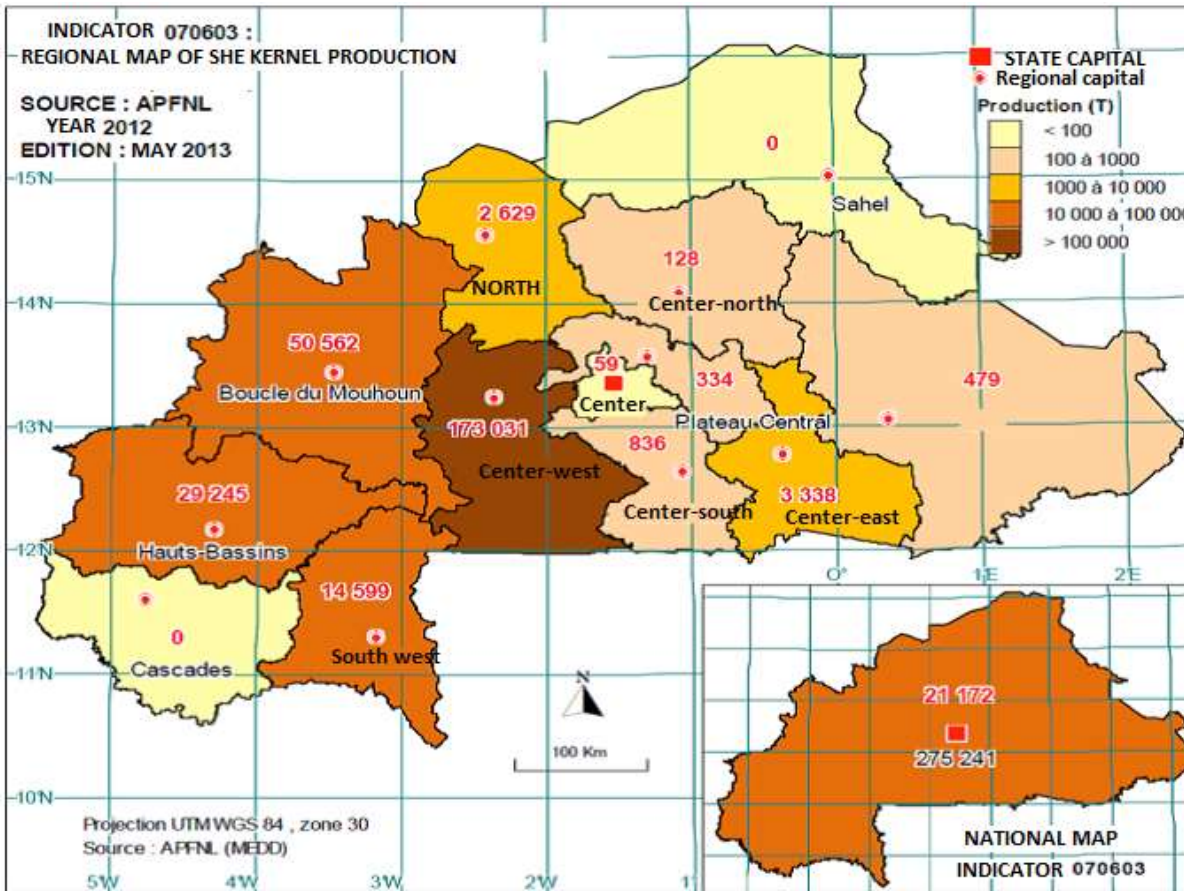


Figure 53: Regional map of almond production in 2012[65]

Source cited: Agency for the Promotion of Non-Timber Forest Products (APFNL), with technical assistance from FAO.

In 2017, this breakdown of production is as shown in Table 52.

Table 52: Population and potential of Vitellaria paradoxa[66]

REGION	Stand of shea trees		Potential		Potential actually exploited
	Number of feet	%	Tons of shea almonds	%	Tons of shea almonds
Boucle du Mouhoun	29 586 960	10,54	166 119	13,32	80 060
Cascades	43 935 223	15,65	252 119	20,21	75 636
Center	2 541 139	0,90	3 099	0,25	930
Center-East	8 475 318	3,02	10 335	0,83	3 100
Center-North	2 007 043	0,71	2 447	0,20	734
Center-West	43 455 260	15,48	211 978	17,00	63 593
Center-South	19 819 308	7,06	56 628	4,54	16 988
East	34 892 868	12,43	42 548	3,41	12 765
Hauts Bassins	45 466 080	16,19	255 274	20,47	76 582
North	4 610 532	1,64	5 830	0,47	1 749
Plateau-Central	3 965 164	1,41	4 835	0,39	1 451
Sahel	0	0,00	0	0	0
South-West	42 047 965	14,97	236 083	18,93	70 825
National	**280 802 860**	**100,00**	**1 247 295**	**100,00**	**404 412**

[65] (Ministry of Industry, 2016)
[66] Promotion Agency of Exports of Burkina Faso (APEX), 2019

Source: Report of the study on the socio-economic aspects of priority non-timber forest product chains (2017).

By observing Figure 53 and analyzing Table 52, it can be deduced that the main shea production areas in Burkina are the regions of the Hauts-Bassins, Center-Ouest, Sud-Ouest, Cascades and Boucle du Mouhoun.

Almond processing remains the main challenge in the sector. It is reported that the country processes only 3% of its production and exports 97% of the almonds produced[67]. This value seems far from reality. Indeed, there are several organizations active in the production of shea butter. While some of them use industrial methods, others use semi-industrial and traditional methods.

The most active companies producing shea butter industrially are OLVEA Burkina and International Oils and Fats (IOF), based in Bobo-Dioulasso. Among those using semi-industrial and traditional methods are the Nununa Federation, the Union of Shea Producers (UPROKA), the National Union of Shea Producers (UNAPROKA), the Union of Groups of Producers of Shea Products of Koundougou (UGPPK/Koundougou), among others, Union of Shea Producers of Comoé Shea Products (UGPPK/Comoé), RAGUSSI Association, Association for the Promotion of Women of Gaoua (APFG), Union of Women's Groups Ce Dwan Nyee (UGF- CDN/Réo), Baowendmanegré Grouping, Yeelen Grouping, Yam lendé, Dollebou Association, Zemstaaba Association, AFD/Buayaba, etc.
According to Nitidae's shea sector specialist, OLVEA (created in 2016) and OIF (created in 2013) have respective processing capacities estimated at 10,000 t and 80,000 t of almonds. This would make it possible to obtain around 31,000 t of butter and around 50,000 t of oil cake. It should be remembered that cake is a production residue obtained after extraction of shea butterfat. This cake is used as fuel, either directly or densified.

These two industries therefore produce the largest amount of waste. However, IOF, which already uses OLVEA's oilcake for a second fat extraction, exports all the cake to Ghana. On the basis of the information received, it would be possible to purchase these cakes locally in Burkina Faso from IOF.

According to the APEX shea industry monograph, the total capacity of the industrial units processing almonds into butter installed in Burkina Faso is 79,500 tonnes in 2014, although it is difficult to give an estimate of the production capacity of women's organisations and individual women producers.

Table 53: Industrial units processing shea almonds into shea butter in Burkina Faso (2014 capacity estimate)

Location	Estimated capacity (Tonnes)	Treatment methods
Bobo-Dioulasso	3 000	Mechanical extraction
Bobo-Dioulasso	75 000	Mechanical extraction / Solvent extraction
Ouagadougou	1 500	Mechanical extraction
TOTAL	**79 500**	

Source: (*Agence pour la Promotion des Exportations du Burkina (APEX), 2019)*[68]

Source cited: Extract from Table 2 of the national strategy document for the sustainable development of the shea sector in Burkina Faso, completed by the TFK.

According to the same source, the difference between the total processing capacity of the industrial units currently installed in Burkina Faso (79,500 t) and the existing processing potential (415,765 t, taking into account the almond production potential of 1,247,295 t/year), is a positive 336,265 t of shea butter that can still be produced if additional processing units were to be set up.

Assuming the 79,500 t of processed almonds, from which up to 40,000 t (approximately 50%) of cake can be obtained, and assuming that processing units use up to 30% of this cake (i.e. 12,000 t), it can be estimated that 28,000 t of waste cake will be potentially recoverable in 2014.

[67] Promotion Agency of Exports of Burkina Faso (APEX), 2019
[68] A new processing unit is currently being set up in Bobo-Dioulasso.

This is an estimate. Obviously, a project to recover this waste will require further study, taking into account the possibility of buy-back or free acquisition from large processing industries. On the other hand, at the level of semi-industrial and craft organisations, small-scale recovery projects could be envisaged, such as the production and marketing of oil-cake briquettes to substitute wood in households.

4.2.3.2.3.13 Conclusion

Burkina Faso is a Sahelian country with very limited forest resources. The local timber production sector is very weak and the country is 90% dependent on the outside world for its consumption. The two main sawmills are modest in size and production. As a result, waste from the timber industry is very negligible and is used by households.

As for the wood-energy sector, it plays a very important role in the country due to the high consumption of this energy source by households and production and processing units. However, the waste generated and not yet recovered in the sector remains almost non-existent. Indeed, although there are forest management sites that are exploited and exclusively intended for wood energy, non-recovered waste is difficult to find because the populations surrounding these sites use this waste for their own consumption. Moreover, in cities where this wood is marketed, it is practically impossible to find residues after use that could be recovered. Almost all the wood is burned.

However, some agricultural sectors such as cashew nuts and shea butter offer an alternative residue. The cashew nut sector is highly organized and with active associations. The quantity of processing residues (cashew nut shells) is estimated at 17,200 t in 2019. With production prospects, this residual quantity could reach more than 50,000 t by 2030. The shea industry also offers interesting potential (around 30,000 t of potentially recoverable oilcake). However, for this sector, prior negotiations will be necessary to dispose of this cake, a large quantity of which is sent to Ghana.

4.2.3.3. Case of Côte d'Ivoire

4.2.3.3.1 Forest resources in Cote d'vore

From 16 million ha in 1900[69], the dense forest area has decreased to 10.3 million ha in 1969 (Orstom, 1969). Today, the dense rainforest would represent only 2 million hectares of natural forest (Government of Cameroon, 2020). The decrease in forest area is thus estimated at nearly 80% in 30 years.Estimates are very diverse due to the use of different definitions for forests and the absence of a National Forest Inventory (NFI) since 1978 (BNETD, 31 July 2015). Today's most optimistic estimates indicate 2.5 million hectares of scattered forest patches, heavily degraded by shifting agriculture and impoverished by mining-type exploitation (BNETD, 31 July 2015).

The Permanent Forest Domain currently covers 6,268,204 ha, or 19% of the national territory, and includes all classified forests (FC) and protected areas (national parks and reserves) (Forest Investment Plan, May 2016):

- The country's 233 **Classified Forests**, belonging to the State, cover a total area of 4,196,000 ha. Exploited mainly for timber, they are severely degraded, partly due to the development of agriculture and large urban areas within the forest zone.
- **The network of Protected Areas** includes 8 national parks and 5 nature reserves (of fauna or flora), all belonging to the public domain of the State. They cover a total area of 2,072,204 ha and contain a

[69]Source: OIBT, atelier sur les directives OIBT pour restauration des forêts dégradées

representative sample of the country's ecosystems. The rate of degradation of these settlements varies considerably from one region to another.

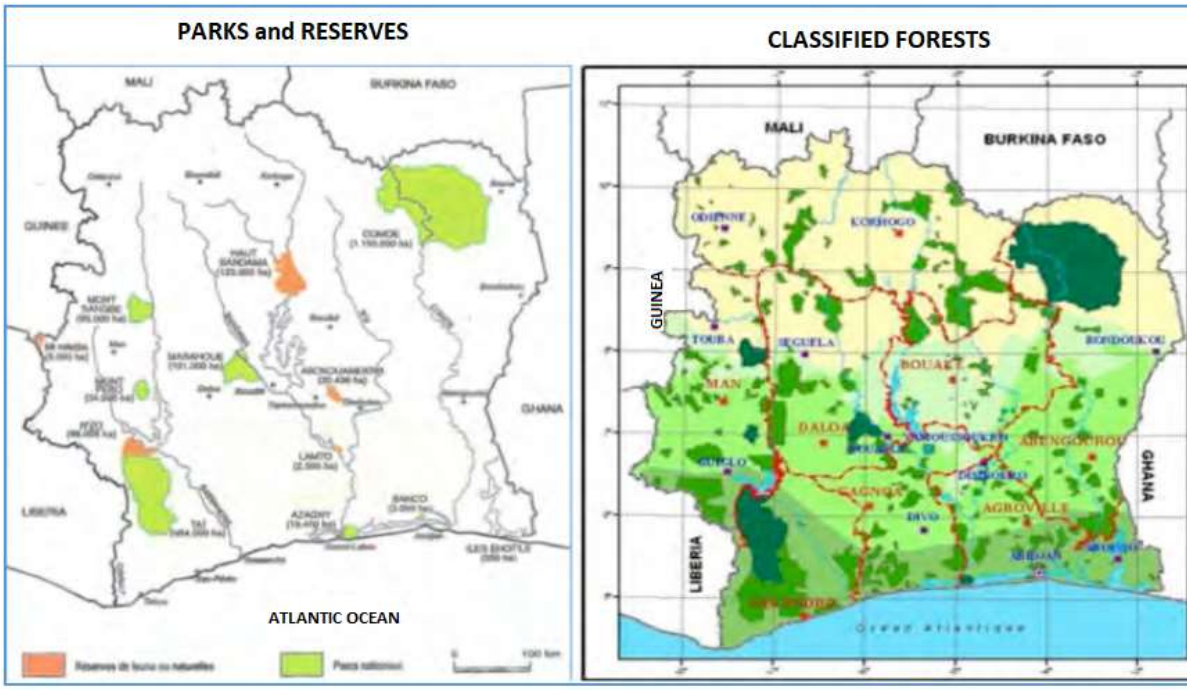


Figure 54: Location of parks and reserves (left) and classified forests (right) in Côte d'Ivoire
Source: Forest Investment Plan, May 2016

Industrial-type forest plantations covered a total area of 120,000 ha in 2000, mainly of Teak, Gmelina, Terminalia, and some local species. The classified forests are expected to be largely timber production forests. SODEFOR is responsible for maintaining this productive potential, notably through plantations or reforestation. The areas planted by SODEFOR were 3,977 ha in 2012, 2,975 ha in 2013 and 4,608 ha in 2014, i.e. an average of about 3,850 ha. Different types of reforestation are used: planting in full of pure species or mixed, or planting in association with crops (Taungya, "Complantation" ...).

Table 54: The main species planted by SODEFOR (SODEFOR)

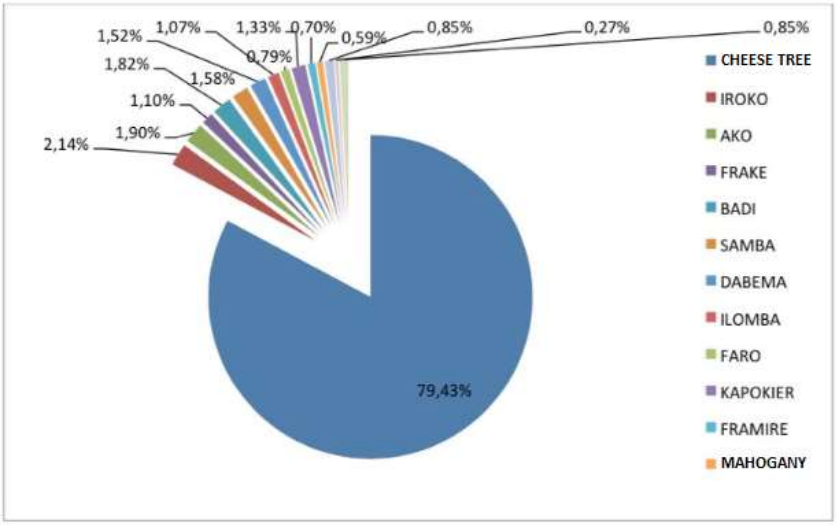
Species	Area (ha)	Species	Superficie (ha)
Teak	85 997	Niangon	9 294
Mixed plantations	39 012	Gmelina	7 474
Fraké	25 824	Samba	3 627
Framiné	14 180	Acajou	2 668
Cedrela odorata	11 035	Sipo	1 016

Table 55: Area of compensation plantation between 1996 and 2014 (DCDF)

Year	Realized areas (ha)		
	Rural estate	Classified forests	Total
1996	6 700	-	6 700

1997	7 274	526	7 800
1998	8 877	1 828	10 705
1999	9 494	2 225	11 719
2000	4 396	2 604	7 000
2001	4 469	2 460	6 929
2002	3 402	2 067	5 469
2003	3 534	1 506	5 040
2004	4 575	1 825	6 400
2005	2 546	1 024	3 570
2006	3 508	1 500	5 008
2007	2 400	1 742	4 142
2008	3 215	1 105	4 320
2009	3 000	1 200	4 200
2010	2 500	1 000	3 500
2011	Not transmitted	Not transmitted	Not transmitted
2012	629	1 545	2 174
2013	2 147	1 231	3 378
2014	1 061,3	2 419,3	3 480,6
Total	72 666	25 388	98 054

The industrial sector exploits a limited number of species, but they are gradually being depleted, prompting industries to diversify. It is estimated that there are nearly 400 different species, of which only 60 are exploited. In 2009 and 2010, some species had almost disappeared (mahogany & iroko) and were replaced by cheese tree, a white wood of lower quality, which now accounts for nearly 80% of production.



(See figure 55 opposite).All exploited species seem to be running out. The volumes of logs produced are declining for all species. Classified forests provide only about 7% of the resource, so the industry depends on highly degraded secondary forests in rural areas (CIRAD, August 2017).

Figure 56 below shows PIF zones in Cote d'vore. There are xx forested zones in Cote d'vore namely:

- Central Zone: The zone contains 42 relatively small Classified Forests (FC) with a total area of about 0.23 million hectares, while the Rural Domain (DR) in the centre covers about 3.3 million hectares.
- South West Zone: The area includes 17 Classified Forests (for a total area of about 1.1 million hectares).

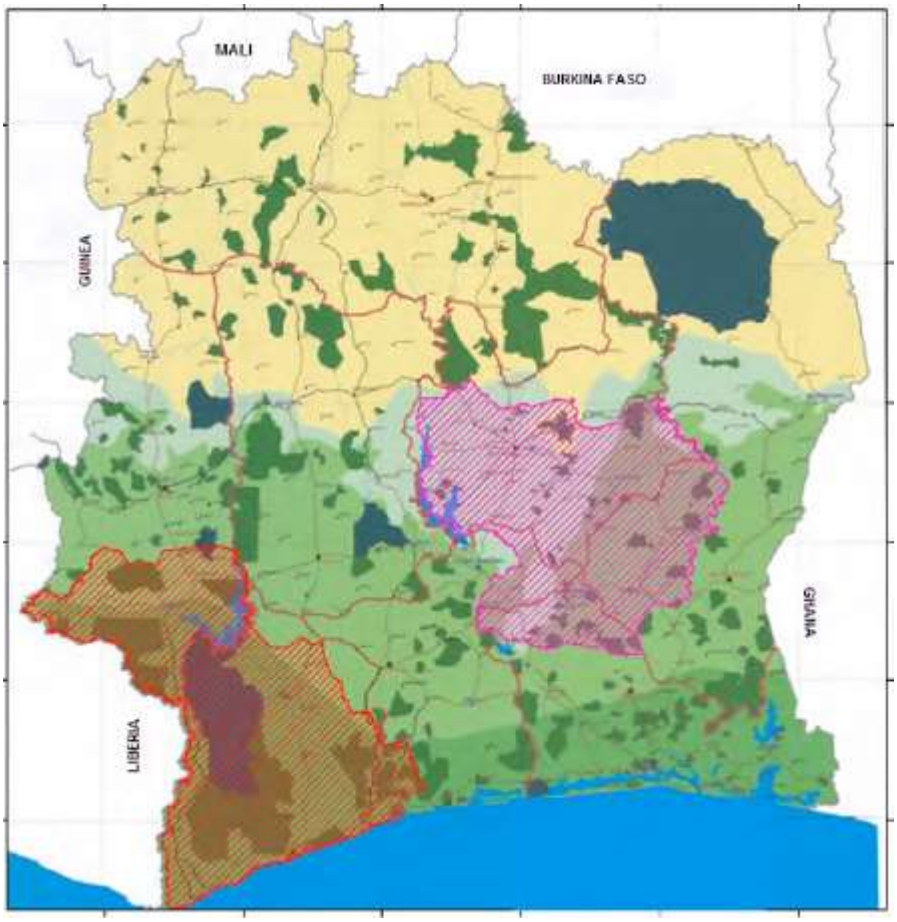


Figure 56: Location of PIF zones

Source: (Forest Investment Plan, May 2016)

Wood energy situation

In general, the demand for forest products is very high, both in the local market and globally. This strong demand has resulted in pressure on forests, which has decreased in area. Today, supply is expected to be around 10,000m^3. It is estimated that fuelwood accounts for 80-90% of all wood consumption in the country. Therefore, with the supply and demand of wood, it is estimated that the country will experience a shortage of fuelwood, which could well be compensated by other fuels, notably hydrocarbons, butane gas and electricity. In 2002, the National Survey on Household Living Standards revealed that nearly half (47%) of urban dwellers cook with charcoal, compared to only 4% of rural dwellers (INES, 2002). Conversely, firewood is largely dominant in rural areas (95%) and accounts for only 35% of energy consumption in cities (National REDD+ Strategy, August 2017). The analysis of the issues shows that wood is the basic domestic fuel for rapidly growing urban populations. Its exploitation constitutes an important economic sector practiced mostly in the informal sector by many rural households and other actors along the value chain.

Table 56: Wood supply projections (kilotonnes) [70]

	2010	2014*	2015	2020	2025	2030
Total wood supply (in kilotonnes)	455,23	377,98	381,82	407,36	459,29	596,93
Total wood supply for wood energy production (in kilotonnes)	1,51	3,87	4,91	16,17	53,27	175,52

[70] From 2015, assessments are made by the consultant on the basis of: 1m3 ≈ 0.8 t of miscellaneous wood supplied by DEPIF

Total wood supply for carbonization (in kilotonnes)	453,72	374,11	376,91	391,19	406,02	421,41

Source: (MEF/DEIF)

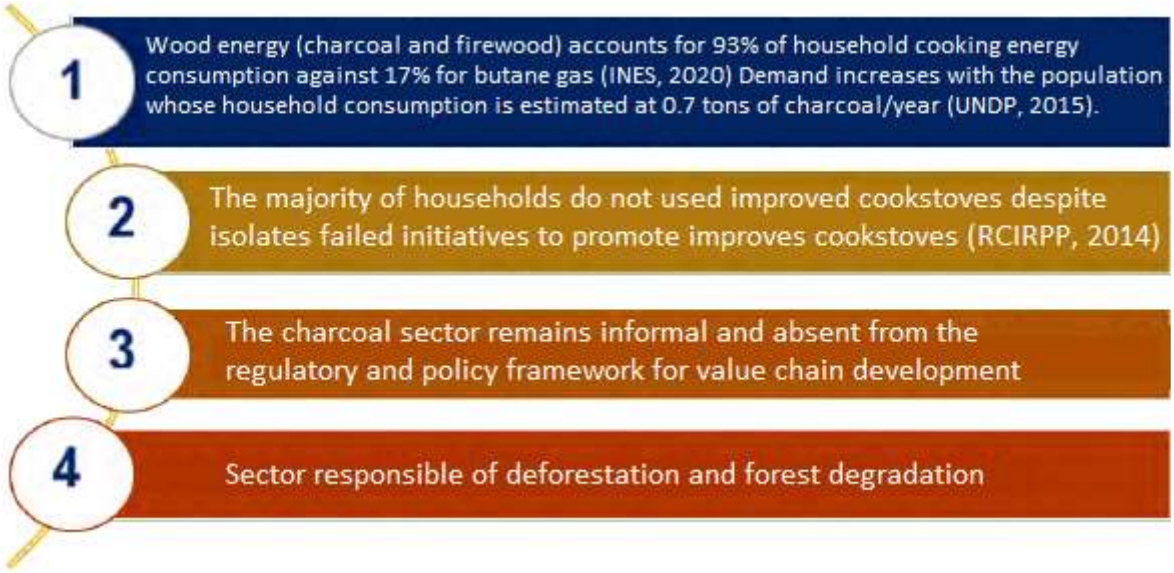


Figure 57: Issues related to wood energy

Source: (National REDD+ Strategy, August 2017)

4.2.3.3.1.1 Timber industry sector

Logging in Côte d'Ivoire began in the 1880s. At first, it initially involved only a few species, but then quickly diversified the number of species used. This trend continues today, given the increasing scarcity of flagship species. As a result, previously unused secondary species are now appearing on the market. Timber production boomed after independence. The volume of felling became very important in the 1970s. It reached its highest level in 1977 (5,321,000 m^3) before decreasing to 630,000 m^3 in 2011. (BNETD, 31 July 2015)

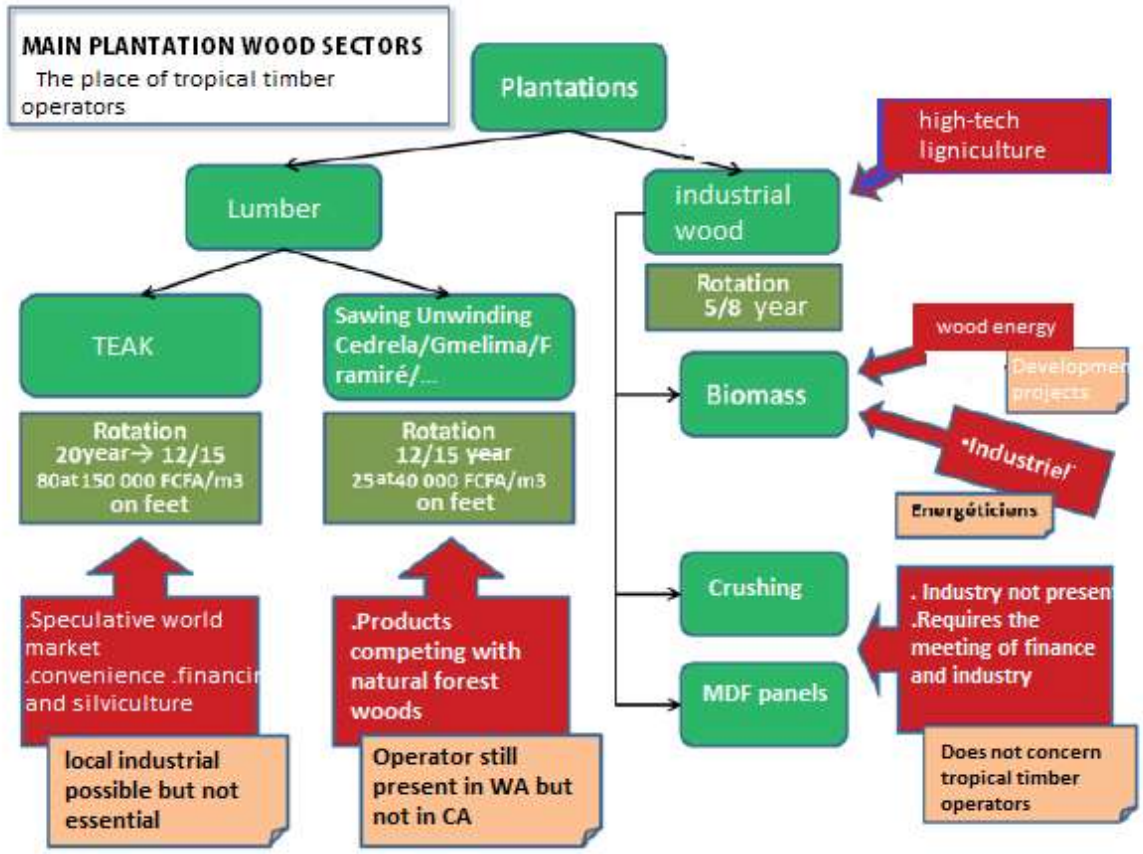


Figure 58: Main sectors of plantation timber and the place of tropical timber operators

Source: (BNETD, 31 July 2015)

4.2.3.3.1.2 Wood processing industry

The timber industry, once the country's third largest export sector, has seen its weight in the country's economic growth diminish due to the demand for agricultural land, especially for cocoa and coffee. This decrease in the resource is causing enormous difficulties in supplying factories and has led to the closure of some of them. The production of timber and woodwork in rural areas thus increased from 1.3 million m^3 in 2005 to 1.1 million m^3 in 2015 (Ministry of Water and Forests). Timber exports also decreased from 650,559 m^3 in 2010 to 479,755 m^3 in 2015 (Activity Reports, DEIF). In 2012, the wood industry still accounted for around 50,000 jobs, including 12,000 direct jobs.

4.2.3.3.2 Forest value chain in Cote d'vore

4.2.3.3.2.1 Timber value chain

Most companies in Cote d'vore either have logging permits or manage protected forests The industry consists mainly of sawmills and produces wood that is circular in shape and cut into small pieces. Government forest estates dominate the supply of wood products. However, the supply of timber from community forests and plantations is increasingly observed in the market place. Due to the improved level of governance in the country's community and private forests, value chain efficiency appears to be higher in these areas.

The local market is supplied with sawn raw planks, with white woods used in construction and redwoods used in the furniture industry. However, it appears that actors at different links in the chain are improving their ways of operating, particularly in the areas of sustainable harvesting, measuring techniques and the processing process. The following figure shows the overall value chain for timber harvesting and services.

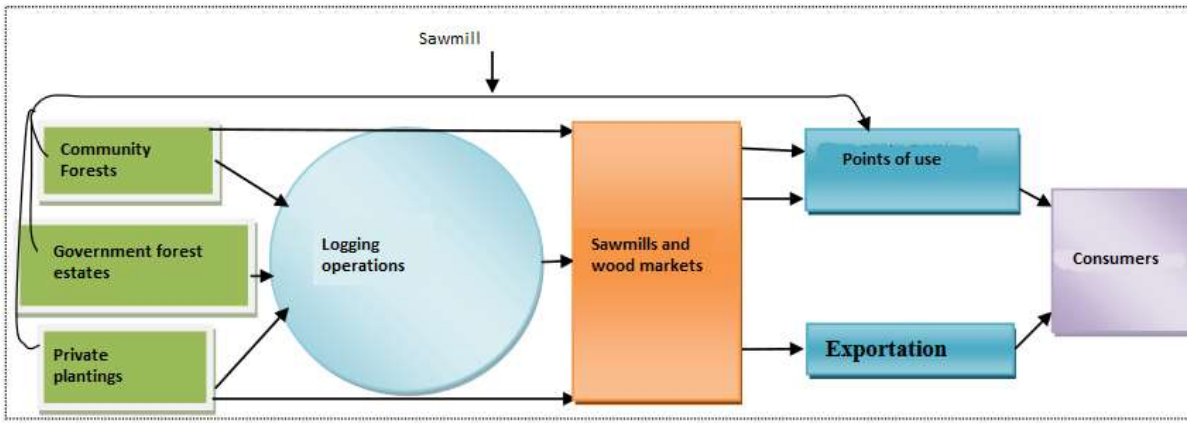


Figure 59: Overall value chain for timber and service operations
Source: Forum, 2014

4.2.3.3.2.2 Charcoal value chain

The charcoal value chain is not exempt from the rule of economic activities and focuses on supply and demand, namely: supply (biomass supply; biomass carbonization; charcoal transport, distribution and retailing) and demand (charcoal consumption). This sector is very largely dominated by the informal sector and is generally poorly organised. As with any manufacturing process, the charcoal value chain begins with the supply of raw materials, namely woody biomass and/or agricultural residues/waste. In Côte d'Ivoire, the majority of the biomass used comes directly from natural forests. The raw materials are collected by the rural poor who recover the biomass by pruning or felling trees. The actors involved in the charcoal value chain in production areas are the (MINEF) whose role is that of regulation, forest 'owners', EFP holders, permit holders, informal producers, workers & contractors), distribution (transporters, wholesalers and retailers) and consumer (households and productive users) actors.

The different actors along the value chain are described below:

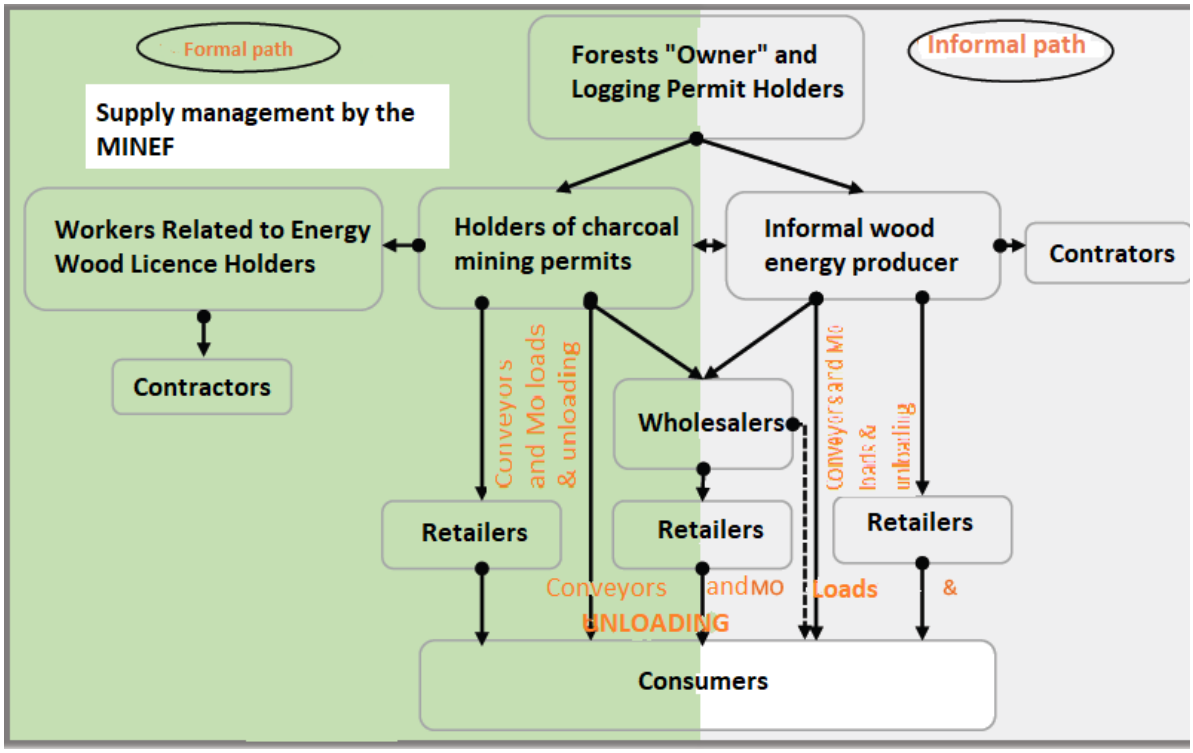


Figure 60: Charcoal value chain
Source: (Nitidae, 2019)

4.2.3.3.2.3 Firewood value chain

The fuelwood sector is driven by different actors, including self-consumers and commercial operators, including craft and modern operators. This sector is also dominated by the informal sector despite the regulations in force in the country. Any exploitation of fuelwood for commercial purposes requires a permit. different actors along the value chain are presented below:

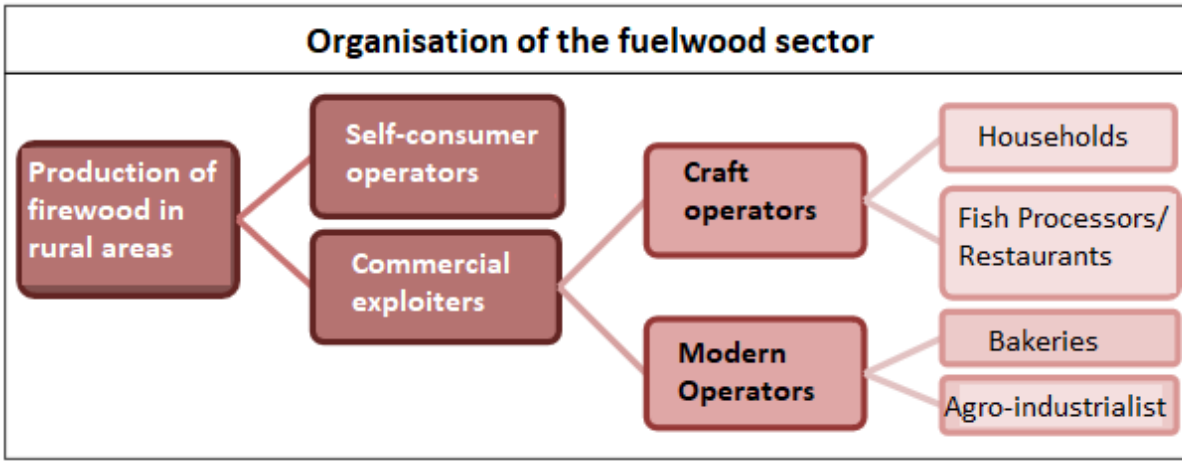


Figure 61: Firewood value chain
Source: (Nitidae, 2019)

4.2.3.3.3 Players involved in Cote d'vore forest value chain

The key actors in the timber sector in general (administration, forest operators, forest managers, communities, processors, traders, consumers, etc.) in Côte d'Ivoire are presented in the following table (adapted from a recent study conducted by the SPIB[71]). For each, the roles and functions are presented, and possible interactions with reforestation initiatives of private operators are indicated (Chevalier, May 2018).

Table 57: Key actors in the wood sector in general

Actors	Role and function	Possible interaction with private plantation initiatives
Owners		
State	- Owner of State classified forests, on land registered in the name of the State and in protected forests located on unregistered land or on unowned land, but with the exception of "" non-forest" "trees"	Forest policy orientations Political will
Regional councils and municipalities	- Provide support to State structures for the resolution of local problems and preparation of development proposals in the interest of local communities. No local authority forest created to date	Potential facilitators for the identification of large reforestation blocks
Rural Communities	- Owner of all forest resources on lands registered in the name of rural communities or in forests established in their name - Owner of trees outside the forest and resources from trees planted on community land	Provision of land for reforestation
Private Owners	- Owner on land registered in the name of such persons or in forests established in their name - Owner of the trees on the land used by these persons according to custom	Provision of land for reforestation
Managers		
Forest administration including the DCDF	- Develops national policy on forest management - Follows up and monitors the reforestation activities of EFP concessionaires	Facilitation and monitoring of reforestation in the Rural Domain
Forest Development Corporation (SODEFOR) under the supervision of MINEF	- Manager of classified forests (231) with obligation to develop them - Elaboration of development and exploitation agreements with the wood processing operators.	Facilitation and monitoring of reforestation in the central forests
Ivorian Office of Parks and Reserves (OIPR)	- Protected Areas Manager (8 national parks and 5 nature reserves)	Facilitation and monitoring of reforestation in the immediate periphery of the PAs
Forestry Research (CNRA)	Today, the CNRA is not very active in forestry. SODEFOR has capitalized on the achievements of forestry research in its technical itineraries.	
Timber growers		
Union of Industrial Wood Producers (SPIB)	- Defends the interests of the members of the sector - Strengthens the link between the different members (24) - Collaborates with MINEF	Knowledge of the sector and the markets, Mediation

[71]13. SPIB, ATIBT, Cartographie des acteurs du secteur prive de la filière foret-bois en Côte d'Ivoire, 2017

Dealers in a classified forest	Economic operator, generally a timber industry approved for logging, delegated manager of a classified forest, implementation of the development plan.	Reforestation measures Protected areas registrants
Timber growers	Licensed Individual Timber Operators	- Obligation to reforest for EFP dealers, planted species operators and operators of so-called secondary wood products
Industrials approved in logging quality	Industrials certified as timber growers	
Logging cooperatives	Obligation for national operators to form cooperatives with a minimum of 7 individual hammers	
Civil Societies partnerships	Formal partnership between certified forest operators and industrial processors	
Bioenergy operators (firewood and charcoal) and service providers	Exploitation of wood energy for domestic use, recovery of logging residues, windfall wood, rubber wood or of processing waste for use in boilers or for the production of electricity, operation of wood for services	
Wood processors		
Wood manufacturers	Industrial wood processing	Opportunities for the production of wood from plantations
Sawmill Residue Processors	Generates waste	
Craftsmen, carpenters,	Use of semi-finished products	
Traders		
Exporters / merchants	Possess an approval as an exporter of wood products	Opportunities for the production of wood from plantations
Wholesalers, timber and wood energy dealers	Operates under annual approvals	
Local Lumber Dealers, Retailers	Operates under annual licensing	
Consumers		
Households	Consumers of wood energy and service wood (crafts, household uses and traditional construction)	Market Opportunities for Plantation Wood Production
Craftsmen	Use of wood energy in large quantities (food industry)	
Building and construction professionals	Significant timber requirements: formwork, framing and joinery timber. Operators' needs are not currently being met. Difficulties relate to the quality of the wood, the targeted species and the lack of dry wood in the local market.	
Others		
Non-Governmental Organizations	- National NGOs working for the protection of forest resources (SOS Foret, ci-écologie, croix verte, etc.). - International NGOs with a role of technical and financial partner (WWF, IUCN, etc.) - Ivorian Observatory for the Sustainable Management of Natural Resources: federated NGOs	Reforestation activities with local communities Possible interface for reforestation in the Rural areas

Food processing industries	Agricultural production (rubber trees) and food industry (chocolate...)	Interface for the introduction of trees into cocoa farms, nursery know-how
Technical and financial partners in development	Work for sustainable forest management (WB, ADB, EU, ECOWAS, UNDP, UNEP, GEF, JICA, GIZ, KfW, ITTO, FDA, ATIBT...)	Provide support to planting programs

Source: (Chevalier, May 2018)

4.2.3.3.3.1 Actors involved in primary and secondary transformations

The primary processing industry is dominated by three types of activities: sawing, peeling and slicing. The second transformation, on the other hand, includes plywood, mouldings, parquet flooring, friezes and pallets, etc. The first transformation is the production of wood products. Industrial woodwork products, such as windows, and doors, and many other finished products, are the result of third transformation. Since the adoption of Decree No. 95-682 of 6 September 1995 prohibiting the export of raw wood, squared timber and plots, Côte d'Ivoire has experienced spectacular development in the forest resource processing industry. All wood from natural forests is therefore systematically subjected to at least initial processing before being exported or marketed abroad.

However, timber exports existed until the entry into force of Decree No. 2014-179 of April 9, 2014 repealing Article 2 of Decree No. 95-682 of September 6, 1995 prohibiting the export of raw wood, squared timber and plots and only concerned plantation wood, more specifically, Teak and Gmelina. Since then, the export of these woods has required prior processing.

Further processing of wood is a strategic option for Côte d'Ivoire's development. Table 55 below provides a list of approved wood processing units as of 2018.

Table 58: List of approved wood processing units

N°	SOCIAL REASON	FACTORY CODE	PRODUCT TYPES FACTORIES	LOCATION
1	ETS GEDEON	0	Cuttings (planks/rafters/...)	DABOU
2	TBA	1	Cuttings (planks/rafters/...)	AGBOVILLE
3	NOUVELLE SOCIETE BEUGLOT FRERES'' en abrégé NSBF	3	Cuttings (planks/rafters/...)	KOTOBI
4	SNTRA/CARDONA/IBT	5	Cuttings (planks/rafters/...)	AKOUPE
5	CIB	9	Planks/rafters/doors/windows/veneers/plywood	GAGNOA
6	SOCIETE MULTISERVICES DE LINDENIE "SMI"	15	Cuttings/veneers/plywood	ABENGOUROU
7	ALPICI/INDUSBOIS	17	Planks/rafters/doors/windows/veneers/plywood	ABIDJAN/YOPKOUTE
8	IDES	22	Planks/rafters/doors/windows/veneers/plywood	N'Douci
9	Compagnie Des Scieries Africaines (SCAF)	23	Planks/rafters/doors/windows/veneers/plywood	BASSAM
10	Nouvelle Scierie Adzopé (NSA)	26	Planks/rafters/doors/windows/veneers/plywood	ADZOPE
11	THANRY	27	Cuttings (planks/rafters/...)	DANANE
12	African Industrie	29	Planks/rafters/doors/windows/veneers/plywood	SAN-PEDRO

13	NSBI	38	veneers/plywood	TIASSALE
14	SITRANSBOIS	39	Planks/rafters/doors/windows/veneers/plywood	ABENGOUROU
15	SNG	40	Cuttings (planks/rafters/...)	GADOUAN
16	SC ANYAMA/SMI	43	Cuttings (planks/rafters/...)	ANYAMA
17	MOGADOR (SNBI)	45	veneers/plywood	Abidjan/yop Z.I
18	Société Ivoirienne des Placage CATALA (SIPCATALA)	48	veneers/plywood	SAN6PEDRO
19	TRANCHIVOIRE	49	Cuttings/veneers/plywood	Abidjan/Koumassi Z.I
20	Nouvelle Exploitation Forestière des Bois d'Afrique (NEFBA)	53	Cuttings (planks/rafters/...)	ZAGNE
21	THANRY (SIT)	58	Cuttings (planks/rafters/...)	DUEKOUE
22	SMCI/MAN	187	Cuttings (Planks/rafters/doors/windows/veneers/...)	MAN
23	SMCI/SAN-PEDRO	63	Cuttings (Planks/rafters/doors/windows/veneers/...)	SAN-PEDRO
24	ETABLISSEMENT NOURRA (ETS NOURRA)	73	Cuttings (planks/rafters/...)	SAN-PEDRO
25	SITBAI	74	Board/rafters/veneers/plywood	AGNIBILEKROU
26	Industries et Promotion du Bois (INPROBOIS)	88	Cuttings/veneers/plywood	ADZOPE
27	ITS	89	Cuttings (planks/rafters/...)	Abidjan/yop Z.I
28	SMCI/ABIDJAN	92	Cuttings	Abidjan/yop Z.I
29	TROPICAL BOIS (TB)	94	Cuttings/veneers/plywood	ADZOPE
30	Fabrique Ivoirienne de Parquet (FIP)	97	Cuttings/Floors/Doors/Windows	ADZOPE
31	SCIERIE BEKI	100	Cuttings (planks/rafters/...)	YAKASSE FEYASSE S/P ABENGOUROU
32	FOFANA BOIS ///OBB	104	Cuttings (planks/rafters/...)	SAN-PEDRO
33	ESDI//SCIERIE LOH DJIBOUA	107	Plank/rafters/veneers/plywood	DIVO
34	SOCIETE IVOIRIENNE DE SCIAGE ET DE TRANSFORMATION DE BOIS (SISTB)	108	Planks/rafters/doors/windows	DIVO
35	SOCIETE FORESTIERE ET INDUSTRIELLES DE BOIS (SOFIBEX)	109	Cuttings (planks/rafters/...)	SAN-PEDRO
36	IFEX-CI	113	Planks, rafters, veneer, plywood	BOUAKE

37	IVOIRIENNE POUR LE DEVELOPPEMENT DES ECHANGES (IDEC)	117	Cuttings (planks/rafters/...)	DIVO
38	SCIAGE DE GRUMES DE COTE D'IVOIRE (SGCI)	128	Cuttings (planks/rafters/...)	DIVO
39	Débités du Sud-Ouest (DSO)	138	Cuttings (planks/rafters/...)	SAN-PEDRO
40	Nouvelle plantation d'Hévéa et de Palmier (NPHP)	139	Cuttings (planks/rafters/...)	Grand-Bereby
41	Nouvelle Société d'Exploitation Forestière de l'Indénié (NSEFI)	144	Cuttings (planks/rafters/...)	ABENGOUROU
42	Sergio Legno Côte d'Ivoire (SLCI)	145	Planks, rafters, veneer, plywood	MAN
43	CIEL-YU	147	Cuttings (planks/rafters/...)	ZAMBAKRO/YAKRO
44	Compagnie de Transformation de Bois de l'Ouest (COTRANBO)	148	Cuttings (planks/rafters/...)	MAN
45	MARYSE	149	Cuttings (planks/rafters/...)	AGBOVILLE
46	Générale de Construction en Côte d'Ivoire (GCC°)	157	Cuttings (planks/rafters/...)	YAMOUSSOUKRO
47	Ets Coulibaly	161	Cuttings (planks/rafters/...)	DALOA
48	Bois Local Export de GAGNOA (BLEG)/BAMBA BOIS LOCAL EXPORT DE GAGNOA (BBLEG)	164	Cuttings (planks/rafters/...)	GAGNOA
49	YUYUAN	168	Cuttings (planks/rafters/...)	ABIDJAN-Yopougon Z.I
50	AK INTERNATIONAL	170	Planks, rafters, veneer, plywood	ABIDJAN-ALOKOI
51	HONGFA CO	171	veneers/plywood	ABIDJAN-ALOKOI
52	WORLD WOOD AFRICA (WWA)	173	Cutting(planks/rafters//veneers/plywood)	ABENGOUROU
53	SCIERIE MODERNE DE L'OUEST (SMO)	175	Cuttings (planks/rafters/...)	ISSIA
54	SUSTAINABLE TECK EXPORT ''S.T.E EXPROT''	176	Cuttings (planks/rafters/...)	TOUMODI
55	Ets MBO	180	Cuttings (planks/rafters/...)	OUME
56	EUNICE ENTREPRISE-EE	182	Cuttings (planks/rafters/...)	OUME
57	IVOIRIENNE DES BOIS DU CAVALLY	183	Cuttings (planks/rafters/...)	MAN
58	IVOIRE TRAVAUX PUBLICS (ITP)	184	Cuttings (planks/rafters/...)	YAMOUSSOUKRO
59	BALAJI AFRO	185	Cuttings (planks/rafters/...)	AHEREMOU1/TIASSALE

60	SOCIETE NOUVELLE SCIERIE	189	Cuttings (planks/rafters/...)	TIASSALE
61	SCIERIE RODA	190	Cuttings (planks/rafters/...)	ABIDJAN/ATTINGUE
62	SOCIETE DE DEROULAGE EN COTE D'IVOIRE	191	veneers/plywood	ABIDJAN

Source: (MEF, February 2018)

4.2.3.3.4 Sources and types of forest biomass residues in Cote d'vore

The main sources of forest biomass residues related to wood energy and lumber and service wood remain :

- Biomass production sites ;
- Biomass processing sites;
- The distribution and consumption sites of products resulting from production and processing;

The following tables describe the different types of residues related to each forest biomass sector and the actors involved in the value chain.

Table 59: Sources of forest biomass residues related to the "charcoal" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	Charcoal dusts	Charcoal production sites	Independent (coal) producers Contract producers (coal producers)	*Unknown*
Distribution	Dust available after sorting before retail sale	Retail outlets	Wholesalers Retailers	*Unknown*
Consumption	Dust available after sorting before coal consumption	Private homes Restaurants ...	Households and professional users such as restaurants	*Unknown*

Table 60:Sources of forest biomass residues related to the "fuelwood" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary logging (felling and timber harvesting)	Caps	Forests Fallow land Plantations	Households Individual operators	*Unknown*
	Branchs			*Unknown*
	Strains			*Unknown*
Distribution	Twigs	Points of sale	Traders (retailers, wholesalers)	*Unknown*
Consumption	Charcoal	Private house Agri-food production site	Households Professional users	*Unknown*

Table 61: Sources of forest biomass residues related to the "timber and service" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Caps	Forests Fallow land Plantations	Lumberjacks Timber Operators	*Unknown*
	Branchs			*Unknown*
	Strains			*Unknown*
Secondary exploitation (wood processing)	Bark	Sawmills Millwork	Wood processing industry Craftsmen	Used as a fuel in households and agri-food industries
	Wood chips	Sawmills Millwork	Wood processing industry Craftsmen	Used as a fuel in households and agri-food industries
	Sawdust	Sawmills	Wood processing industry	Partially used as fuel in households
	Coal dust	Carbonization sites	Coal merchant	*Unknown*
Consumption	Coal dust	Coal sales points Houses	Traders Households Craftsmen	*Unknown*
	Recycled wood (pallet, construction wood)	Workcamps Stores	Building and construction professionals traders	*Unknown*

4.2.3.3.4.1 Availability of forest biomass residues

The availability of residues for bioenergy purposes has been assessed by BEFS RA at a country level for Côte d'Ivoire in 2016. The agro-ecological regions that exist in Côte d'Ivoire are shown in Figure 6 (underlined in red):

- A lagoon region running along the coast;
- A forest zone region running from the south to the central part of the country (with four different types of forests);
- A savannah region that covers almost the northern part of the country.

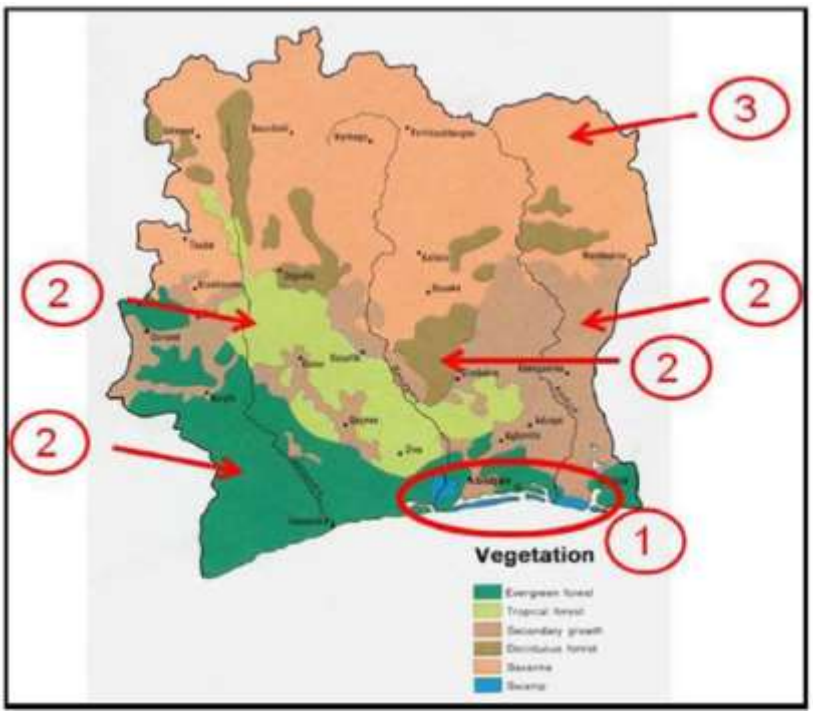


Figure 62: Agroecological zones in Côte d'Ivoire ((Country Pasture/drilling Resource Profiles-Cote d'Ivoire)
Source: FAO, 2009

4.2.3.3.4.2 Logging residues

Concerning biomass from forest residues, the country has a significant potential of arable land representing 75% of the national territory. Only 40% of the arable land is exploited, while the quality of the soil and the agro-climatic conditions allow for a diversity of tropical crops. The potential of irrigable land is estimated at 475,000 ha, divided into 175,000 ha of lowlands, 200,000 ha in the Great Plains and 100,000 ha of coastal marshlands. However, the extent of wetlands is estimated at 7 million ha, of which 500,000 ha is estimated to be lowland suitable for development. Log production was 1,554,013 m3 in 2010 with a local processing rate of 57.70% (CEREEC, National Renewable Energy Action Plan, April 2016).

To estimate the availability of logging for bioenergy purposes, data on industrial wood production was provided by the Ministry of Water and Forests of Côte d'Ivoire. For the production of wood for fuel, the source of information was FAOSTATS statistics (FAO, Bioenergy and Food Security / Rapid Assessment, February 2016). The results obtained in 2016 are presented in the table below.

Table 62: Availability of logging residues for bioenergy purposes in Côte d'Ivoire (BEFSRA analysis - woodfuel use)

Available residues		
Unit	**m^3/year**	**t/year**
Conifers	-	-
Non-coniferous	698 543,7	405 155,3
Total	**698 543,7**	**405 155,3**

4.2.3.3.4.3 Wood processing residues

For the estimation of the availability of wood processing for bioenergy purposes, production data were provided by the Ministry of Water and Forests of Côte d'Ivoire (FAO, Bioenergy and Food Security / Rapid Assessment, February 2016). The results obtained in 2016 are presented in the table below.

Table 63: Availability of wood processing residues for bioenergy purposes in Côte d'Ivoire

Types of residues	**m³/year**	**t/year**
Sawdust	60 192	30 096
plates and chips	209 059	104 529
Total	**269 251**	**134 625**

Source: *(FAO, Bioenergy and Food Security / Rapid Assessment, February 2016)*

Table 64: Evaluation in the availability of wood processing residues for bioenergy purposes in the Côte d'Ivoire from 2004 to 2010

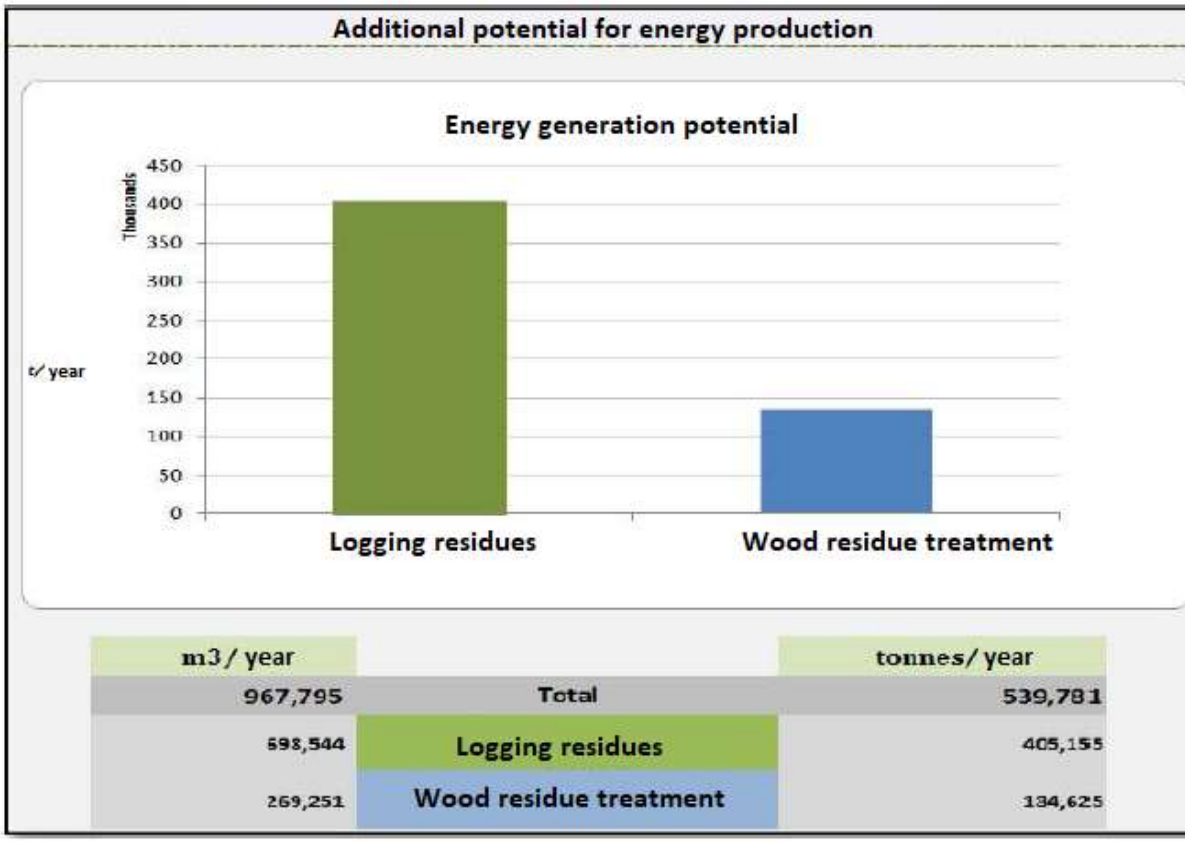
Features	**Volumes in m³**						
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Total volume entered in the factory	1 920 107	1 755 971	1 603 817	1 642 160	1 656 758	1 037 631	1 453 561
Total derived products from primary processing	814 829	752 485	703 919	752 950	740 211	478 352	490 462
Availability of forest biomass residues (m³)	1 105 278	1 003 486	899 898	889 210	916 547	559 279	963 099

Source: MINEF, 2010

4.2.3.3.5 Conclusion on the availability of forest biomass residues

The results with regard to the availability of wood residues from logging and wood processing activities show that there is a high potential in the country. It should be noted that logging residues are located in the sites where the trees are felled and therefore the collection and transport costs should be taken into account when analysing the feasibility of using these residues for bioenergy.

On the other hand, wood processing residues are generated in sawmills and are potentially already available for bioenergy purposes. A summary of the potential availability of wood residues for bioenergy purposes is presented in the following Figure 63 (FAO, Bioenergy and Food Security / Rapid Assessment, February 2016).



m3 / year		tonnes/ year
967,795	Total	539,781
598,544	Logging residues	405,155
269,251	Wood residue treatment	134,625

Figure 63: Summary of the potential annual amount of wood residues available for bioenergy purposes in Côte d'Ivoire

Source: (BEFSRA Analysis)

Apart from forest residues, there is also potential for residues from the processing of NTFPs such as oil palm, cashew nuts, cocoa and rubber that can be used for energy purposes.

4.2.3.4. Case of Mali

4.2.3.4.1 Forest resources in Mali

According to the results of the Inventory of Wood Resources in Mali (PIRL 1985-1991), which exclude pastoral and desert areas, the national forest estate is estimated at 32.3 million hectares (see Table X below), i.e. less than 26% of the country's surface area. Of this, less than 21 million hectares have some forestry production such as classified forests, wildlife reserves or agricultural plant formations.

The areas subject to sustainable development with development plans are limited. These are the :

- Classified Forests: out of the 119 classified forests totalling about 1 million hectares only 20 classified forests with a surface area of 259,200 ha are subject to sustainable development;
- Parks and Wildlife Reserves: these are protected areas managed according to development and management plans in consultation with local populations;
- Forest massifs of the protected area: the sustainable development of the massifs of the protected area is marked today by the work of the Woodfuel Unit (CCL), the PGRN and some NGOs. The country's developed protected area covers about 200,000 ha (of which 81,670 by the CCL: Cellule Combustible Ligneux) are managed according to concerted development plans.

Productive natural stands are mainly located in the Sudano-Guinean and Guinean wetlands in the south and west of the country. They are composed of open forests, gallery forests and shrubby savannahs where the following species dominate: Isoberliniadoka, Vitellaria paradoxa, DetariummicrocarpumParinaricuratelefolia, Afzeliaafricana, Pterocarpus erinaceus and Khaya senegalensis. This forest estate contains the main part of the national potential of wood resources with an estimated total standing volume of nearly 516 million m^3.

Table 65: Administrative categories of forests

Categories	Area (ha)	Total (%)
Classifiedforests	1 300 000	4
Protected areas/national parks/fauna reserves/Ramsar sites	3 900 000	12
Forests of protected area	11 400 000	36
Agroforestryparks / fallow land	15 700 000	49
Total	**32 300 000**	**100**

Source: (PIRL 85 - DNRFFH, 95)

The oldest reforestation dates back to the 1930s. They were generally carried out in classified forests and in peri-urban areas. Several thousand hectares were planted between 1942 and 1960. From 1960 to 1970, 2,100 ha were planted mainly with cashew trees, Gmelina, Teak and Neem. From 1970 to 1978, most of the reforestation was confined to the area around Bamako. From 1980 onwards, external funding enabled a resumption of reforestation throughout the country. Unfortunately, since 1988, this momentum has been broken in favour of the development of natural formations. Plantations planted in Mali as of 1999 are estimated at 60,296.23 ha (M. Gakou n.d.).

Since then, participatory natural forest development trials have been carried out in the regions of Kayes, Koulikoro (Faye and MontsMandingues classified forests) and Sikasso (Kaboila). The productivity of these managed forests is estimated at 3 m^3/ha/year for Gmelina and 7 m^3/ha/year for Eucalyptus. For these trials, activities were carried out under contract between technical services and village communities (DNCN 2000). The plantations, both industrial and village, mainly produce fuelwood and service wood, but their contribution to total national wood production remains very small or even negligible. This is partly due to the lack of silvicultural monitoring of these achievements.

Trees outside forests are limited to country trees and fallow land less than ten years old. They are essentially fully protected species (Shea, Nere, Balanzan, etc.). There are no official data on their number and surface. However, their surface area, all areas combined, can be assimilated to the surfaces of cultivated land and fallows of less than ten years (shea or néré parks), estimated at 15.7 million hectares (DNRFFH 1995).

4.2.3.4.1.1 Wood energy supply/demand balance

The standing volume, at the national level, according to the project inventory of timber resources in Mali (PIRL) is over 520 million m^3or 416 million tonnes of standing timber, with production in the plant formations, which can be classified as not very productive. Annual productivity varies from 0.05 to 0.3 m^3/ha/year in the Sahelo-Saharan zone compared to 1.0 to 1.5 m^3/ha in the Sudano-Guinean zone. The overall average productivity of natural undeveloped forests is very low, around 0.86 m^3/ha/year (Touré 2000).

In all areas of the country, there is over-exploitation of the woody potential, particularly around large cities such as Bamako. According to the National Directorate of Wildlife and Fishery Forest Resources (DNRFFH 1995), more than 100,000 ha of forests disappear every year. In 2001, removals for fuelwood and charcoal were estimated at 5 million tonnes per year (i.e. 400,000 ha) and should reach or even exceed 7 million tonnes in 2010, i.e. 560,000 ha (FOSA, 2001). FAO, on the other hand, estimates the need for wood energy at 7 million tonnes

already in 2003. The regeneration potential (productivity) is estimated at 7 million tonnes per year (FAO, December 2003), which clearly shows that there is currently a strong imbalance between supply and demand for wood energy in the country. Indeed, the estimates of biomass availability in the supply basins carried out for the Bamako region (FONABES, June 2017) and the supply basin of the city of Ségou (AGEFORE, August 2007) concluded negative balances as illustrated in Figures 64 and 65 below: by 2025, more than -4 million m^3 of wood energy in the supply basin of the city of Ségou and more than -2 million tonnes in the supply basin of the city of Bamako.

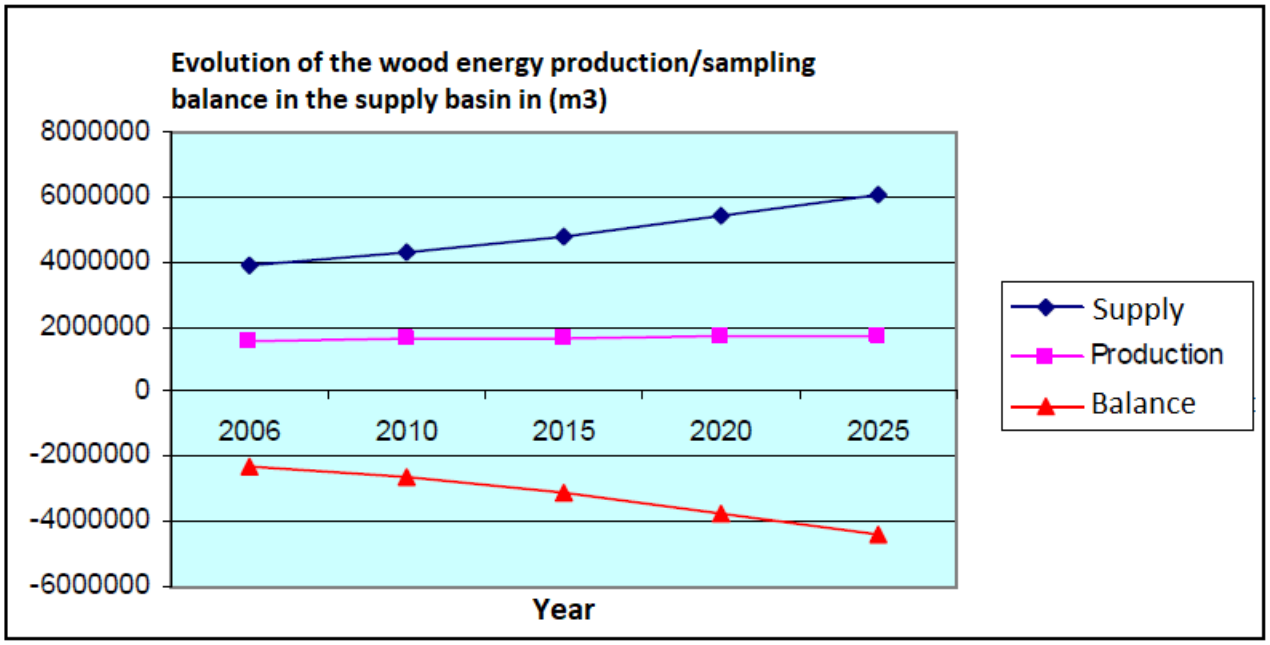


Figure 64: Evolution of the wood energy production/sampling balance in the supply basin of Sègou City

Source: (AGEFORE, August 2007)

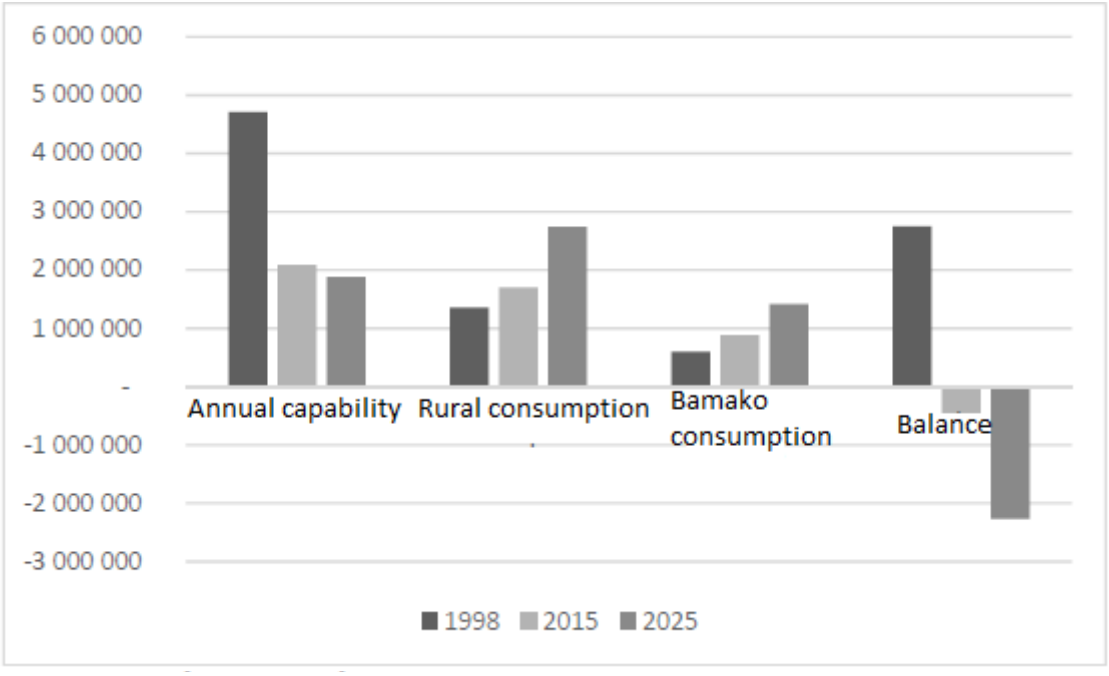


Figure 65: Projected demand for wood energy in Bamako City supply basin 1998-2025(in tons/year)

Source: (FONABES, June 2017)

The legislative and regulatory framework for forest resource management in Mali has undergone many changes since 1960. The first texts were essentially based on the protection of resources and were of a prohibitory and repressive nature. The management of forest resources was governed by the 1968 Code (Law No. 68-8/AN-RM of 17 February 1968). However new laws have been adopted since 1995.

4.2.3.4.1.2 Forest value chain in Mali

The exploitation of timber is often carried out by forestry companies (sawmills, peeling units, etc.) which pay forest royalties and taxes to the State to exploit the forests. Exploitation is carried out by more or less informal companies, which are sawmills, to which the State annually gives exploitation permits or concessions depending on the region. At the production level, the main actor is the State, which holds the rights of access to the resource. The other key actors are local communities, landowners and forest operators as shown in the following value chain.The following figure represents the different levels of transaction involved in the timber supply value chain.

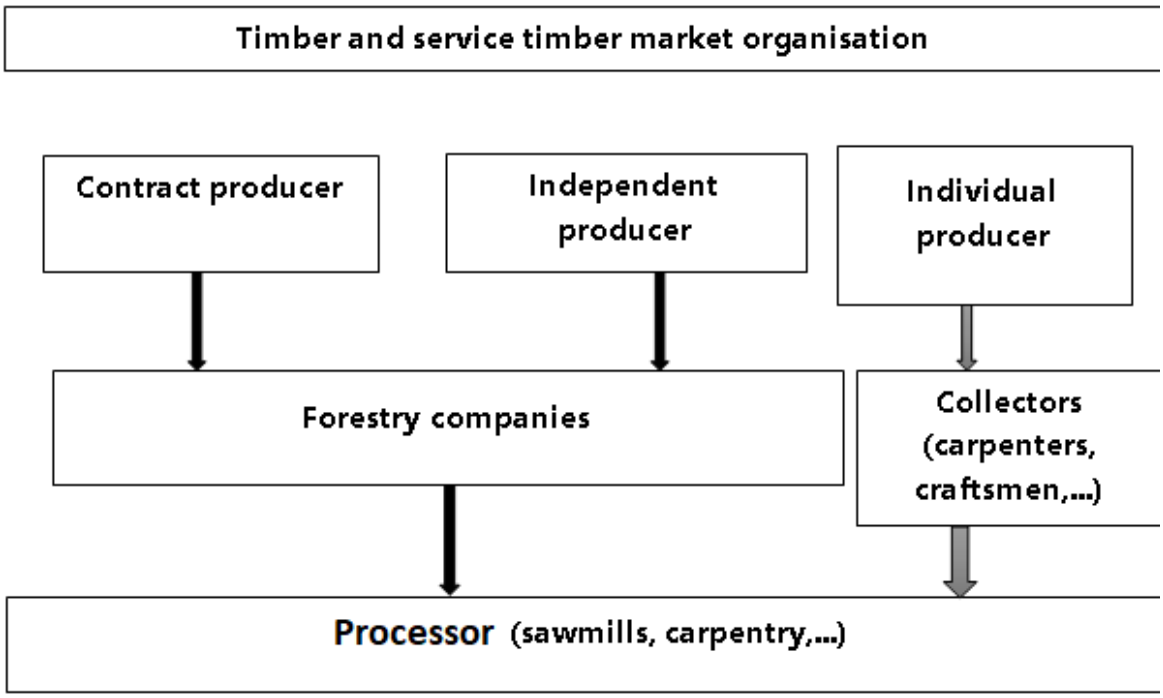


Figure 66: Timber value chain in Mali

Source: (CIFOR, Mai 2006)

The wood energy potential is estimated at 33 million hectares with a standing volume of about 520 million m^3 and a weighted productivity over the whole country of about 0.86 m^3/ha/year (Firewood and charcoal n.d.). The following figures shows the different levels of transaction involved in the charcoal and fuelwood supply chains.

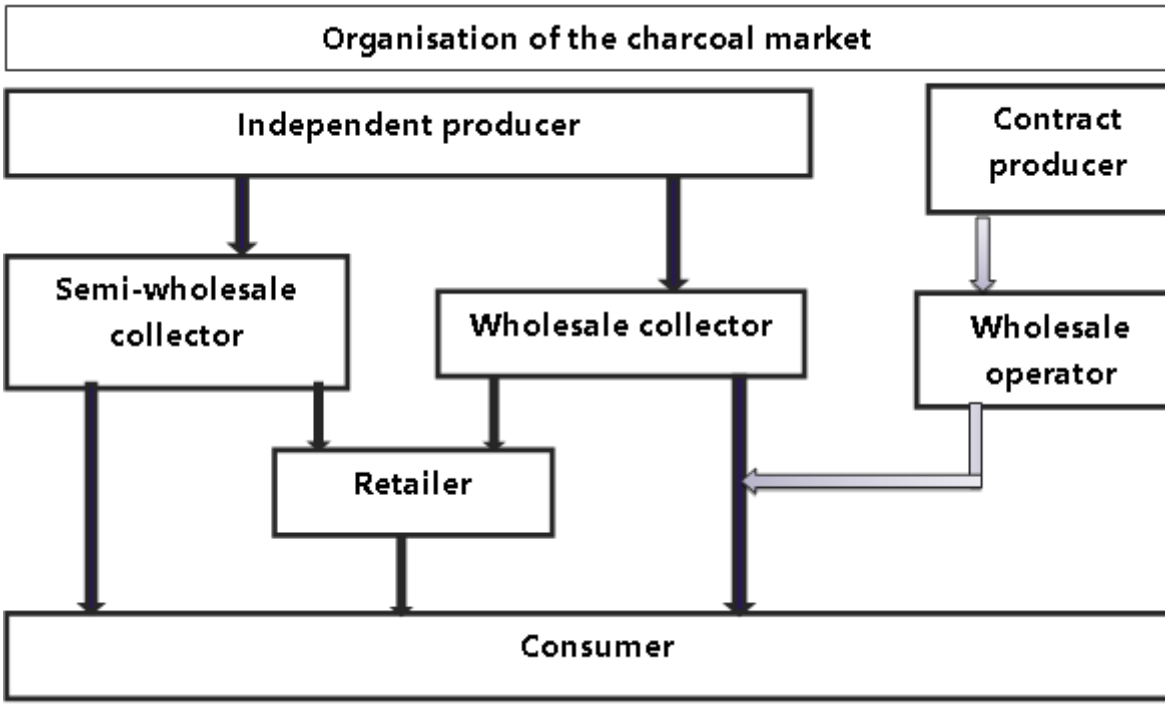


Figure 67: Charcoal value chain

Source: (CIFOR, Mai 2006)

Source: Wood Energy Supply Master Plans (SREP, January 2011)

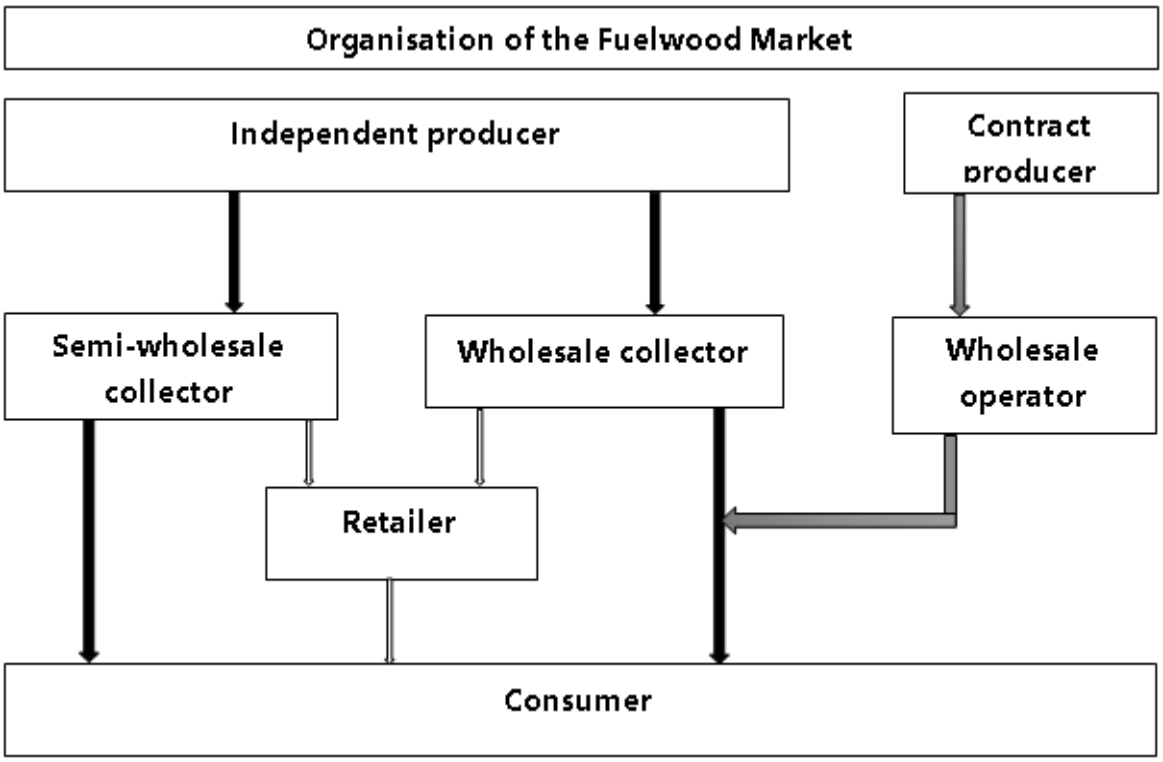


Figure 68: Firewood value chain

Source: (CIFOR, Mai 2006)

4.2.3.4.1.3 Players involved in Mali Forest value chain

4.2.3.4.1.3.1 Forest management and conservation actors

In Mali, all forests belong to the State, but the State may concede management to a community. In practice, public forests (the State forest estate, which includes the State protected forest estate and the State classified forest estate) are managed by the State. Private forests (private individuals' domain) cover small areas (plantations for timber production and services on private land, with a land title). The right to manage all forest estates belongs to the State. **Invalid source specified.**.

4.2.3.4.1.3.2 Production actors

In case of charcoal and fuelwood, cutting is done in the "bushes" and fallows of the villages. Once the wood has been cut, packaged in bundles or charred, it is transported by the producers to points of sale in rural areas. These points of sale may be individual or collective; permanent (on the roadside or in a village) or periodic (usually on market days or weekly fairs). They are visited by urban traders who come to collect the products (charcoal and firewood) for transport and sale in the city.

4.2.3.4.1.3.3 Exploitation /harvesting actors

Exploitation of wood in Mali is essentially reduced to artisanal, often informal, processing, so there is little official data on residues in the exploitation of timber and service wood. Nevertheless, data on the amount of timber harvested for this type of wood will give an idea of the quantities of residues from this sector. Poorly known, timber and service needs would represent only 5-10% of the total consumption of cut timber. Logging is

currently based on the needs of small sawmills and merchants with mechanized logging equipment and is most often carried out on the fringes of new sustainable management rules.

4.2.3.4.2 Actors in primary and secondary transformation

The country produces almost no timber that can be processed industrially. The reduction of the wood stock, following deforestation and forest degradation, limits the development of the forest industry. The supply of wood for carpentry is marginal. Most of the timber used is imported from Côte d'Ivoire and Ghana (85%) (Konaté 2001).Thus, only primary processing takes place in small sawmills. This transformation is carried out by sawmills supplying planks for making canoes as well as planks, rafters and battens for joinery. The need for lumber for the manufacture of dugout canoes is estimated at 2,500 tonnes/year in 2003. Apart from this type of manufacture made from local species, other products are not very competitive compared to imported products. Malian sawmills are characterised by obsolete equipment, semi-mechanisation (except for a match factory) and their energy dependence on the Société Energie du Mali. They suffer from poor management due to inadequate training of contractors and workers, outdated equipment and poor organisation of the timber sector. As a result, operators in the sector are considering investing in a modern sawmill to improve and expand the range of products (Konaté 2000).

4.2.3.4.2.1 Transporters / logistic operators

The transport of wood energy by private individuals is authorized and limited to quantities for self-consumption and must be justified by a transport ticket called Coupon issued by the Forest Administration, certifying the origin of the product. These quantities will be determined by order of the Minister in charge of Forests. In the case of fuelwood exploited in a plantation or in a private forest, the coupon is issued by the forest owner.

For timber, logs are most often transported directly from the logging sites to the sawmills where they are processed. Given the low level of equipment in these sawmills, processing is often primary and not very diversified (planks, trays, etc.) and the level of yield is rather low. Charcoal and fuelwood are transported to cities by hired vehicles by wood merchants. Once in the city, wood fuel is either sold directly to consumers by the collecting dealer or resold to retailers in urban markets or at the street/roadside.Retailers like for charcoal obtain their supplies in town from wholesalers in the markets or sometimes from lorry drivers (especially tanker drivers) who conveniently bring in charcoal in addition to their official load.

4.2.3.4.2.2 Consumption

The final consumer of forest products does not play a decisive role in the structuring of supply circuits. Suppliers collect products in rural areas, and dominate the main types of supply circuits. In terms of energy consumption, more than 90% of the energy consumed in Mali comes from wood products whose annual needs are estimated at 0.9 m^3 /inhabitant (FAO, December 2003). This high consumption of ligneous fuel would correspond to an annual deforestation of nearly 600,000 hectares 20 years ago (Touré, 2000) and is very likely much higher today.

The main actors involved in the wood energy and timber industries are summarised in the following table.

Table 66: Summary of the main forest actors in Mali

Category/component of the value chain	Key players	Names of key players	Location	Role played in the production of forest residues
Forest biomass sources	State	National Directorate for Nature Conservation DNEF (National Directorate of Water and Forests)	Natural forests, wooded savannahs and shrublands Productive agricultural plantations and fallow; land forest plantations	Definition of national forest policy, development of legislation and regulations. Conservation and production of forest, wildlife and fishery resources. Transfer of competences and resources from local authorities to communities.
	Local authorities &Municipalities	Regional and local councils CCL (Wood Fuel Cell)		Sustainable management of the exploitation and conservation of forest resources. Support, training, advice, from the design of development plans to the marketing of products. Represents communities in concessions and negotiations
	Private Owners	Economic operators: forest operators, processors, distributors, cooperatives, associations, etc.		Take measures to create an adequate framework for consultation among all stakeholders in forest management. Information, education and communication conducive to investment and the responsible involvement of local communities and partners outside the forest sector. Provision of services on behalf of the state, local authorities or individuals.
Harvest	Forest Owners	Forestoperators Peasants	Natural forests, wooded savannahs and shrublands Productive agricultural plantations and fallow land forest plantations	Harvesting of trees leaving wood residues on the cutting and charring sites.
	Forestry contractors	Contractors Timber producers		
	Transporters	Drivers WholesaleDistributors		
Primary processing	Wood sawmillingcompanies	Transformers Operators	Sawmills Joineries	Production of forest biomass residues during processing (bark, chips, sawdust, coal dust, etc.).

	Charcoalproducers	Charbonniers Lumberjacks	Carbonization sites and charcoal sales sites	
	Tmber Processors	Sawyers Carpenters Craftmen		
End Consumers	Households	Households	Private homes	Production of residues from the consumption and use of forest biomass (wood waste, recovered[72]wood, charcoal residues, [73]used pallets).
	Professionals	Bakers Restaurants	Activity sites	
	Building and public works companies	Carpenters Masons	Building sites usingwood	

[72] Wood initially used for construction being at the end of its life ("used" construction wood).
[73] The "used" pallets would mainly come from the agri-food industries.

4.2.3.4.3 Sources and types of forest biomass in Mali

The main sources of forest biomass residues from the wood-energy and, timber and service industries are located on the sites where forest biomass is produced and processed, as well as on the sites where the final products are distributed and consumed.

Logging residues are those resulting from the final felling of wood for fuelwood (firewood and charcoal) and timber and service wood. They are mainly the crowns, branchs and stumps of felled trees whose trunks are intended for processing by industrialists or craftsmen.

Wood processing residues are the residues of industrial and artisanal wood processing. They have their origins in the carbonization of wood, in industrial (sawing, peeling, slicing, etc.) or artisanal (carving, joinery, etc.) processing. They are mainly bark, sawdust and wood shavings, but also scraps and coal dust.

Residues from distribution and consumption mainly concern those from the marketing and use of charcoal and those from the end-of-life of timber processing and service products. These include charcoal dust at points of sale, recovered wood from construction sites, wooden pallets, and packaging wood.

The following tables describe the different types of residues related to each forest biomass chain and the actors involved in each corresponding value chain.

Table 67: Sources of forest biomass residues related to the charcoal sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	Charcoal dust	Charcoal production sites	Independent (coal) producer / under contract	Left on site
Distribution	Dust available after sorting before retail sale	Retail outlets	Wholesalers Retailers	Thrown Backfill
Consumption	Dust available after sorting before coal consumption	Private homes Restaurants and other professionals	Households Professional users such as restaurants	Purchase by blacksmiths (only for coarse dust: small pieces of coal)

Table 68: Sources of forest biomass residues related to the "fuelwood" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Houppier	Forests Set-aside Plantations	Individual operators Households	Not known
	Branch	Forests Set-aside Plantations	Individual operators Households	
	Strain	Forests Set-aside Plantations	Individual operators Households	

Distribution	Twig	Points of sale	Traders (retailers, wholesalers)	

Table 68: Sources of Forest Biomass Residues Relative to the Timber and Service Sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Houppier	Forests Fallow land Plantations	Loggers Timber Operators	Not known
	Branch	Forests Fallow land Plantations	Loggers Timber Operators	Not known
	Source	Forests, Fallow land Plantations	Loggers Timber Operators	Not known
Secondary exploitation (wood processing)	Bark	Sawmills Joineries	Wood processing industries Craftmen	Used as a fuel in households and agri-food industries
	Wood Chip	Sawmills Joineries	Wood processing industries Craftmen	Used as a fuel in households and agri-food industries
	Sawdust	Sawmills	Wood processing industries	Partially used as fuel in households
Consumption	Recycled wood (pallets, wood from construction sites)	Workcamps Stores	Professionals of the building and building Dealers	Not known

Table 69: Sources of forest biomass residues related to the "NTFP/Shea butter" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Picking / gathering of shea fruits	Pulps	Forests Agroforestry areas	Shea nut producers	Amendment of fields Food consumption
	Hulls	Places where fresh nuts are processed (especially in homes)	Shea nut producers	None (discarded or left on the hulling site)

Transformation of almonds into butter	Tourteaux	Places of artisanal production of shea butter (houses of individual or collective processors) Butter production plant	Butter production groups / cooperatives Individual transformers Shea processing industries	Use as fuel (bakeries...) Compost production
	Sewage water[74]	Places of artisanal production of shea butter (houses of individual or collective processors)	Butter production groups / cooperatives Individual transformers	None (discarded)
	Black residue[75]	Places of artisanal production of shea butter (houses of individual or collective processors)	Butter production groups / cooperatives Individual transformers	Use as fuel

4.2.3.4.4 Sources and types of forest biomass residue in Mali

Landlocked and characterized by a Saharan climate in the north, a Sahelo-Sudanian climate in the centre and a Sudano-Guinean climate in the south, Mali is made up of forests of modified natural and semi-natural types as well as forest plantations and other wooded or tree-covered land, according to the classification defined by the FAO. With an estimated standing volume of nearly 520 million ^{m3,} its national forest estate is spread over nearly 32 million ha, representing about 25% of the territory, and comprises mainly shrubby to tree-covered savannah and open or gallery forests, half of which are agroforestry parks or fallow land.

Traditional biomass, particularly firewood and charcoal, is largely the main fuel used by the population to meet its energy needs, accounting for nearly 90% of the total. Due to population growth and low forest productivity, there is a strong imbalance between supply and demand for wood energy, especially in the supply basins of large cities, such as Bamako, where the projection for 2025 shows an annual negative balance of more than 2,000,000 tonnes of wood energy.

In view of the current context linked to the degradation of forest resources, the use of forest biomass residues for the production of thermal energy or even electrification would be necessary in order to increase the country's energy supply. In the wood energy sector, the most promising residues in terms of energy recovery seem to be coal dust. Indeed, which can represent up to 20% of the total weight of a sack of charcoal, fairly large deposits of fine and coarse dust could be collected in large cities, especially from charcoal distributors, particularly retailers sorting before sale and, to a lesser extent, from end consumers buying by the sack, particularly relatively well-off households or professionals such as restaurant owners. Once mixed with a binder and then compacted using a press, this raw material would be used to produce biochar as an alternative fuel to charcoal.

As for the timber and service sector, residues generated in sawmills, such as sawdust or wood chips, seem to have little potential for valorization in the country. With a low production of wood specifically dedicated to this sector and a low level of industrialisation for processing, the deposits of these biomasses are indeed not very concentrated and scattered in the various small artisanal sawmills. Moreover, according to local sources, poultry farmers are already using these biomasses as litter in poultry houses.

[74] Liquid residue after decanting of the liquid cake obtained after churning of the crushed amalgamates
[75] Residue obtained after settling of the oil (liquid butter)

Concerning non-timber forest products, one of the most relevant sectors in terms of residues generated that can be used for energy recovery seems to be shea butter.

Indeed, the transformation of nuts into shea butter leads to the production of nut shells and cakes. Assuming that the recently installed MaliShi plant reaches its target production capacity, the residue deposits generated annually by its activity would then be 20,000 tonnes of shea nut shells and 15,000 tonnes of oilcake. With appropriate technologies, the valorization of these residues would make it possible to replace the use of firewood, or even charcoal, for professional or domestic cooking but also to produce electricity.

In terms of small-scale processing, assuming that 10% of the national shea nut production potential is exploited, although there are significant deposits of residues, their use does not seem feasible or profitable because of logistics, since (i) the shells are relatively dispersed among individual or collective producers located in rural areas and (ii) the oilcake is already used as fuel by rural bakers.

Finally, other cash and tree-related crops, such as cashew nuts, present opportunities that may prove promising in the future, through the energy conversion of the shell, if the processing of the nut were to become established on a sustainable basis in Mali.

4.2.3.4.4.1 Shea butter industry waste

In Mali, shea industry waste seems more available at present for efficient and large-scale conversion to bioenergy. The world's second largest shea producer after Nigeria, Mali produced an average of about 130,000 tonnes of shea almonds between 2010 and 2017. (Semega, 2018-2019). The production of shea is based on a very vast park of Vitellaria paradoxa trees which is naturally renewed and has been exploited by the population for several centuries. The nut producers, or rather nut collectors, ensure the collection in an individual or collective way, in the form of cooperatives of a few dozen to several hundred members. From the graph (see figure below), it is clear that the large variations in shea nut production are due to variations in the area harvested at the same times.

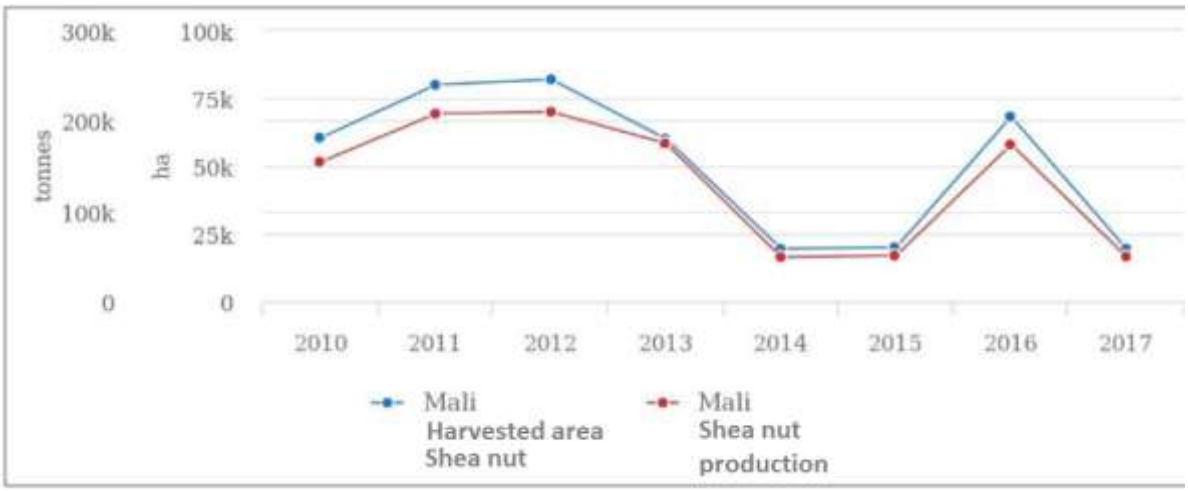


Figure 69: Evolution of the harvested area and production of shea nuts in Mali from 2010 to 2017

Source: (FAOSTAT, juin 2019)

The *Vitellaria paradoxa* species is normally protected by the forestry code, which prohibits its felling. However, as its regeneration is natural, many seedlings grow every year in cultivated fields or fallow land. Their conservation or protection is done according to the will of the owners of the plots, but many seedlings are

destroyed during field work. (Nouvellet et al., 2006). Due to a lack of monitoring and regulation, many trees (young or not) are also felled to facilitate access to the fields or even for charcoal production.

In Mali, processing activities are mainly artisanal and manual. Mechanized processing units can be used as for almond milling, which reduces the time spent on this task but also increases the butter extraction rate. Two shea processing plants used to exist on Malian territory, but they closed down several years ago. However, a new plant, MaliShi, was established in the Sikasso region in 2019. This plant has an overall processing capacity of 30,000 tons of almonds per year. (Ecofin Agro, 2019). As it is currently in the start-up phase, it has not yet reached its overall processing capacity.

4.2.3.4.4.2 Availability of solid shea processing residues for energy purposes

The two woody residues resulting from the transformation of shea nuts into shea butter are : (i) the husks from shelling the nuts to extract the almonds and (ii) the cakes from processing the almonds to produce shea butter. It presents the available residues on the basis of (i) the 10% of the exploited potential (in relation to the production capacity of the shea park at the national level), (ii) the processing yield according to ITC (from the collection of the nut to the production of butter) and (iii) according to the artisanal ([76]churning method) but also industrial (pressing method) processing process depending on the overall capacity of the Malishi factory.

Table 70: Evaluation of residues from shea almond processing in Mali

	Almond processing capacity (tons/year)	**Butter production (tonnes/year)**	**Residue Production (tons/year)**	
			Hulls[77]	**Cake**[78]
Processing by individuals or cooperatives	13 000	6 500	8 667	6 500
MaliShifactory	30 000	15 000	20 000	15 000
Total	43 000	21 500	28 667	21 500

This table shows that solid residues for energy purposes from shea processing in Mali are estimated at 50,167 tonnes per year, of which 57% are shells from shea nut processing and 43% are cake from almond processing. Currently, at the level of artisanal processing, a very marginal share of the hulls is used in the construction of traditional houses in the villages by the almond producers, but these residues have not been used for energy recovery, even though they can be used as fuel to replace firewood or even charcoal. The deposits of shells resulting from artisanal processing are found at the level of the almond producers in the villages, therefore in a relatively dispersed manner. Concerning industrial processing by MaliShi, this factory buys the almonds (shelled nuts) directly from cooperatives or individual producers. It is therefore more likely to be from the latter that the valorisation of the shells could be envisaged, provided that logistics are optimised to reduce transport costs.

Of the 21,500 tonnes of cake that could be generated annually, 6,500 tonnes would come from processing by the traditional method (churning) and would thus be found at individual processors or cooperatives, but currently almost all (raw cake) would be sold to bakeries for energy recovery (according to MaliShi officials). Of the 15,000 tonnes of cake from the only functional plant in the country (MaliShi), around 20% (3,000 tonnes/year) will be recovered within the plant in their boiler for energy purposes (production of steam for the process) and the latter is looking for solutions to recover the remaining 80% (i.e. almost 12,000 tonnes/year).

[76] Churning method: consists of beating the crushed almonds in a bowl or churn to obtain butter.
[77] Hulls represent 40% of the nuts and almonds represent 60% of the nuts.
[78] Cake represents 50% of the almonds.

4.2.3.5. Case of Senegal

4.2.3.5.1 Forest resources in Senegal

Senegal has been subdivided into six relatively homogeneous eco-geographical zones (ZEG) from the point of view of the potentialities and constraints related to forestry and rural development with various types of vegetation (steppes, savannahs and forests) in relation to the climatic gradient and topography.

- Shrubby and tree-covered regions covering 3,244,448 ha (PFS, 2014) in the Sahelian domain. They are characterized by a very open woody stratum dominated by thorny trees (*Acacia senegal*, *Balanites aegyptiaca*, *Boscia senegalensis* ...) and accompanied by a discontinuous herbaceous carpet dominated by annual grasses;
- Shrubby and wooded savannahs, with 8,120,513 ha (PFS, 2014), located in the south of the Sahelian domain and in the Sudanian domain;
- The clear forests, with 1,785,457 ha (PFS, 2014), correspond to the southern part of the Sudanese domain, with a woody stratum whose cover is higher than 50%;
- Gallery forests, representing 725,177 ha (PFS, 2014), corresponding to the Sub-guinean domain (extreme south-west of the country) ;

The global diagnosis of the forest sub-sector, carried out within the framework of the elaboration of the forest policy document 2005 - 2025 carried out in 2006 and its revision in 2014, confirmed a trend of degradation and regression of forest resources under the effect of recurrent drought combined with harmful anthropogenic actions such as: abusive cutting, recurrent bush fires, overgrazing and agricultural clearing.

In addition to these large plant formations of the different climatic regions, there are different types of vegetation linked to particular topographic conditions, these are the:

- Gallery forests bordering watercourses and located in the Sudanian and Sub-guinean domains;
- Fluviolacustrine vegetation with hydrophytes such as *Pistia stratiotes*, *Typha australis*, *Nymphea lotus*... (invasive species);
- Mangroves with Avicennia africana and Rhizophora racemosain estuaries;
- Niayes, a coastal wetland in the middle of the Sahel with a zonal vegetation with Sudano-Guinean species;
- Specific plant formations due to the dominance of a single species (oil palm grove,rôneraie, bamboo grove or gonakeraie).

4.2.3.5.2 Analysis of wood energy supply and demand

In Senegal, as in other Sahelian countries, traditional fuels (firewood and charcoal) are the main sources of household energy. Indeed, Senegal depends on more than 70% of forest resources to meet its cooking energy needs (Frank Richter, Marion and Abdoul A SOW, August 2014). This is one of the causes of the degradation of forest resources, especially when combined with agricultural clearing and bush fires.

In 2013, with the support of PROGEDE 2, a national survey was conducted on domestic fuel consumption and household practices. They reveal that the quantities of cooking fuels used in Senegal are :

- 1,735,219 tonnes for firewood;
- 482,248 tonnes for charcoal;
- 108,001 tonnes for butane gas.

The regional distribution of the different fuel types is given in the table below:

Table 71: Breakdown of consumption of different fuels in Senegal's main cities [tonnes]

	Urban			Rural		
	Wood	Charcoal	Gas	Wood	Charcoal	Gas
Dakar	54 374	209 938	67 158	6 147	3 505	1 336
Thies	79 087	36 128	12 537	226 927	26 182	3 289
Diourbel	10 001	10 363	1 332	110 633	38 806	3 246
Fatick	7 568	5 909	1 127	100 318	13 801	1 213
Kaolack	12 999	20 942	3 014	109 428	12 480	826
Kafrine	6 807	4 942	327	107 792	8 921	83
Louga	15 916	4 125	1 676	137 146	2 280	363
ST-Louis	35 088	16 960	2 740	72 302	10 214	2 298
Matam	10 814	568	332	114 026	-	1 198
Tamba	25 630	10 231	758	121 345	8 784	383
Kédougou	3 556	1 082	108	24 685	212	32
Kolda	57 257	9 009	457	117 883	3 515	135
Sedhiou	14 079	2 374	221	60 721	1 947	90
Ziguinchor	12 907	16 773	1 316	79 783	2 257	406
Total	346 083	349 344	93 103	1 389 136	132 904	14 898

(Source: PROGEDE/SEMIS-2013 consumption survey)

Analysis of the above table on the distribution of consumption reveals a changing situation: the capital, which a few years ago concentrated 90% of charcoal consumption, now accounts for only 44% of demand. The rest, i.e. most of the demand (56%), is scattered throughout the country between urban, semi-urban and rural areas.

Taking into account the carbonization techniques used and assuming that all wood fuel consumption is the result of a homogeneous method of extraction, it is estimated that charcoal consumption is equivalent to a forest extraction of 2,471,340m^3 of wood, which is twice as heavy on the forest resource as that of fuelwood (1,306,986 m^3).

However, SIEF estimates (2013 report) show that domestic fuel consumption in 2012 was estimated at around 900,000 tonnes for firewood, 400,000 tonnes for charcoal and 100,000 tonnes for butane gas. These estimates note that (i) the consumption of fuel wood and charcoal increased between 2000 and 2012 with an annual average rate of 3%, (ii) that of LPG increased between 2000 and 2005 with an annual average growth rate of 7% and decreased between 2005 and 2012 with an annual average rate of decrease of 4%. The energy transition is almost complete in the capital (Dakar) where 86% of households use butane gas as their main fuel. However, charcoal is still present and is the main fuel for 12% of households in the Dakar region and wood is now the main fuel for only a residual 1% of households.

In response to the threats to forest resources, Senegal has since 1997 defined new strategic policies to reduce the pressure of logging for fuel needs. These policies are based on sustainable management of wood resources with the involvement of people living near forests in order to better control supply; and promotion of a policy of substitution of traditional energies through the use of butane gas and improved stoves at household level to contain the growing demand for wood fuel.

4.2.3.5.3 Forest Value chain in Senegal

Forest value chain in Senegal is dominated by the woody energy value chain that is largely comprised of charcoal and firewood. Fuelwood plays a very significant role in meeting the energy needs of households, especially rural households. It accounts for 49% of the energy balance according to the household consumption survey conducted by PROGEDE 2 in 2014. Charcoal is still the first cause of forest resource extraction for energy purposes (61% of primary resources for charcoal against 39% for fuelwood). Themain sources of wood energy supply are developed forests, undeveloped forests, trees outside forests and wood from reforestation (see Figure 70 below).

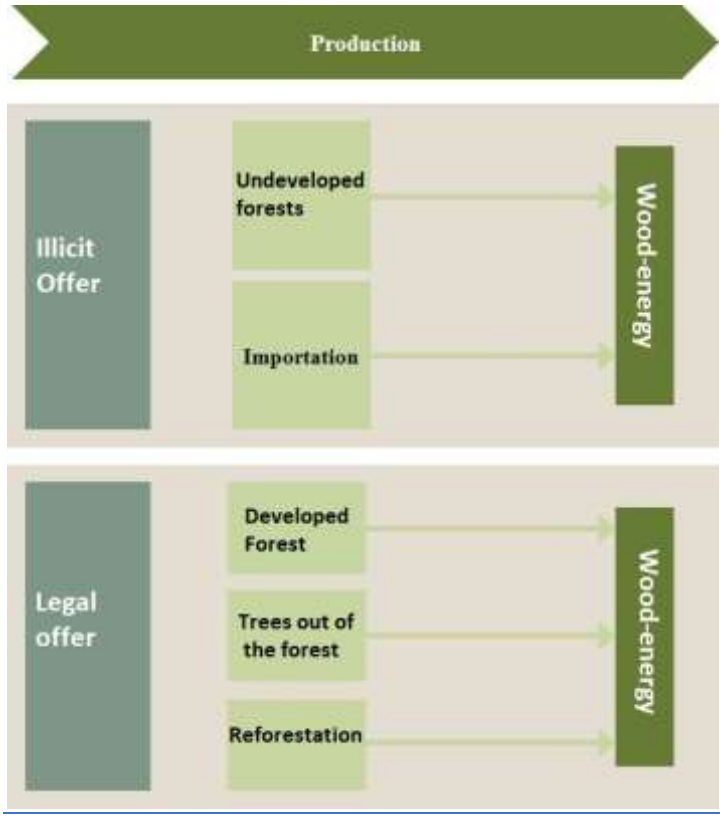


Figure 70: Sources of wood energy production

Source: **Frank Richter, Marion Mundhenk& Abdoul Aziz Sow (2014)**

4.2.3.5.4 Players involved in Senegal forest value chain

4.2.3.5.4.1 Wood charcoal value chains actors

The actors of the charcoal sector are: forest operators, the "sourga", local producers, transporters, "bana-bana s" or "coxeurs" and retailers called "diallokerigne". In the diagram below, we present the position of each actor within the sector and the interrelationships that exist between them.

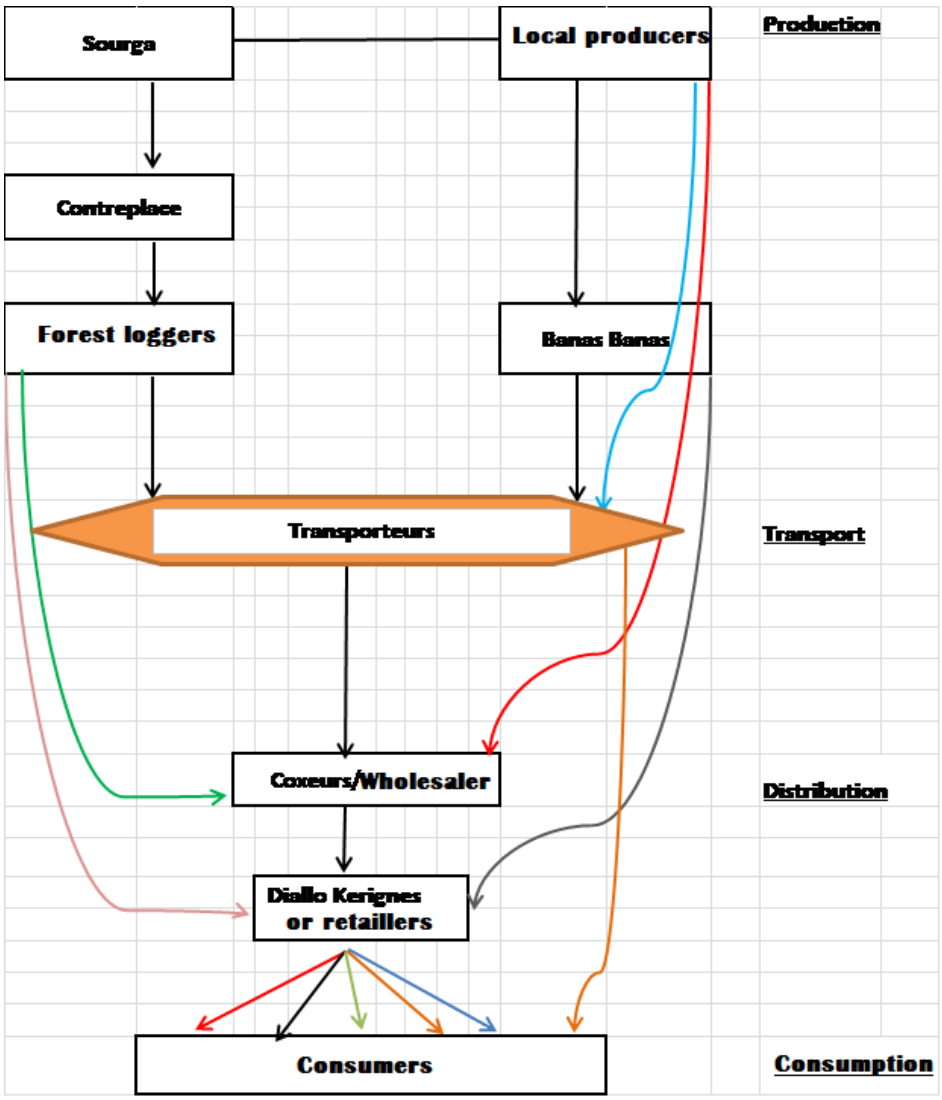


Figure 71: Organization of the charcoal industry

As for the fuelwood industry, there is no particular organization for the fuelwood industry, apart from the required administrative documents. As it is not a product subject to quotas, collection of dead wood and is allocated by the Directorate of Water and Forestry on request, mainly for religious events. Local communities around forests are authorised to freely collect dead wood as part of the exercise of the right of use.

4.2.3.5.4.2 Timber value chain actors

Timber is subdivided into two categories:

- Timber harvested by sawmills and used in carpentry/joining, construction (framing) and industry. Minimum logging diameters are specified in the decree setting taxes and royalties for logging;
- Timber species used by craftsmen/joiners affiliated to the Chamber of Trades of the regions of Tambacounda, Kédougou. The logging diameters are smaller than those specified in the decree setting the taxes and royalties for forest exploitation;

Concerning the exploitation of timber species, the forest service sets each year, through the ministerial order issued for this purpose, the number of feet to be exploited according to an empirical assessment of the existing situation, which does not relate either to surface area or volume.

The main sampling areas are the regions of Kolda and Sédhiou for approved sawmills and Tambacounda and Kédougou for craftsmen and carpenters affiliated to the Chamber of Trades. Given the extent of fraudulent timber exploitation in theKolda and Ziguinchor regions bordering the Gambia, quotas are currently confined to the Kédougou and Tambacounda regions alone. The species concerned are the kapok tree (*Bombax costatum)*, the cauliflower (*Khaya senegalensis), the* linker (*Afzeliaafricana), the*Cayor pear or "Dimb" (*Cordylapinnata)* and the santan (*Danielliaoliveri*). In 2016, the quantities exploited by species are presented in the table below:

Table 72: Quantities of timber harvested by number of feet

	Caïlcédrat		"Dimb"		Linked to		Santan		Kapokier		TOTAL	
	KD	SD	KD	SD	KD	SD	KD	SD	KD	SD	**KD**	**SD**
TOTAL	100	345	85	230	125	340	75	195	85	155	**470**	**1.265**

KD = Kolda SD = Sedhiou

The sawmills approved by the Ministry of the Environment and Sustainable Development (MEDD) are made up of 15 organizations (GIE, Company, Cooperative) of GIEs (GIE EXPL. F. SUD, GIE T DIA, GIE Guorgorlou, GIE Bois du Sud and companies (RENAISSANCE, DERICOURT/SAB, SAT/ TOBOR, Nouvelle Scierie de Tobor, SCIERIE KAMOU, GETPLS, KOUSSY, CASA- BOIS, BOUTOLATTE, SOCEFCA, GYLS).

The quotas allocated by the State for the exploitation of timber are based on the number of feet and not in terms of surface area (see table below).

Table 73: Changes in the quantities of timber allocated and harvested in number of feet

Year	Timber Quota (feet)	Quantity exploited
2014	1 600	587
2015	1 600	587
2016	1 838	1 570
2017	1 680	1 095
2018	300	281
2019	350	350

Source DEFCCS

Service wood includes bamboo poles, crinting boards, stakes, posts and poles. For the exploitation of bamboo stems and crinting boards, the quotas set by the State and the quantities exploited are presented in the following table:

Table 74: Allocated and operated volumes of bamboo stems and crinting boards

Year	Bamboo stems		Crinting panel	
	Allocated quota	Quantity exploited	Allocated quota	Quantity exploited
2014	30 000	29 500	70 000	63 300
2015	51 000	39 700	70 000	63 300
2016	71 300	20 600	94 300	41 080
2017	40 000	7 750	95 000	43 470
2018	15 000	15 000	35 000	34 400
2019	15 000	15 000	35 000	35 000

Source DEFCCS

The reduction in the quantities of timber and services since 2018 is explained by the suspension of logging in the Kolda, Sédhiou and Ziguinchor regions following the tragic events that occurred in the Boffa-Bayottes forests in 2018.

4.2.3.5.5 Sources and types of forest biomass in Senegal

Table 75: Sources of forest biomass residues related to the charcoal sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	*Charcoal residue (dust)* Branches, shavings Bark, sheets	Charcoal production sites forest	Wood cutter	Collection for firewood (domestic) Bark and leaves for the pharmacopoeia
Distribution	Dust available after sorting before retail sale	Retail outlets	Retailers	…… .
Consumption	Dust available after sorting before coal consumption	Private homes Restaurants …	Households and professional users such as restaurants	…… .

Table 76: Sources of forest biomass residues related to the "fuelwood" sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Bark	Forest	riparian	Pharmacopoeia (some species, not systematically exploited)

4.2.3.6. Case of Togo

4.2.3.6.1 Forest resources in Republic of Togo

Togo, like its eastern neighbour Benin, is not a forested country. It is not easily possible to distinguish in Togo a mosaic of plant formations composed of semi-deciduous forests (located in ecological zone IV), dense humid forests (located in ecological zones III and V), dense dry forests (which have almost disappeared in Togo), open forests, savannahs (palm savannah, wooded savannah, shrubby savannah), gallery forests, mangroves[79]. Togo's forested area is estimated at 3,376,188 hectares in 2016, i.e. a coverage rate of 24.24% of the country. The breakdown of the area by land use category and economic region is presented in Table 77.

Table 77: Breakdown of area by category and region, 2016

Stratum	Area by region [ha]						
	Savanes	Kara	Central	Plateaux	Maritime	TOTAL countries	% of total country
Semi-deciduous and deciduous dense forests	330	1 604	30 699	71 930	22 968	127 531	1%
Gallery Forest	36 467	67 920	103 172	115 899	19 516	342 974	4%
Clear forest and wooded savannah	44 926	125 201	210 933	351 967	125 348	858 375	9%
Savannah with trees and shrubs	218 077	466 409	600 497	578 722	122 848	1 986 553	22%
Mangrove	0	0	0	0	0	-	0%
Plantations	805	1 769	10 544	25 347	14 193	52 658	1%
Marshland formations	41	0	0	0	8 056	8 097	0%
Wooded Sub-Total	**300 646**	**662 903**	**955 845**	**1 143 865**	**312 929**	**3 376 188**	**37%**
Cultivated land	465 900	366 096	255 338	460 929	200 272	1 748 535	19%
Grassy formations	67 834	89 884	62 586	67 518	26 062	313 884	3%
Human settlements	12 584	22 693	22 081	30 614	56 784	144 756	2%
Other land	14 752	11 299	28 647	19 762	30 227	104 687	1%
non-wooded subtotal	**561 070**	**489 972**	**368 652**	**578 823**	**313 345**	**2 311 862**	**26%**
Total countries	**861 716**	**1 152 875**	**1 324 497**	**1 722 688**	**626 274**	**5 688 050**	**63%**

Source: (ECO Consulting, JUIN 2017)

The two most forested regions are the Plateaux region and the Central region with 1,143,865 ha and 955,845 ha respectively. The regions with the largest cultivated areas are the Savannah region (465,900 ha) and the Plateaux region (460,929 ha).

[79](Ministry of Environment and Forest Resources (MERF), November 2011)

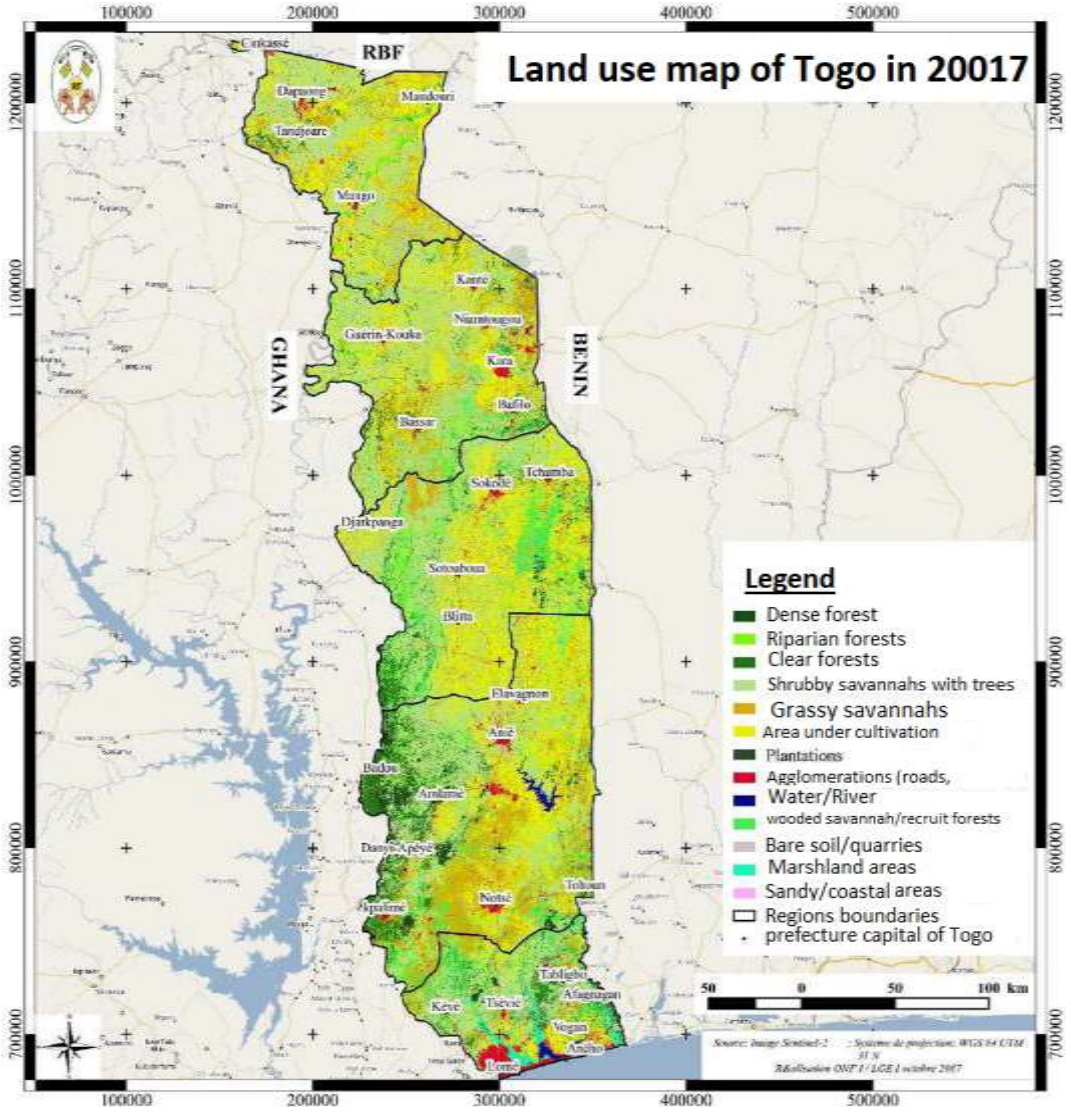


Figure 72: Land use map of Togo in 2017[80]

Although Togo is not a forest country, it has set up a mechanism to strengthen and revitalize its forest sector with a global vision: "to achieve by 2035 a forest cover of 20%, fully covering its needs for wood energy, conserving its biodiversity and ensuring sustainable protection of areas at risk and wildlife habitats"[81]*. This ambitious vision shows the importance that Togo attaches to the wood energy sector without neglecting the timber and service wood sector. Indeed, in Togo, as in some non-forest sub-Saharan countries, the wood energy sector plays a predominant role, in that it represents not only an important source of employment, but also the main source of energy for the population. According to a study carried out in 2017, the number of jobs generated in 2010 by the wood energy sector was estimated at 655 425 for commercial fuelwood producers and 206 239 for charcoal producers*

4.2.3.6.2 Wood energy supply and demand

A study commissioned by REDD+ Togo, carried out in 2017 by ECO Consult and entitled " Etude approfondie sur la dynamique de l'utilisation du bois-énergie au Togo "[82]*, allowed for a diagnosis based on the needs*

[80] (REDD+, March 2018)
[81] Forest Policy in Togo
[82] (ECO Consulting, JUIN 2017)

and available resources of stakeholders in the sector. In its study, the ECO Consult firm, in order to specify the potential production of fuelwood, considered only i) natural forests, ii) reforestation and forest plantations and iii) trees outside forests. Thus, forest areas with specific status such as protected areas, classified forests and community forests that are primarily oriented towards conservation were not accounted for.

On the basis of information gathered such as the average standing volume, the average volume of wood for wood energy use, calculations made and taking into account certain parameters of good management (rate of removals, rotation), the firm ECO Consult estimates, in 2016, the potential national supply of wood energy at 3.28 million cubic meters per year, equivalent to 2, 297,225 tonnes of wood (average wood density 0.7 t/m³). This supply can be broken down as follows:

Table 78: Total wood energy supply in Togo, 2016

Source of wood energy	Offer		
	(m³/year)	(t/year)	(%)
Production from natural forests	2 228 090	1 559 663	68
Forest plantation production (reforestation)	98 207	68 745	3
Trees outside forests	954 409	668 817	29
Total	**3 280 706**	**2 297 225**	**100**

Source : Consulting, JUIN 2017

This annual value is achieved by applying a rotation of 12 years for natural forests and trees outside forests and eight (8) years for reforestation, based on the experiences of the Office for the Development and Exploitation of Forest (ODEF).

The ECO Consult firm has estimated, in 2017, the total consumption of wood energy in Togo at 7.576 million cubic meters per year. This estimate is made using an elaborate simulation model and on the basis of total household consumption and that of professional consumers.

Table 79: Annual consumption of wood energy by socio-professional categories in Togo, 2017

Wording	Wooden Demand		
	(m³/year)	(t/year)	(%)
Urban and rural households			
Firewood	2 150 294	1 505 206	28,4
Charcoal[83]	4 074 923	2 852 450	53,8
Sub-totalhouseholdconsumption	6 225 217	4 357 656	82,2
Professional consumers			
Firewood	883 125	618 188	11,7
Charcoal[6]	468 580	328 010	6,2
Sub-total consumption of professionals	1 351 705	946 198	17,8
Total	7 576 922	5 303 854	100,0

Thus, in 2017, demanded exceeded potential wood energy production in Togo and the theoretical deficit between supply and demand amounted to 4,296,216 m³/year, a factor of 2.3.

[83] In wood equivalent, calculated with a carbonisation efficiency of 10% and a wood density of 0.7 t/m³.

4.2.3.6.3 Wood energy supply basins

The location of the main logging basins in each of the country's economic regions is illustrated in the following figures[84]:

[84](ECO Consulting, JUIN 2017)

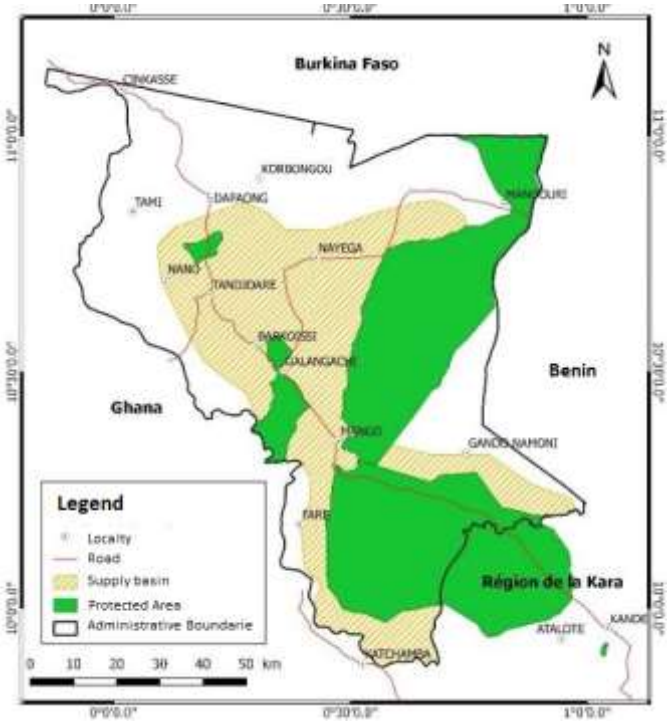


Figure 73: Location of the main exploitation basins. Savannah region

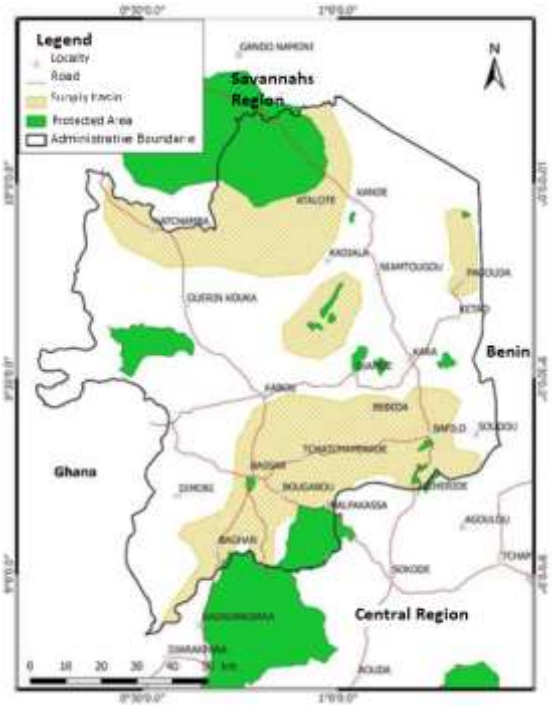


Figure 74: Location of the main exploitation basins, Kara region

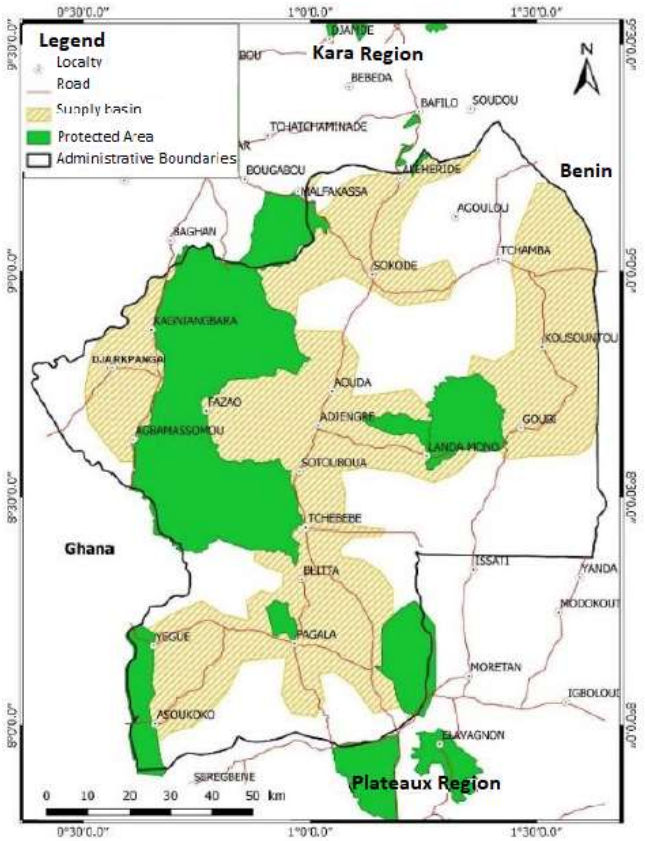


Figure 75: Location of the main operating basins, Central region

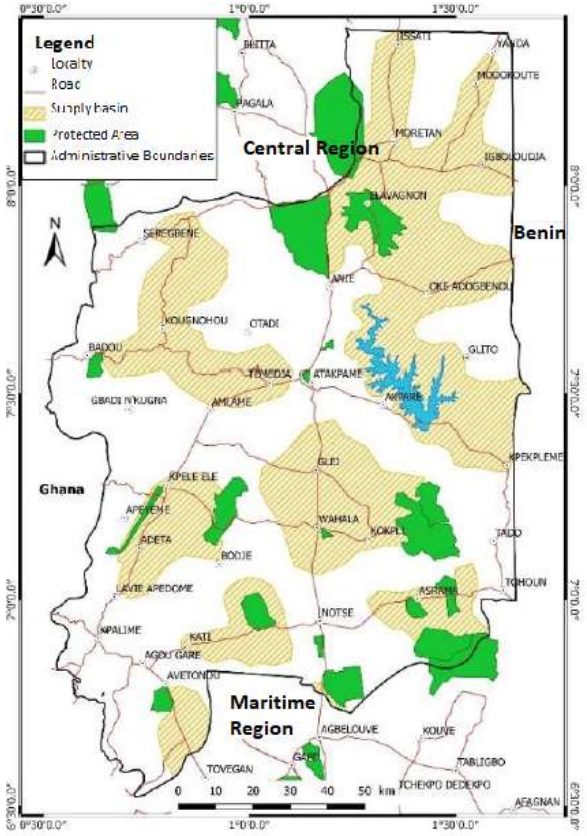


Figure 76: Location of the main operating basins, Plateau region

Region/PrefectureCanton concerned

Table 80: Region/Prefecture and concern areas

Tchaoudjo	Kolina
Tchaoudjo	Kpangalam
Tchamba	Bago
Blitta	Yaloube
Blitta	Langabou
Tchamba	Alibi 1
Tchaoudjo	Alheride

Region/Prefecture Canton concerned

Table 81: Region/Prefecture and concern areas

Ogou	Glei
Wawa	Ounabé
Wawa	Okou
Anie	Pallakoko
Kpele	Bodjé
Kloto	Yokélé
Danyi	Atigba

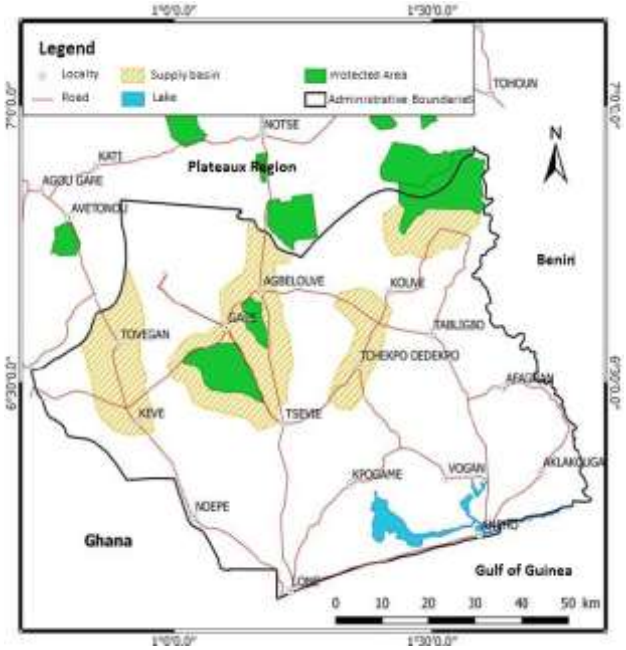


Figure 77: Location of the main operating basins, Maritime region

Region/Prefecture	*Canton concerned*

Table 82: Region/Prefecture and concern areas

Yoto	Kouvé
Zio	Gblainvié
Zio	Gbatopé
Zio	Davié
Zio	Agbelouvé
Zio	Dalavé
Zio	Bolou

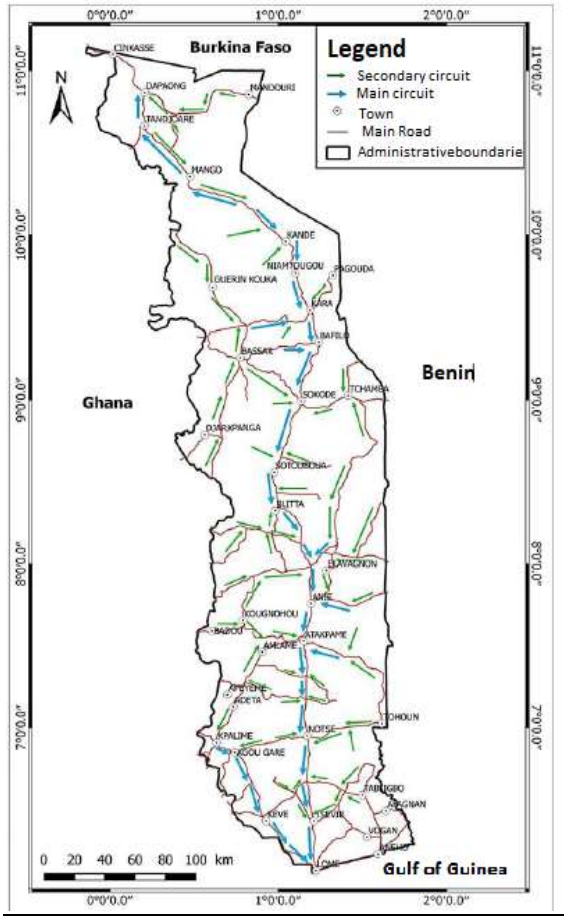


Figure 78: Location map of the main wood energy flows, 2017[85]

4.2.3.6.4 Forest species exploited for wood energy

According to the study carried out by ECO Consult, 94 forest species exploited for wood energy in Togo have been identified. These species are classified among twenty-six (26) families of which the most represented are fabaceae (acacia) and combretaceae. The number of species cited varies by region and the species listed have been classified into two categories:

- Category I, grouping the species preferred by producers/consumers (about 58 species);

[85](Abotsi K.E /ECO Consulting Group, 2017)

- Category II grouping species used alternatively or by default when preferred species are not, or no longer, available.

4.2.3.6.5 Players involved in Togo forest value chain

As for the wood energy the value chain ranges from the production to the consumption link, as shown in Figure x.

Figure 79: Landscape oj olders inTogo

Source: (ECO Consulting, JUIN 2017)

4.2.3.6.5.1 Forest management and conservation

According to Article.7, paragraph 3 of the Togolese Forest Code, the forest estate is "all the forests distributed over the national territory". According to the Code, there are three forest estates to be distinguished: the State forest estate, the forest estate of territorial collectivities and the forest estate of private individuals. The State forest estate consists of forests, woodlands and land to be reforested, registered in the name of the State or having been classified before or after the promulgation of the Code. Classification refers to the procedure by which a piece of land is incorporated into the State forest estate". (Art. 8). These forests thus belong to the State, which establishes the rules for their management and exploitation through the intermediary of the Forest Administration, but with the participation of the riparian populations in such management.

In Togo, the Office for the Development and Exploitation of Timber (ODEF) of the Ministry of Environment, Sustainable Development and Nature Protection has among its main objectives the management,

equipment and development of the national forest estate, the development and treatment of all existing state-owned forest stands on the national territory and studies for the introduction of new species[86].

According to article 20, the forest estate of the territorial authorities is made up of forests and woodlands allocated by the competent Forest Resources Administration to the decentralized territorial authorities (village, municipality, prefecture, region), in agreement with the local authorities. This domain is the property of the State (the region, the prefecture, the municipality), which therefore has the management of it.

According to article 24 of the Forestry Code, "The forest estate of private individuals consists of forests, woodlands and land to be reforested that are registered or recognized in the name of private individuals and forests, woodlands and forest land developed and exploited by private individuals". These forests may, in accordance with article 45 of the Forest Code, be freely exploited by these private individuals or by one or more supply contracts concluded between them and one or more local processing companies, provided that a management and development plan is drawn up.

For this purpose, individuals are defined as "natural or legal persons, rural or grassroots groups or communities which do not fall within the category of territorial authorities". (Art.25). Community forests are therefore also private forests. Examples of "private individuals" are peasants or groups of peasants, Civil Society Organizations (CSOs), etc. (Art. 25). There are two national associations of private planters (Association des PlanteursPrivés du Togo and Afrique Verte Togo), a consortium of CSOs for wood energy composed of five organizations (NGOs AJA, EQUI-NAT, APDPE, CADO and SYNPA-Togo), and eight cooperatives of wood energy producers (CoProBE) set up in the pilot areas of the Program for Rural Development and Agriculture, particularly the economic zones around Tsévié, Kpalimé and Sokodé[87].

4.2.3.6.5.2 Forest operators

The Togolese Forest Code does not specifically define "trade in forest products". Moreover, it only mentions it in Article 7, in the definition of "forest operators". In fact, the term 'forest operator' refers to 'any natural or legal person involved in the development, collection, exploitation, processing, transport and trade of forest products'. (Art.7, para.10).

4.2.3.6.5.3 Forest exploitation and harvesting actors

The forestry code describes forest exploitation[88] as "the harvesting of forest products such as wood, exudates (liquid oozing from a plant such as **gums**, **resins** and **latex**), honey, leaves, herbs, fruits, bark, roots; the harvesting of wildlife and the use of the forest for tourism and recreation. "(Art.7, para.8)

Article 31 of the Forest Code states: "The exploitation of a parcel of forest belonging to the State forest estate may be granted to one or more forest operators, by the allocation of a permit to cut a limited a category of wood or forest products". According to article 39, the exploitation of forests and woodlands in the State forest estate may be carried out by management cutting, sale of timber, cutting permits or forest management contracts.

Private individuals' forests or woodlands may be freely exploited by such individuals or by one or more supply contracts concluded between them and one or more local processing companies (Art. 45). The Forest Resources Administration must encourage such private individuals to :

- develop a plan for the rational development and management of their forests ;
- design and implement jointly with neighbours an integrated development plan for their land for a balanced exploitation of the environment (Art. 45).

[86] (Office de Developpement et d'Exploitation du Bois, 2020)
[87](ECO Consulting, JUIN 2017)
[88] (LAW NO. 2008-09 ON THE FORESTRY CODE, 2008)

The exploitation of private individuals' forests is therefore subject to a management and development plan drawn up by them.

Several private actors are involved in the forest sector in Togo, including timber exploitation companies, wood processing industries and units, etc. However, the sector remains dominated by the informal sector. Thus, a total of 570 individuals (mainly peasants or rural dwellers), often referred to as farmers and working in the informal sector, are involved in chainsaw sawing of forest species from natural forests in general and rarely in private teak plantations[89].

As for the wood processing sector, it is very poorly developed. Indeed, there are no real wood processing units in the country. Togo has no large sawmills or peeling or slicing units. Sawing of wood is generally done in an artisanal way using chainsaws.

4.2.3.6.5.4 Actors involved in exploitation of wood energy

There are three categories of wood collectors/operators[90]:

- *Rural (more than 80%) and urban/peri-urban (46%) populations collecting for self-consumption: in rural areas, especially women and children collect dead wood or cut small wood. No statistics are available as no prior application or administrative document is required.*
- *Occasional (91%) or regular (professional loggers (9%) foresters, living in the locality, who collect or cut trees for marketing: mostly men, 74% of the farmers are loggers woodcutters engaged in felling and cutting trees.*
- *The ODEF (Office for the Development and Exploitation of Forests) which produces and markets a certain amount of firewood. The wood, of modest quantity, put on the market by ODEF comes from the valorization of by-products resulting from the works of preparation of the grounds during the actions of reforestation, from the products resulting from thinning and from the waste of sawing of teak.*

4.2.3.6.5.5 Transporters / logistic actors

The transport of wood energy differs according to whether it is used for self-consumption or commercial purposes. For household self-consumption, the transport of woodfuel is mainly done by head carrying (mostly by women and children) and sometimes by bicycle or motorcycle by men.

For the transport of wood energy (firewood and charcoal) used for commercial purposes, there is a short supply circuit to secondary towns and a long circuit to the main towns (regional capitals) and the Grand-Lomé. Different transporters provide the link between the production areas and the main centers of consumption.

- Wholesale transporters: they mainly supply the Greater Lomé region on journeys from north to south using semi-trailers or *Titans* (35 tonnes) for the transport of goods destined for the interior of the country or the hinterland.
- *Semi-wholesale transporters: they use six (06) wheel trucks (between 10 and 35 tons) to supply the main urban centers (regional or prefecture capitals); their main customers are bakeries, soap factories, and agricultural product processing units.*
- *Collector-Retailer Conveyors : They collect wood or coal from rural areas within a radius of about 30 kilometers and transport it to urban centers to sell it directly to customers using motorized logistics means such as tarpaulins, minibuses, etc.*

[89] *(Ministry of Environment and Forest Resources (MERF), November 2011)*
[90] (Rural Development Program including Agri-culture (ProDRA) Component III, 2014)

- Private transporters: these are private individuals who occasionally transport small quantities of wood (less than 500kg) or charcoal (3 bags maximum) purchased on the road for domestic needs. Theygenerally use pick-up trucks or privatevehicles.
- Retail transporters**:** They transport wood in small quantities (one bag of charcoal or less than 100 kg of wood) in urban centers, particularly by bicycle or on their heads (walking transport).

In terms of stakeholder organization, there are woodfuel shippers' associations in most regions but none at the national level.

The transportation of timber is mainly done with trailers or semi-trailers from logging sources. The same applies to service timber when the distance is long.

4.2.3.6.5.6 Wood fuel traders and consumption actors

In Togo, the use of forest biomass (firewood and charcoal) for domestic energy needs plays an important role. Self-consumption of firewood and charcoal represents 76% and 14.5% of national production respectively. While the marketing of fuelwood represents 24% and charcoal 85.5% of national production. Only 30% of the volume of fuelwood and 65% of the volume of charcoal traded is controlled by the forest services.[91]Fuelwood is mainly marketed by heap (63.3%), by bundle (30.3%) and by cart (4.6%).

Firewood is used in a high proportion by rural households while charcoal is used in large part by urban households. The choice of fuel use (firewood or charcoal) depends on several factors such as availability, convenience of use (smoke, soiling, etc.), cost, storage, etc. The choice of fuel (firewood or charcoal) depends on several factors such as availability, convenience of use (smoke, soiling, etc.), cost, storage, etc. The choice of fuel (firewood or charcoal) depends on several factors such as availability, convenience of use (smoke, soiling, etc.), cost, storage, etc.

The reference units for charcoal marketing are variable throughout the chain. Upstream, between producers and traders, marketing is mainly done by bag. Downstream of the sector, at the level of wholesale and retail traders, the reference units are: the bag (34.51%), the basin (31.86%), the pot (7.96%) and the plastic bag (25.66%). In the vast majority of cases, the marketing activity (wholesale and retail sales) is carried out by women including through cooperatives.

In its study, ECO Consult considered two major actors in the consumption of wood energy. These are the households and socio-professional categories (CSP) among which we can cite artisanal bakeries, school canteens, local breweries, fish smoking, Gargotes / Maquis, traditional soap factories, pottery / ceramics cooking, the Forge, units processing agricultural products, the preparation of gari and the preparation of oil (peanut oil, palm oil).

4.2.3.6.5.7 Timber traders and consumption actors

There are several private actors involved in the forest products trade in Togo, including timber import and export companies. Timber import companies maintain a marketing circuit for logs or sawn timber products between Togo and neighbouring countries. They also import furniture or peeling products for national consumption. Togo is largely dependent on the outside (mainly Ghana) for sawn timber, which provides about 62% of consumption. The main companies involved in timber exports to Togo are : SODETRANS, TOGO-BOIS, SUPER AVENIR, GLOBAL SUCCES, GAT, TRASDETO, JUMEAUTRANS, DOUKKEHTRANS, TRANSACOM, SECATRANS, CDA, SOKEY, ETS SHAKTI

[91]*(Ministry of Environment and Forest Resources (MERF), November 2011)*

OVERSEAS, DRAGON D'OR, etc. These companies associate other activities with the export of wood, so that they are not usually registered as wood sector companies[92].

Timber is mainly consumed in rural areas, which with 60% of the population and a poverty incidence of 74.3%, uses 63% of production[93]. Forest products such as shells, poles, bamboos, posts, raffia, etc. are used as building materials. The average consumption of service wood is estimated at 0.08 $m^{3.}$ In addition to teak plantations, nearly 90% of the other plantations in Togo are of fast-growing species, mainly *Eucalyptus*, *Terminalia, Cedrela*, *Bambusa,* etc. They mainly meet the objectives of service wood and firewood production[94].

4.2.3.6.6 Main sources and types of forest biomass residues in Togo

The following tables describe the different types of residues related to each forest biomass chain and the actors involved in each corresponding value chain.

Table 83: Sources of forest biomass residues related to the charcoal sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (charcoal production)	Charcoal residue (dust) Poorly charred wood	Charcoal production sites (Central, Kara, Plateaux regions)	Occasional and professional charcoal mongers	*Not known*
Distribution	Dust available after sorting before retail sale	Retailoutlets	Retailers	Sale to forges Filling of holes to prevent water stagnation Disposal in the garbage
Consumption	Dust available after sorting before coal consumption	Private homes Restaurants Seller on the street	Households and professional users such as restaurants	Disposal in the garbage Filling of holes to prevent water stagnation

Table 84: Sources of forest biomass residues related to the fuelwood sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Small Branches Sheets	Cutting sites	Lumberjacks	*Not known*
Distribution	Small woods	Retailoutlets	Retailers	Rejection
Consumption	Charcoal	Private homes School Restaurants and Canteens	Households, food production and processing units	Reuse of charcoal produced

[92](Ministry of Environment and Forest Resources (MERF), November 2011)
[93] (Ministry of Environment and Forest Resources (MERF), November 2011)
[94] *(Ministry of Environment and Forest Resources (MERF), November 2011)*

		Artisanal bakeries Smoking of poisons Local breweries (''tchoucoutou'') Gari producers in the Zou, the Couffo, the Hills Red palm oil or peanut oil producers		

Table 85: Souces of forest biomass residues relative to the timber and service sector

Categories in the value chain	Type of residues	Location	Actors	Current use
Primary exploitation (felling and logging)	Branches Small Branches Bark Sheets	Cutting sites	Lumberjacks	*Not known*
Secondary exploitation (woodprocessing)	Sawdust, shavings, bark	Sawmills	Furniture production units	Chips used in animal husbandry Sawdust sold to housewives for combustion
	Chips	Joineries	Carpenters, Cabinetmakers	Chips used in animal husbandry
	Bark, shavings	Craft stores	Sculptors of objects, manufacturers of percussion instruments, mortar, dugout canoes, etc.	*Not known*
Consumption	Used pallets	Warehouses, stores	Supermarkets,	Sale for recuperation
	Furniture at the end of the cycle	Houses, services	Households, service units	Disposal in the garbage Use as fuel

After studying the different sources of residues generated in the wood products supply chains, it appears that the most easily recoverable waste in terms of availability (quantity and accessibility) is charcoal dust, particularly that available in large urban centers. Indeed, since it can represent up to 20% of the total weight of a bag of charcoal, fairly large deposits of fine and coarse dust could be collected in large cities, especially from charcoal distributors, especially retailers sorting before sale, and, to a lesser extent, from final consumers purchasing per bag, especially relatively well-off households or professionals such as restaurant owners. Once mixed with a binder and then compacted using a press, this raw material would be used to produce organic coal as an alternative fuel to charcoal. A major difficulty arises, however, because for the time being the available data allowing us to assess the real availability of this residue are not necessarily conclusive. It would be necessary to undertake more research with local stakeholders in order to better refine this potential.

4.2.3.6.6.1 Logging residues

The situation in Togo is almost similar to that in Benin. The country is not a major timber producer. It does export timber, but mainly in the form of logs. And at this level, processing generates only an insignificant amount of waste, especially branches and foliage obtained after pruning.

As can be seen in the export table below, the quantity of wood exported in the form of processed products (plywood, profiles, boards) remains effectively low to very low (e.g. profiled wood). This confirms the absence of the large processing plants mentioned above.

Table 86: Timber exports to Togo (in tonnes)

Type	HS Code	2015	2016	2017	2018	% weight of AO6 (2018)
Raw wood (logs)	4403	104 518	33 882	30 537	13 150	9,5%
Planks th>6mm	4407	2 083	204	959	396	0,2%
Firewood	4401	-	807	10	7	0,8%
Vegetablecoal	4402	99	-	17	168	1,9%
Profiledwood	4409	14	1	2	3	0,1%
Plywood, densified wood and veneer sheet	4408, 4411, 4412 and 4413	573	817	281	2	0,0%
Others	4404, 4405, 4406, 4410	-	-	-	-	0,0%
Total		**107 287**	**35 712**	**31 805**	**13 726**	

Source : N Comtrade

4.2.3.6.6.2 Residues from other pathways

The two promising value chains are cashew nuts and shea butter. Togo is the seventh largest producer of Shea butter in Africa. The production areas, the quantity produced and the potentially recoverable quantity of waste for these two sectors are presented as follows:

4.2.3.6.6.2.1 Cashew nutchain

> *Togo started producing cashew trees very early. The first large-scale cashew tree plantations were carried out between 1967 and 1975 (establishment of nearly 5,000 ha of state and private plantations) thanks to the TOGOFRUIT company (National Society for the Development of Fruit Cultivation) accompanied by the Regional planning and development corporations (SORAD). However, certain problems - such as the complete disorganization of the actors, the absence of official statistics on the sector and national strategies, and the lack of coaching and advisory support - have led to a decline in the sector.*

Today, the sector is experiencing renewed interest thanks to a political will to relaunch the agricultural sector initiated in 2010 and supported by technical partners such as the GIZ through its Program for Rural Development and Agriculture (ProDRA). The sector is better organized and professionals are united within the Interprofessional Council of the Cashew Industry of Togo (CIFAT) and the sectors'[95] umbrella organization.

The industry is doing well at the moment. Over the period 2017-2019, production has indeed increased by about 47%, rising from 15,000 to 22,000 tonnes. The CIFAT plans to market 25,000 tonnes during the 2020 campaign.

[95](Ministry of Agriculture, October 2015)

This corresponds to a growth of about 14% compared to 2019 (22,000 tonnes marketed) (Akoda, Togo to produce 25, 000t of raw cashew during the 2019 - 2020 campaign, 2020).

In Togo, the "cashew production" link of the cashew nut chain totalled in 2014 more than 18,000 producers (about 16,000 small individual producers and about 2,600 producers organized in cooperatives, themselves organized in the National Association of Cashew Producers and Cooperatives (ANCPA)). In the same year, 21,417 plantations were sown on an area of 18,527 ha with an average yield of 390 kg/ha and a production of 6,268 tons. Of the four cashewnut producing regions, the two main producing regions alone accounted for more than 86% of these plantations. These are the Central region (7,523 producers for 6,448 ha and 2,760 tonnes of nuts produced in 2014) and the Plateaux region (7,391 producers for 9,643 ha and 2,844 tonnes of nuts produced in 2014)[96].

Generally speaking, the 18,600 producers declared in Togo in 2014 were cultivating plantations which are mostly made up of small orchards, 46% of which have an area of about 0.5 ha. The overall distribution is as follows:

- 70% own less than one hectare ;
- 27.2% own between 1 and 5 hectares;
- 0.7% have farms larger than 10 hectares.

However, since 2012, there has been an expansion of plantations and the creation of new plantations, some of which are real commercial investments. As a result, a few producers have stood out from the crowd, with plantations ranging from 80 to 550 ha in size[97]. This trend could explain the current good shape of the sector.

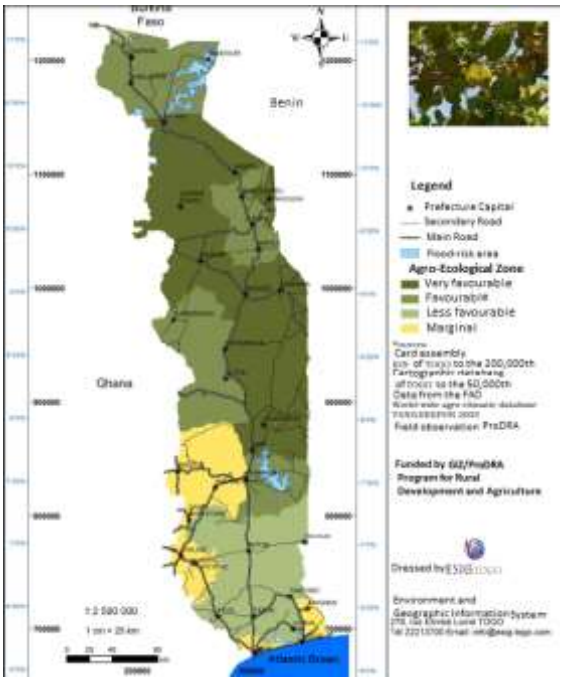


Figure 80: Overview of agro-ecological zones for cashew nut cultivation in Togo

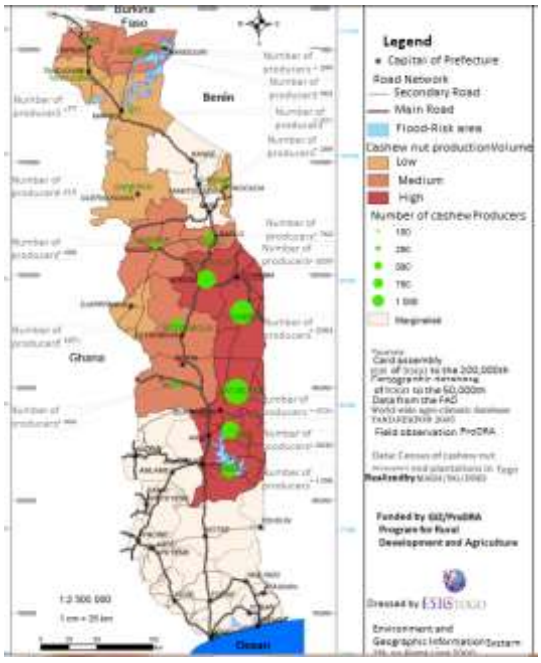


Figure 81: Number of cashew producers and production volume 2013/2014

Until 2015, the "processing" link was marked by the presence of a single company processing nuts into almonds, theCajou Espoir company. Established in theTchamba region (400 km from Lomé, northern Togo) since 2004, this company is the first industrial cashew nut processing unit.

[96] (Ministry of Agriculture, October 2015)
[97] (Ministry of Agriculture, October 2015)

The company's production increased from 30 tonnes of raw nuts processed in 2005 to 2,400 tonnes in 2014, 250 tonnes in 2010 and 1,200 tonnes in 2012. In Tchamba, the company processed 2,600 tonnes of cashew in 2015. The nuts come from the surrounding villages and also from neighbouring Benin. It opened a second plant in 2015 in Blitta (300 km from Lomé), which started with a production capacity of 1,500 tons of raw nuts. It hopes to reach a production of 7,000 tons of cashew nuts.[98]

Togo is banking on the industrial processing of cashew nuts (cashew nuts) to boost this sector and its exports. In 2019, the Togolese government and the Japanese Export Trading Group have started talks to set up an industrial processing unit in Togo[99]. According to CIFAT forecasts, 7,000 tonnes of cashew nuts should be processed in 2020, before export (Akoda, Togo to produce 25, 000t of raw cashew during the 2019 - 2020 campaign, 2020).

4.2.3.6.6.2.2 Estimated amount of cashew waste available in Togo

In order to estimate the quantity of cashew nut shells available and eligible for a recovery project from the total quantity of nuts processed in the country, the following elements are considered:

- the year 2020 with 7,000 tonnes forecast for processing;
- the percentage by mass of the hull being 70%, i.e. 4 900 tonnes of hulls,
- units using on average only 20% of the hulls for their energy needs; consequently, 80% will remain unrecovered by these units.

Thus, the theoretical quantity of hulls available and recoverable is estimated at nearly 3,920 tonnes in 2020.

The next few years will be reassuring for the "transformation" link. Indeed, since 2018, the State has introduced a tax on cashew nuts for export, called the Cashew Nut Tax (CNT). The amount of this tax (levied at the customs cordon) is 40 CFA/kg on raw cashew nuts and 05 CFA/kg on processed cashew nuts (Akoda, Togo: Government implements tax to boost cashew export revenues, 2018). This tax is intended to provide an incentive for processing, which would encourage the production of shells as residues to be valorized.

4.2.3.6.6.2.3 Shea butter value chain

Ranked among the top 10 shea butter producing countries in Africa, Togo is part of the Global Shea Alliance. This product is mainly manufactured in the northern region of Togo (Central, Kara and Savanes). It mainly occupies women in this region through the production and marketing of shea butter and its by-products.

According to an independent study, commissioned by the Global Shea Alliance and USAID and reported by the Agridigitale.net site, shea exports have increased from 50,000 to more than 350,000 tonnes per year over the past 20 years. This indicates the good health of the sector in Togo (Agridigitale, 2018).

However, at the processing level, little information is available. One company is mentioned quite often. It is thenew company Oilseed Industries of Togo (NIOTO) which transforms shea kernels into butter for the cosmetics industry. According to a specialist of this sector inNitidæ, this factory would have a processing capacity of 30,000 tons/year. The activity of this plant should generate, theoretically and annually, as waste (i) 20,000 tons of shells, to be collected from the various nut producers, where the profitability of the operation linked to logistics should be analysed in detail; and (ii) 15,000 tons of oil cake, of which 10,500 tons could potentially be recovered in the

[98] *(Ministry of Agriculture, October 2015)*
[99] (Séna Akoda, Togo: Towards industrial cashew processing, Friday, 30 August 2019)

plant, considering a self-consumption of 30%. These hypotheses could not be confirmed as it has not been possible until now to obtain any feedback from the company on this point.

The N'Kalô service in Nitidæ reports that between 2015 and 2019, 55,128 tonnes of shea butter were exported from Togo, corresponding to 137,820 tonnes of processed almonds.

Knowing that a quantity of almonds produces up to 50% of oilcake, it can be estimated that over this period, the production of butter for export generated approximately 68 900 tonnes of oilcake. Assuming that processing units use up to 30% of this cake (i.e. 20,673 tonnes), we can then estimate 48,237 tonnes of cake as potentially recoverable waste between 2015 and 2019.

We can therefore say that there is a significant amount of shea waste in Togo. On the other hand, are these potentially recoverable waste cakes currently available? Or, are they marketed, recovered through projects, used for other purposes? These questions will have to be answered during a feasibility study on shea cake recovery.

4.2.3.6.6.3 Conclusion on the availability of forest biomass residues

Bordering the Atlantic Ocean to the south, Togo has a tropical climate of the Sudanian type on the northern half and Guinean on the southern half. Its national forest estate is made up mainly of shrubby or wooded savannahs and clear, gallery or dense dry/humid forests, not forgetting the various plantations. From the point of view of the FAO classification, these are modified natural or semi-natural forests and forest plantations. Covering almost a quarter of the country, its total forest area is almost 3.38 million hectares in 2016.

Accounting for 76% of the country's final energy consumption, firewood and charcoal are widely used to meet the energy needs of the population, particularly for domestic and professional cooking. Without considering conservation forest areas, the country would present a theoretical negative deficit between supply and demand for wood energy of about 4.3 million $^{m3\ in}$ 2017, due to the insufficiency of potential wood energy production compared to its ever-increasing demand.

In view of this observation, it is becoming necessary to study the potential for energy recovery from residues from the various forest biomass sectors.

In the wood energy sector, the most promising residues in terms of energy recovery seem to be coal dust. However, the data allowing a realistic estimate of the deposit is very limited.

As regards the timber and service sector, the sector is dominated by the informal sector and wood processing is poorly developed because it is carried out by hand in small stores, with the exception of ODEF, which is the largest wood processing unit in the country. Togo would not be self-sufficient in timber since it would import a significant quantity to meet its national consumption, about 29,104m^3 in 2010. Thus, the country mainly exports logs and, more rarely, planks, while the volumes of processed products are minute. In Togolese sawmills, as in neighbouring countries, the residues produced, such as sawdust and wood chips, are already used locally, especially by poultry farmers. Consequently, the potential should be studied at the ODEF stores level, or even in the small private sawmills that have been booming in the big cities since 2017, whose waste generated could not be characterized or quantified and whose recovery rate has not been verified.

As regards forest plantations for agricultural use, the use of residues from the cashew nut chain can be of major interest. Indeed, the country (i) has two industrial cashew nut processing units, not to mention the project underway between the state and a Japanese company to set up a new large factory there; and (ii) should reach this year, according to CIFAT, the 7,000 tons of nuts processed industrially before export. On this basis, the potential for recoverable hulls for energy purposes would then be estimated theoretically at almost 4,000 tonnes in 2020.

In addition, another relevant avenue seems to be the "shea" sector. Togo is indeed ranked seventh in Africa in terms of shea butter production, and industrial processing is said to be dominated by the NIOTO company, which has *a* capacity of 30,000 tons of almonds per year. Recoverable waste would theoretically be available on a single site and at volumes of around 10,000 tonnes per year - but this availability remains, once again, a hypothesis to be confirmed.

4.3 Eastern Africa

4.3.1 Forest value chain in Eastern Africa countries

The forestry value chain in East Africa covers:

- Input suppliers (Planting material): Nurseries (government and private) and local unknown sources;
- Production (establishment): Government and private supported and community plantations;
- Harvesting: large companies, pitsaws, chainsaws and portable sawmills:
- Timber traders: Many small urban associations and traders, large, medium and size companies;
- Primary processing: SMEs, large companies, individuals and communities;
- Secondary processing: Informal sector, SMEs and companies;
- Consumption: Construction companies, hardware stores, other large consumers such as electricity power generating companies, corporate companies, individual buyers and exports.

The figure below shows an overview of steps in product value addition from forest resource to end-market as well as actors involved.

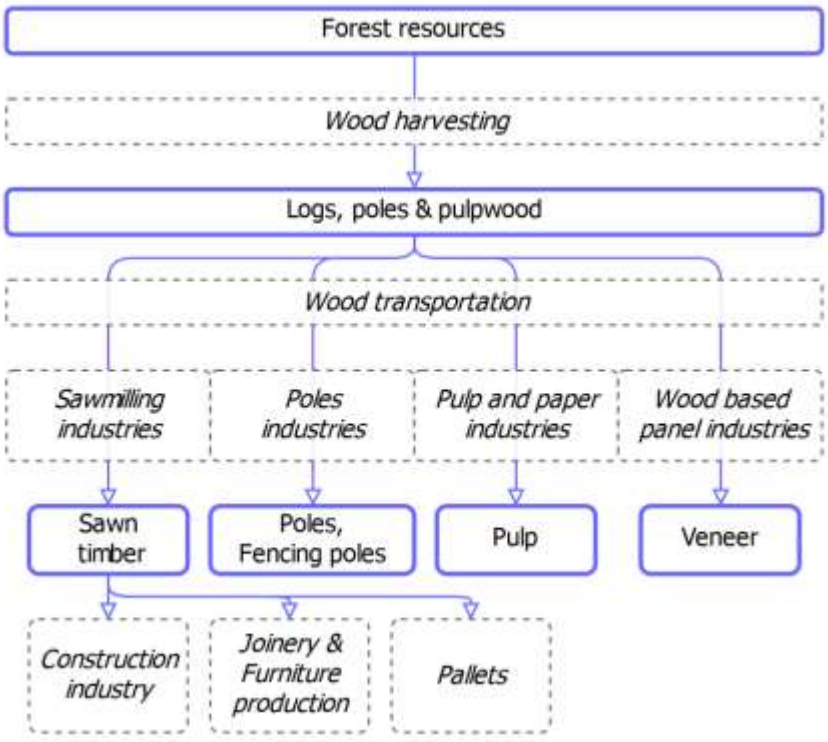


Figure 82: Production flow in the forest value chain

4.3.2 Key players involved in forest biomass management

In East Africa, forest value chain actors directly or indirectly involved in forest biomass can be summarised as follows:

- Management actors: Water, forestry and environment ministries and agencies, and private sector entities;
- Finance and investments: Development partners, commercial banks, development banks, private investments, offshore investments, investment authorities, Ministry of Finance and other donors;
- Training institutions: Universities, forestry and environmental colleges and schools;
- Technical support: Forestry institutions, forest certification schemes, technical support programmes such as the Sawlog Production Grant Scheme (SPGS) in Uganda, and forestry associations;
- Research and development: Forestry research institutions, forestry schools, universities, researchcenters, etc;
- NGOs and civil society: International, national and local based NGOs and Community Based Organisations (CBOs).

4.3.3 Mapping of forest value chains in Eastern Africa target countries

4.3.3.1. The case of the Republic of Burundi

4.3.3.1.1 Forest resources in Burundi

Burundi covers an area of 27,830 km3 Land use is predominantly covered by grasslands (34%) and trees (26%) (Figure 22, Table 29).

Figure 22. Land cover in Burundi by area and percentage

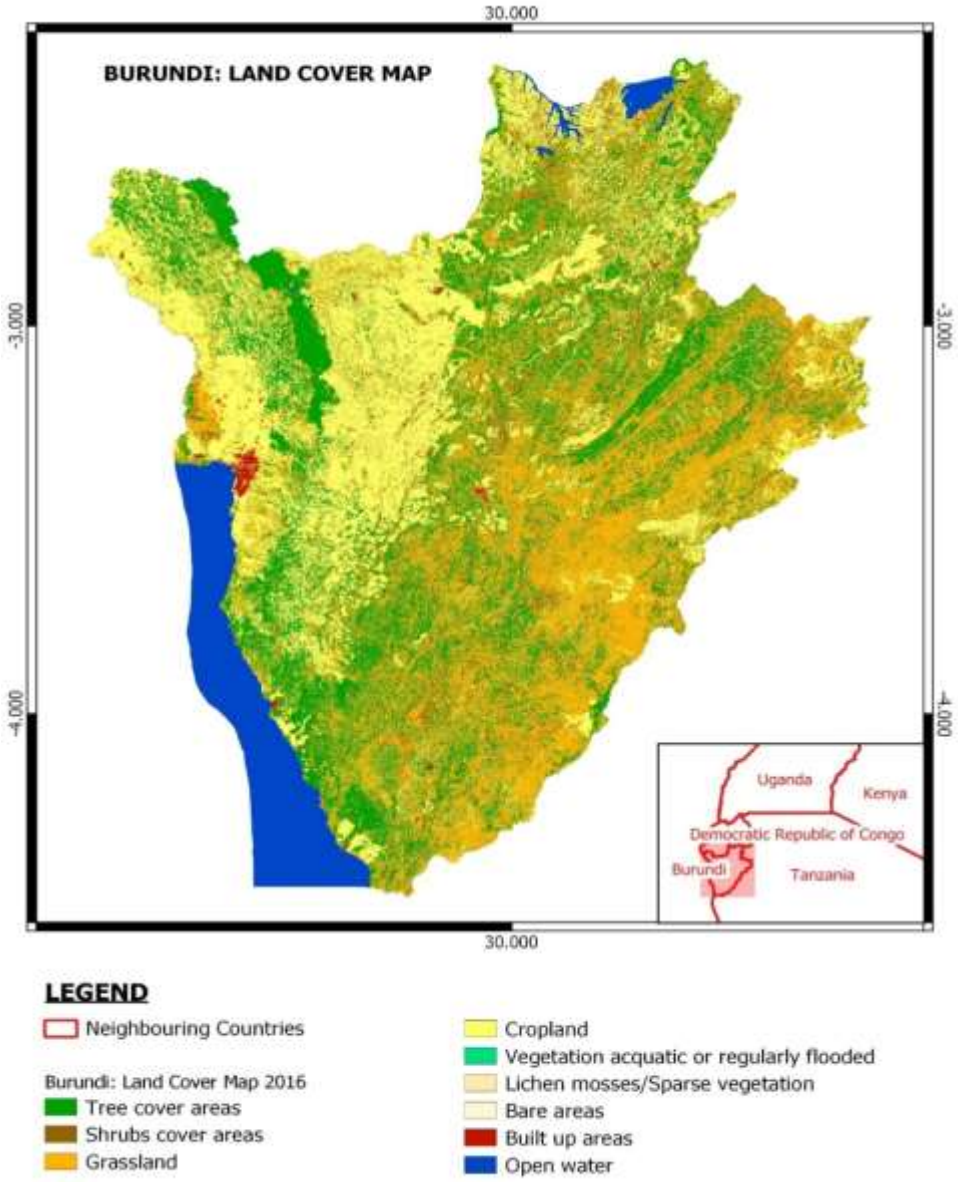


Figure 83: Landcover in Burundi

Table 87: Landcover in Burundi by area

Table 88: Forest biomass sources and generators in State Forest of Gakara-Gahunirea and percentage

Land cover	Square Kilometers	% Cover
Grassland	9109.844	33.82
Trees cover areas	6965.562	25.86
Cropland	6913.763	25.67
Open water	2005.779	7.45
Shrubs cover areas	1781.224	6.61

Built up areas	133.244	0.49
Bare areas	18.214	0.07
Vegetation acquatic or regularly flooded	9.197	0.03
Lichens Mosses / Sparse vegetation	1.047	0
TOTAL	26,937.87	100

According to FAO, 6.7% or about 172,000 ha of Burundi is forested. Of this 23.3% (40,000) is classified as primary forest, the most biodiverse and carbon-dense form of forest. Burundi has around 69,000 ha of planted forest. Forest statistics for Burundi are generally estimates from various sources and vary from one source to the other. This is because there has been no forest inventory since the late 1970s, with the last forest inventory in Burundi having been carried out in 1976. The forestry sector and agroforestry contribute about 2% to the GDP and provides 6% of employment. Burundi's forests contain 17 million metric tons of carbon in living forest biomass. Potential wood consumption is estimated to require production of about 180,000 ha, which is higher than the current forest coverage of 172,000 ha. These figures underline the need for both reduction of wood consumption and need for more afforestation. Much of Burundi‘s forest land has been lost due to an ever growing demand for wood products, and expansion of agricultural lands. Plantations have replaced most natural forests. FRA (2010) has reported that between 1990 and 2010 Burundi lost an average of 5 850 ha, or 2.02%, of forest per year. In total, between 1990 and 2010, Burundi lost 40.5% of its forest cover, or around 117,000 ha (FRA, 2010). One of the largest remaining natural forestlands is the Kibira National Park which, together with the adjacent Nyungwe National Park in Rwanda forms one of the greatest remaining tracts of mountain forests in East Africa and the most biodiversity rich ecosystem in the Albertine Rift.

State-owned plantations are composed of stands of more than 10 ha planted under projects funded through external aid. The main species planted in Burundi are *Eucalyptus sp.,* tropical pines, *Callitriscalcarata* and *Grevillea robusta*. The management of these plantations leaves much to be desired given the weakness of the country’s forestry institutions. The sharp decline of plantations is caused by poor forest management coupled with the population’s massive demand for fuelwood and building poles and the destruction caused by refugees and displaced people.Communal plantations are made up of individual stands not exceeding 10 ha. These are microplantations that the government handed over to the local authorities so that rural households can obtain the fuelwood and building poles that they need. Management is extremely haphazard, which explains the gradual loss of these plantations, many of which have been turned into agricultural land or building sites.

Most state forest plantations were established in proximity of protected areas and urban areas such as Bujumbura as a way of reducing pressure on remaining natural forests by ensuring provision of wood products and fuelwood but also at the same time allowing the protection of fragile ecosystems. Most plantations were established in the 1980s but due to the crisis in the 1990s, they did not receive adequate silvicultural treatment, e.g. pruning and thinning. Moreover, although most of the plantations are yet to be harvested, it is not clear how much and which forest plantations are still standing after the long political crisis. A comprehensive forest inventory is therefore needed to gather baseline data on forest situation in Burundi in order to set up clear strategic plans for the development of the forest sector. Data on encroachments and excisions of forest plantations are scanty and although this practice is frequently reported no exact figures are provided for any specific period or location. For example, the Forestry Department (Annual report 2009) talks about illegal distribution of forest lands at Kanyosha plantation including sites like Ntaruko I, Sabutukura, Nyabiti, Kanga, Kamutwe, Gatwaro, Rwangage and Nyamutendere but no figures are provided on size of area illegally given away. Beck et al. (2010) reported that state forest land is often given away by the Governor or the Communal

administration and harvested or simply converted into other land uses such as pastures or settlements. Moreover, the war situation and the resulting lawlessness led to the loss of forest plantations through arson fires, annexation or illegal clear felling. In fact, during the 1990s, Burundi experienced the highest deforestation rate in the world at about 9% (Athman et al., 2006). Estimates of forests destroyed during the civil war vary from 8,000 to 32,000 ha (Banderembako, 2006).

The practice of forestry in Burundi is constrained by land scarcity in general and severe poverty of the people coupled with political instability. The other problems include lack of accurate forest statistics, insufficient financial and technical capacity of the government (human and financial resources), land conflicts and political ambitions, population pressure, lack of forest management plans, disorganisation in the wood industry and lack of supporting research to help adapt forest production to needs and provide guidance to proper forest management (FAO, 2002; Banderambako, 2006). Burundi has limited government capacity to manage its forests or undertake forest-related programmes. In many communes, national forests are subject to unrestricted illegal harvesting, clearing for agriculture, and collection of fuelwood. In efforts to reduce unsustainable activities, the government has engaged local communities in plantation projects, but results have been mixed, with economic pressures on the population often overwhelming the government‘s capacity to manage sustainable use programmes (Banderembako, 2006).

There are very high risks associated with forest investments because of the political instability in the country and the lack of financial incentives that could attract large investment in forestry ventures. The lack of sufficiently large block of forest land also makes it impossible for big investment in forestry business in Burundi. For example, some of the Pinus plantations established in the 1980s were intended for a pulp and paper plant but this objective was finally abandoned largely due to lack of reasonable amount of raw material that would warrant investment in such an expensive plant (Beck et al., 2010). Governance issues and fiscal policy also impose high risk to forest investment because of corruption at the level of local authorities and police.

Nevertheless, there are opportunities that could enhance forestry business in the country. Such opportunities include the mobilisation of the Burundian people and the international community for the promotion of sustainable environmental management; the existence of skilled human resources with varying levels of expertise since the establishment of the Higher Institute of Agriculture (ISA); a pattern of rainfall (nine months of rain a year in many regions of the country) conducive to the rapid growth of many forest species; a growing awareness on the part of the government of the importance of forestry, guaranteeing action, funding, and training for intensifying reforestation and rural forestry programmes; versatility of Burundian peasant farmers, enabling them to engage in crop farming, stock-raising, and forestry activities simultaneously (Banderembako, 2006).

4.3.3.1.2 Forest value chain in Burundi

The forest value chain in Burundi is similar to that of the Eastern African countries presented earlier in this chapter.

4.3.3.2 The players involved in Burundi's forest value chain

4.3.3.2.1 Forest management and conservation actors

4.3.3.2.1.1 Public actors

Forests in Burundi are managed by the Directorate of Forests under the *Office Burundais pour la Protection de l'Environnemen* (OBPE), the office in charge of environment in the Ministry of Water, Environment, Land Management and Urban Planning. There are three main types of forest ownerships in Burundi; State forests, Communes forests (Local governments) and forests belonging to private individuals. There is no reliable data on extent of forest plantations owned by these different entities since no recent inventory has been conducted. State forests include natural forests, which are inalienable and within either national parks or protected forest reserves. State plantations are usually 10 or more hectares.

The Forestry Department is the key institution responsible for management of state forests while forest communes are management by local governments. All smaller state plantations (below 10 ha) have been allocated for management to Communes. Most tree seeds used in public and forest project nurseries are supplied by the Tree Seed Centre (Centrale de GrainesForestièresetAgroforestières) which is managed by the Forestry Department.

INECN (Institut National de l'Environnementet de la Conservation de la Nature) also has forestry responsibilities and has been engaging local communities in forest management programmes in some parts of the country such as in Kibira National Park since the 1970s. Burundi is a partner country within USAID's Central African Regional Programme for the Environment (CARPE) initiative aimed at promoting sustainable natural resource management in the Congo Basin. CARPE programmes help governments implement sustainable forest and biodiversity management practices, strengthen environmental governance, and work to monitor forests and other natural resources throughout the region (AFF, 2011) (Nduwamungu, 2011).

4.3.3.2.1.2 Private actors

Private forests including forest plantations owned by organisations such as religious groups (churches, religious congregations), schools, cooperatives and tea plantation companies are managed by respective private entities.

4.3.3.2.1.3 NGOs and Civil Society Organisations (CSOs)

The International Union for Conservation of Nature (IUCN) has in the recent past been involved in forest conservation programmes in Burundi. A number of local NGOs are alsoinvolved in treeplanting and forest conservation in Burundi, including: Association of Women for the Environment in Burundi (AFEB); ACVE (Action Ceinture Verte pour l'Environnement); ENVIRO PROTEC, Association Burundaise pour la Protection des Oiseaux (ABO), Organisation de défense de l'environnement au Burundi (ODEB), Association des Femmes pour l'Environnement au Burundi, Association pour le Développement Intégré et la Conservation de la Nature (ADICN), and Centre de Médecine Traditionnelle de Buta; CARITAS Belgium and Reseau Burundi 2000.

4.3.3.2.1.4 Donors

Major funders that have helped in afforestation projects from 1976 onwards include Belgium, Saudi Arabia, France, the European Union, IDA, ILO, World Bank, UNDP and others. However, due to the war situation that prevailed between 1993 and 2005, many donors have not been very active in Burundi.

4.3.3.2.2 Transporters and logistics players

Transportation of forest products, whether from private, communal or state forests require a transport permit and a copy of a valid harvesting permit or proof of forest ownership for private forest owners. There are several

road blocks for controlling transport of forest products throughout the country and particularly on major entrances to Bujumbura and other important towns in the country. Most of the forest products is transported by roads.

4.3.3.2.3 Actors in primary and secondary transformation

The wood processing business sector in Burundi is generally characterised by individual businessmen and informal groups, there is limited industrial scale processing. Pit sawyers, secondary processors and charcoal makers are informally organised in cooperatives and self-formed associations. The main commercialised forest products are firewood, charcoal, construction wood (poles, posts and lumber) and sawn wood for furniture. With the exception of major towns like Bujumbura where there are few wood working machines, wood processing is carried out mainly with hand tools. Most of the wood finished with hand tools haverelatively low quality since the handling and conversion process is inefficient with considerable degradation. The lack of well-trained skilled artisans in the timber processing industry is also a factor for poor quality of products and a lot of wood waste during processing (AFF, 2011).

Some of the large companies and sawmillers involved in primary and secondary processing in some of the big forest plantation estates in Burundi include Woodperfect, Participatory Management Group (PMG), Coopérative INEZA des menuisiers du Marché de Mutanga Nord (INEZA), Cooperative of carpenters - Mutanga North Market and different carpenters associations working at the artisanal training center of Jabe (Centre de Formation Artisanal (CFA).

4.3.3.2.4 Consumers

There are no wood processing industries in Burundi with the exception of sawn wood (for furniture and other uses) and construction wood (such as building timber, poles and posts). The greatest proportion of saw-logs in Burundi is mainly processed by hand using the pit sawing technique. The forest trade flow in Burundi is a mix of direct consumption, barter and sales. The prices of forest products vary from one place to another (generally being higher in major towns and the city of Bujumbura) and from one species to another. As for the exports, the industrial roundwood is the major wood product exported (AFF, 2011).

4.3.3.2.5 Sources and types of forest biomass resides in Burundi

The main sources of forest biomass production are:

1. State forest of Gakara-Gahuni;
2. The co-managed afforestation from Magara to Ngozi;
3. The co-managed afforestation from Ntamba to Muyinga;
4. State forest of VYANDA-BURURI;
5. State forest of Rugazi; and
6. Private afforestation.

The tree species planted, area covered and volume of timber produced varies between forests, and hence forest biomass residues:

1. ***State forest of Gakara-Gahuni:*** The main tree species is Eucalyptus. The total forest (Gakara-Gahuni) extends over more or less 2,000 hectares, of which nearly 1150 (Rufuguta, 2010) are jointly managed. Usable volume of timber on the co-managed area is estimated on average at 670,197 m^3. In terms of management, the Gakara-Gahuni block is co-managed between the State represented by the Forestry Department and groups of people called participatory Management Group (PMG) namely:
    a. Mashambaramba

b. Dukingiribidukikije

c. Rwanyubukene

d. Garukirigiti

2. ***The co-managed afforestation from Magara to Ngozi***: Tree specie is Eucalyptus with a total area of 60.45 hectares with a total timber production volume (Nyengayenge, 2002) of 2,891 as in 2010. Current production is unknown.
3. **The co-managed afforestation in Ntamba of Muyinga:** Tree species: Eucalyptus; Area: 30 hectares; volume - unknown.
4. **State forest of Rugazi:** Tree species; hardwoods and softwoods including pine, callitris, eucalyptus, grevillea, etc.' Area: 2,175 hectares; Usable volume – unknown
5. **Private afforestation:** Private forest plantations are very concentrated in the regions of medium and high altitude (1,200 and 2,000 meters of altitude) and precisely in the provinces of Bururi, Bujumbura rural(nyabiraba), Muramvya (Bugarama and Ryarusera), Mwaro (Bisoro et Gisozi) and Gitega (Ryansoro et nyarusange), etc. Several tree species are planted; area and timber produced are unknown.

The table below presents the sources of forest biomass residues from different areas and forest types, main uses and generators of the residues.

Table 89: Forest biomass sources and generators in State Forest of Gakara-Gahuni

Source of forest biomass residues	Forest biomass residue category	Type of forest biomass residue	Main uses / users of forest biomass residues	Name of waste Generating companies
Forest damage	Wind losses	Chablis and volis	Chablis and volis are sometimes recovered for fuelwood or charcoal	No
Harvesting of service wood (poles)	Logging residues	Stumps Branches and crown Barks Stems	The branches and crown are collected by the surrounding communities for various uses including cooking food and weaving enclosures Barks are collected by the surrounding communities for cooking food The stems are abandoned in forest	Woodperfect and several occasional individual traders
Harvesting of fire wood	Felling and crosscutting residues	Stumps, branches and crown stems	The branches and crown are collected by the surrounding communities for various uses including cooking food and weaving enclosures Barks are collected by the surrounding communities for cooking food The stems are abandoned in forest	PMG
Carbonization process	Logging residues	Stumps	Stems, barks, branches and the crown are collected and used to	PMG

			start the ignition of the fire in an oven Stumps remain standing in the forest where they often perish	
	Residues linked to the carbonization of wood	Ash residual pieces of wood	The ashes are often blown away by wind and runoff water Residual pieces of wood can be recovered for another oven or fuelwood or left in the forest	PMG
Sawnwood production process	Residues associated with primary wood processing	Residues associated with logging and cutting into logs: – Stumps – branches and houpier – stems	The debris from felling, limbing, de-stemming, and cutting are often collected by the surrounding population for use as fuelwood.	PMG
		Residues associated with cutting logs into boards or planks: slabs, sawdust, wood flour, etc.	Sawdust and slabs are collected for respectively abandoned in the forest and construction including stables, cabarets. Wood flour is abandoned in forest.	PMG
	Residues associated with secondary wood processing	Chips, sawdust, wood flour	Chips, sawdust and wood flour are recovered to be used for energy purposes including firing bricks, making briquettes and soap (See SAVONOR, bricklayers)	Coopérative INEZA des menuisiers du Marché de Mutanga Nord (INEZA Cooperative of carpenters Mutanga North Market
				The different carpenters associations working at at the artisanal training center of Jabe (Centre de Formation Artisanal (CFA) de JABE

Table 90: Forest biomass souces from the co-managed afforestation from Magara to Ngozi

Source of forest biomass residues	**Forest biomass residue category**	**Type of forest biomass residue**	**Main uses / users of forest biomass residues**	**Name of waste-generating companies**
Harvesting of service wood (poles)	Logging residues	Stumps stems Branches and crown	The stumps are the stumps are left standing in the forest The stems are abandoned in forest The branches and crown are collected by the surrounding community for various uses	PMG

			including cooking food and weaving enclosures	
Harvesting of fire wood	Felling and crosscutting residues	Stumps Branches and crown Stems	The stumps are left standing in the forest The branches and crown are collected by the surrounding community for various uses including cooking food and weaving enclosures The stems are abandoned in forest	PMG
Charcoal production	Felling and crosscutting residues	Stumps Branches and crown Stems	The stumps are left standing in the forest The branches , crown and stems are collected and used to start the ignition of the fire in an oven	PMG
	Residues linked to the carbonization of wood	Slashes	The slash are used as fuelwood. The ashes are left in the forest where they are carried either by the wind or by runoff.	PMG

Table 91: Forest biomass sources from the co-managed afforestation from Ntaba to Muyinga

Source of forest biomass residues	**Forest biomass residue category**	**Type of forest biomass residue**	**Main uses / users of forest biomass residues**	**Name of waste-generating companies**
Harvesting of service wood (poles)	Logging residues	Stumps Stems Branches and crown	The stumps are the stumps are left standing in the forest The stems are abandoned in forest The branches and crown are collected by the surrounding population for various uses including cooking food and weaving enclosures	PMG
Harvesting of fire wood	Felling and crosscutting residues	Stumps Branches and crown Stems	The stumps are left standing in the forest The branches and crown are collected by the surrounding population for various uses including cooking food and weaving enclosures The stems are abandoned in forest	PMG

Table 92: Forest biomass sources and generators in State Forest of Vyanda-Bururi

Source of forest biomass residues	**Forest biomass residue category**	**Type of forest biomass residue**	**Main uses / users of forest biomass residues**	**Name of waste-generating companies**
Forest damage	Wind losses	Chablis and volis	Chablis and volis are sometimes recovered for fuelwood or charcoal	No

Wood processing into furniture and other objects	Residues associated with primary wood processing	Residues associated with logging and cutting into logs: – Stumps – branches and crown – stems	The debris from felling, limbing, de-stemming, and cutting are often collected by the surrounding communities for use as fuelwood.	PMG
		Residues associated with cutting logs into boards or planks: slabs, sawdust, wood flour, etc.	Sawdust and slabs are collected for respectively abandoned in the forest and construction including stables, cabarets. Wood flour is abandoned in forest.	PMG
	Residues associated with secondary wood processing	chips, sawdust, wood flour	Chips, sawdust and wood flour are recovered to be used for energy purposes including firing bricks, making briquettes and soap (See SAVONOR[100], bricklayers)	Tanzanian forestry companies

[100] Savon d'or, Savon d'Or is a palm oil processing company

Table 93: Forest biomass sources and generators in State forest of Rugazi

Source of forest biomass residues	Forest biomass residue category	Type of forest biomass residue	Main uses / users of forest biomass residues	Name of waste Generating companies
Forest damage	Wind losses	Chablis and volis	The windfall and volis are recovered and sawn	No
Sawnwood production process	Residues associated with primary wood processing	Residues associated with logging and cutting into logs, stumps, branches, crown and stems	The stumps, branches , crown and stems are collected and used as fuelwood.	Administration
		Residues associated with cutting logs into boards or planks: slabs, sawdust, wood flour, etc.	The sawdust is used as mulch in tomato fields. The slabs are used for construction including stables, cabarets. Wood flour is collected for the fertilization of tomato fields	Administration
	Residues associated with secondary wood processing	Chips, sawdust, wood flour	Chips, sawdust and wood flour are recovered to be used for energy purposes including firing bricks, making briquettes and soap	Maendeleo ABo Business The different carpenters associations working at at the artisanal training center of Jabe (Centre de Formation Artisanal (CFA) de JABE
			Sawdust, wood flour and shavings are used as mulch in tomato fields the slabs for the fertilization of tomato fields	Ateliers du marché de Kanyosha, RN3

Table 94: Forest biomass souces and generators from woodlots belonging to institutional organizations and religious denominations

Source of forest biomass residues	Forest biomass residue category	Type of forest biomass residue	Main uses / users of forest biomass residues	• Name of of waste-generating companies
Harvesting of fire wood	Felling and crosscutting residues	Stumps Branches and crown Stems	The stumps are left standing in the forest The branches and crown are collected by the surrounding communities for various uses including cooking food and weaving enclosures The stems are abandoned in forest	Burundi tea office Tea factories Religious denominations

Table 95: Forest biomass sources and generators from Natural forests

Source of forest biomass residues	Forest biomass residue category	Type of forest biomass residue	Main uses / users of forest biomass residues	Name of waste-generating companies
Natural disturbances (insects, diseases , climatic parameters, etc.) and anthropogenic damage	Losses due to diseases, bush fires or old age	Dead trees	Abandoned in the forest or sometimes recovered for fuelwood	No
Harvesting of fire wood	Felling and crosscutting residues	Stumps Branches and crown Stems	The stumps are left standing in the forest The branches and crown are collected by the surrounding community for various uses including cooking food and weaving enclosures The stems are abandoned in forest	Teza tea fatory
Recovery of dead, old or dying trees or illegal cutting	Residues associated with primary wood processing	Residues associated with logging and cutting into logs: Stumps, branches and crown and stems	The stumps are left standing in the forest Branches and crown are collected by the riparian population of the forest for various uses, either for weaving enclosures or fuelwood The stems are often abandoned in forest	Forest administration
		Residues associated with cutting logs into boards or planks: slabs, sawdust, wood flour, etc.	The sawdust and wood flour are often abandoned in the forest The slabs are used for construction including stables, cabarets.	Forest administration
		Residues associated with illegal cutting: residues associated with illegal sawing are	Communities and contractors	Illegal cutters

		the same as those reported above		
	Residues associated with secondary wood processing	Shavings, sawdust, wood flour	Shavings, sawdust and wood flour are recovered to be used for energy purposes including firing bricks, making briquettes and soap	The different carpenters associations working at at the artisanal training center of Jabe (Centre de Formation Artisanal (CFA) de JABE Atelier du Marché Kinama Kamenge Q. Heha première avenue n° 27 chez Mwarabu Abella Coopérative TWITEZIMBERE de Musigati

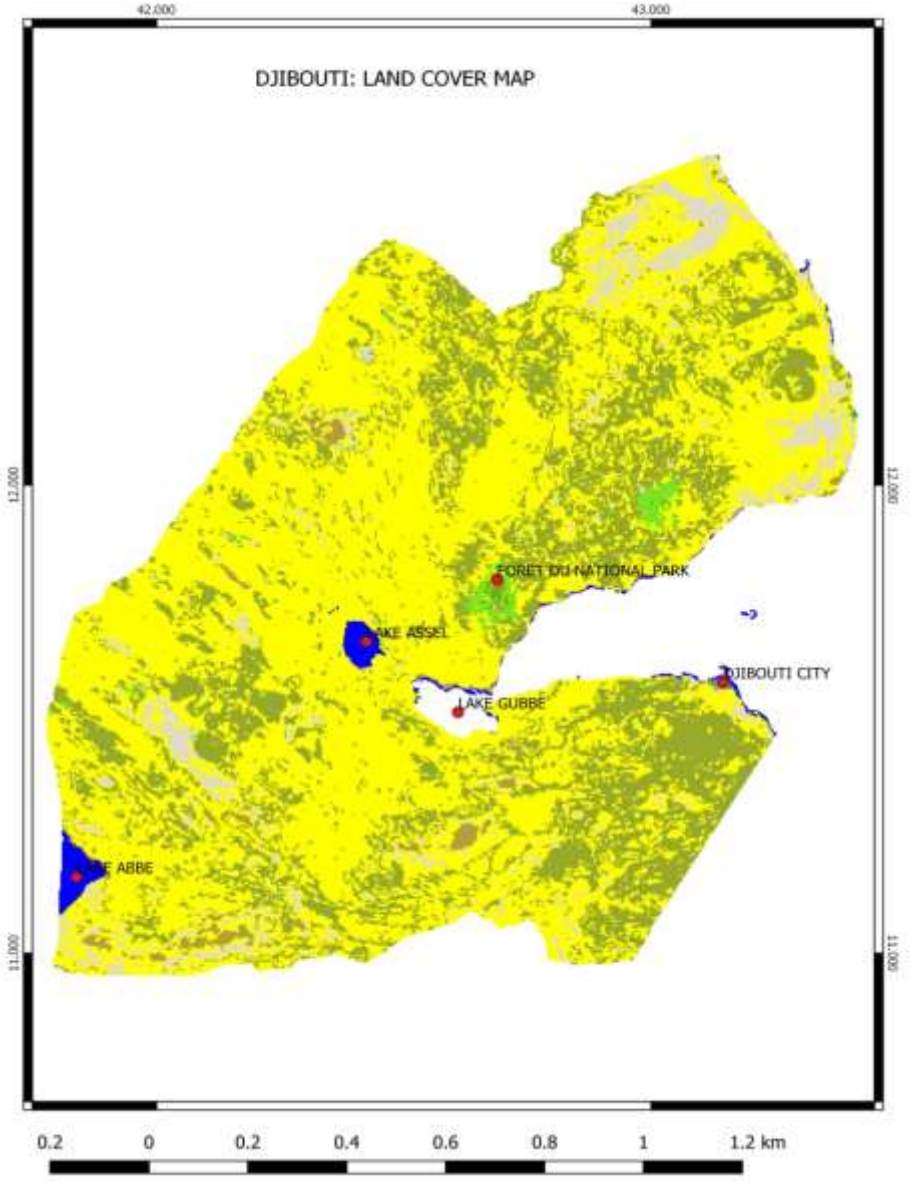
4.3.3.2.6 Conclusion

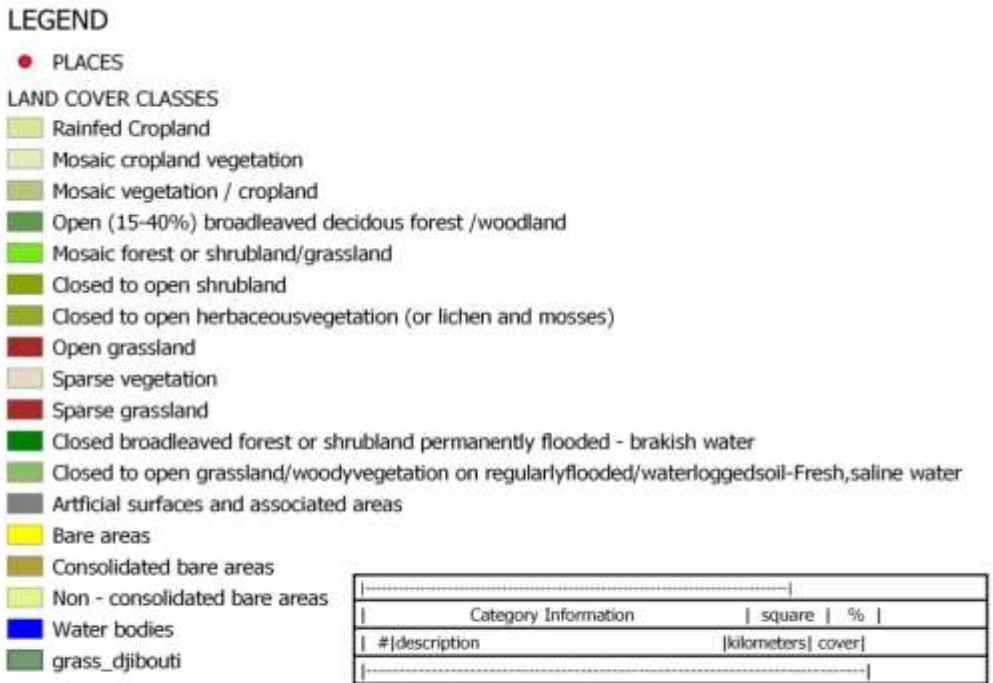
Within Eastern Africa, Burundi is not a highly forested country and compared also to many west and Central Africa may not have adequate forest industrial resources for bioenegy, however, an assessment is needed to provide further recommendations and identify which among the above forests presented above would offer a good opportunity for bioenergy. Agriculture residues in Burundi are primarily used as mulch, followed by fodder (Bacigale, Nabahungu, Okafor1, Manyawu, & Duncan, 2018) and may not be available for bioenergy in large supplies. Overall, agriculture productivity in Burundi is also considered low, because of low farm inputs (specialized equipment, fertilizer etc), acidic soils and hilly landscape that limit the use of mechanized equipment (Collins, Magnani, & Ngomirakiza, 2013).

4.3.3.2. The case of Djibouti

4.3.3.2.1. Forest resources in Djibouti

The area of Djibouti, including both its land and water resources is 23, 200km^2. Landmass accounts for the largest area, at 23,180 km^2 while water resources are few in the country, covering a total 20km^2 (CIA, n.d). Figure 23 below shows the land cover in Djibouti.


42.000
43.000
DJIBOUTI: LAND COVER MAP
12.000
11.000
FORET DJ NATIONAL PARK
AKE ASSEL
DJIBOUTI CITY
LAKE GUBBE
E ABBE
0.2
0
0.2
0.4
0.6
0.8
1
1.2 km



Category Information	square kilometers	% cover
14 Rainfed cropland	1.397	0.01
20 Mosaic cropland vegetation	4.561	0.02
30 Mosaic vegetation / cropland	7.811	0.04
60 Open (15-40%) broadleaved decidous forest /woodland	2.047	0.01
110 Mosaic forest or shrubland/grassland	179.218	0.83
130 Closed to open shrubland	19.443	0.09
140 Closed to open herbaceousvegetation (or lichen and mosses)	5880.434	27.19
143 Open grassland	1.398	0.01
150 Sparse vegetation	1152.470	5.33
151 Sparse grassland	3.630	0.02
170 Closed broadleaved forest or shrubland permanently flooded - brakish water	0.279	0.00
180 Closed to open grassland or woody vegetation on regularlyflooded or waterloggedsoil - Fresh, brakish or saline water	1.209	0.01
190 Artficial surfaces and associated areas	11.078	0.05
200 Bare areas	13,898.080	64.27
201 Consolidated bare areas	228.465	1.06
202 Non - consolidated bare areas	3.710	0.02
210 Water bodies	228.449	1.06
TOTAL	21,623.679	100.00

Figure 84: Landcover map of Djibouti

The country has very few forest resources. The Food and Agriculture statistical database (FAOSTAT) estimates the total area under forestry in the country to be 56 km^2 (FAO, 2019). The forested area of Djibouti is just 0.3% of the country's total land area (Butler, 2010). The forested area is found in the Goda and Mabla massifs, found to the north of the capital city. The forest in Godamountains is enclosed by the Foret du National Park. The main tree species found here are the *Juniperusprocera*, *Olea africana*, *Buxushildebrantii*, and *Tarchonanthuscamphoratus*. However, the country's forested area has declined by 50% in the last 30 years due

to increasing temperatures and deforestation. The most affected of the above four species is *Juniperusprocera*, an afro-montane tree (Fisher, et al., 2009).

Table 96: Size of Djibouti's forests

Description	Area in km2
Forest area	56*
Other wooded land[101]	2.2**

Source: * (FAO, 2019) ** (Butler, 2010)

4.3.3.2.2. Forest value chain in Djibouti

There are no industrial plantations and the country relies on exports. As such the management actors, transport players, and actors in primary and secondary transformation are few and in some places missing. Because the country does not have industrial plantations and the natural forests are not for exploitation, forest biomass is almost nonexistent. Forests in Djibouti are only widely used by surrounding human populations for firewood and charcoal production, the collection of fibres and woody materials for housing, fencing, rope and mat production, wild honey, gums, resins and medicines harvesting and as dry season fodder and grazing areas.

4.3.3.3 The players involved in Djibouti's forest value chain

4.3.3.3.1 Forest management actors

The ministry responsible for forestry s Ministry of Habitats, habitats, urbanism and environment. The Ministry of Energy and Natural Resources is in charge of developing and implementing sectoral policies for energy, water and mineral resources and is also the sector regulator. The Électricité de Djibouti (EDD) is the sole generator, transmitter and distributor of electric energy. EDD is under the jurisdiction of the Ministry of Energy and Natural Resources. The Directorate of Energy within the Ministry is responsible for the development and promotion of renewable energies, the investigation of energy issues, the monitoring of compliance to regulations pertaining to the electricity and oil sectors, the award and withdrawal of licenses for market activities, and the collection and analysis of data for the preparation of a national energy policy. The Centre de Recherché Scientifique de Djibouti (CERD) is the national institute responsible for monitoring and carrying out scientific and technical work in Djibouti.

4.3.3.3.2 Other actors

Information on forestry industry private actors is scarce since there are no industrial plantations in Djibouti. Some of the NGOs that have been active in forestry and conservation in general in Djibouti include Birdlife International and IUCN. A number of donors have also been supporting forestry such as the African Development Bank and the World.

[101] Other wooded land is described as land with a canopy cover of 5-10 percent of trees able to reach a height of 5 m in situ; or a canopy cover of more than 10 percent when smaller trees, shrubs and bushes are included (FAO, 2000)

4.3.3.3.3 Sources and types of forest biomass in Djibouti

Apart from woodfuel, the only available source of bioenergy is Prosopis. There is also no agricultural waste since most of the crops grown are for consumption purposes, and little or none at all are grown as raw materials for bioenergy production. FAO has been piloting use of Prosopis as an alternative woodfuel. The aim of this project is to reduce the continuous destruction of the country's Acacia trees for domestic energy demands, especially from the refugees at Ali Sabieh region, that hosts around 15, 000 refugees (Meshesha, 2017). Prosopis was preferred as an alternative wood fuels since it is an invasive species that spreads rapidly even though it is harmful to both man and livestock through its thorns. The spread of the species has currently reduced the area covered by pastureland and farmlands (Gianvenuti, Farah, Yasmin, Jonckheere, & Xia, 2018). It is for this reason that the FAO office, plus other government stakeholders/partners recommended the sustainable use of this plant as a cheap and alternative woodfuel source.

Most of the Prosopis wood, goes to the Ali Addeh and HollHoll refugee camps. In this case the two camps are assumed to be the largest consumers at a known geographical location. The refugees receive a weight range of 20kg to 80kg of Prosopis fuelwood per month which is dependent on household size.

The study by Gianvenuti, et al. 2018 showed that the processing of Prosopis fuelwood into briquettes was the most viable option owing to its greater energy output and ease of storage compared to dry fuelwood and charcoal. The manufacture of briquettes outperformed dry fuelwood and charcoal in output of energy, cost of transport and ease of storage. The study by Gianvenuti et al. identified four areas that had dense Prosopis cover in Djibouti. These were: Douda, Hanlè, As Eyla and Tadjoura. Hanlè had the largest coverage of Prosopis and subsequently the area with largest potential for the supply of Prosospis fuelwood.

Table 97: The main Prosopis vegetated areas by areal coverage and percentage

Site	Total area(ha)	Area covered by Prosopis (In ha)	Percentage of Area covered by Prosopis
Douda	2 507	1 066	43
Hanlé	7 915	2 737	35
As Eyla	972	440	45
Tadjourah	3 178	864	27
TOTAL	14 572	5107	

Source: (Gianvenuti, Farah, Yasmin, Jonckheere, & Xia, 2018)

Table 98: Potential yield of Prosopis as Biomass and Harvested Wood fuel

Site	Prosopis Cover (ha)	Biomass(tonnes)	Potential wood yield (tonnes/year)
Douda	1 066	6 396	373
Hanlé	2 737	16 422	958
As Eyla	440	2 640	154
Tadjourah	864	5 184	302
Total	5 107	30 642	

Source: (Gianvenuti, Farah, Yasmin, Jonckheere, & Xia, 2018)

Table 99: Potential supply of Prosopis by site

		Hanle		As Eyla		Douda		Tadjourah	
Fuel	Annual quantity required for the Ali-Addeh and Holl Holl refugee camps (in tonnes)	Potential supply (tonnes/ year)	Percent of total demand	Potential supply (tonnes/ year)	Percent of total demand	Potential supply (tonnes/ year)	Potential supply (tonnes/ year)	Potential supply (tonnes/ year)	Percent of total demand
Fuelwood	7359	4242	58	682	9	1652	9	1037	14
Briquette	3952	3075	78	648	17	1569	40	985	25
Charcoal	2523	1273	50	205	8	496	20	311	12

Source: (Gianvenuti, Farah, Yasmin, Jonckheere, & Xia, 2018)

4.3.3.3.4 Conclusion

The UNEC 2011 working paper identifies some of the food crops that can be used in the production of bioenergy to be wheat, maize, sugar, sweet sorghum, sunflower, and soybeans while the non-food crops that are potential bioenergy sources are *Jatropha curcas*, *Croton megalocarpus*, and *Ricinuscommunis.* Of the three non-food crops, *Jatropha curcas* shows the greatest potential since it can grow in areas with an annual precipitation of 300mm. However, this plant is not indigenous to Africa and study is required to assess its growth and yield potential in Djibouti. Because of this, the only known potential for bioenergy and biomass energy remains to be the Prosopis plant probably through its conversion to more energy efficient products such as briquettes. Most of the Prosopis harvest is used as dry fuelwood even though there is data to show its conversion to briquettes or charcoal using improved kilns is less costly and more energy effecient (Gianvenuti, Farah, Yasmin, Jonckheere, & Xia, 2018).

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5.1.1 Annexes

Annex 1

Form 1a. Forest Residue sources and users by names and location in each identified forest area of analysis

Country: X

Forest (area of analysis): x

Source of forest biomass residue	Forest biomass residue category	Type of forest biomass residue	Main uses/users of forest biomass residue	What to Map	Identify point sources of residues and users by names and location in a particular forest area
Harvesting of plantation and natural forests mostly through commercial timber harvest, thinning operations)	Primary forest residues (or logging residue)	1. Prunings 2. Thinnings 3. Clear cut left overs 4. Tree stumps 5. Others???	Fuelwood	Point sources of residues from - Plantations - Natural forests	
				Generators of residues - Chain sawmillers, - Timber harvesting companies	
				Users of the residues - Forest adjacent communities - Peri-urban and Urban areas near the sources who depends on residue for fuelwood - Agro industries (tea, coffee, Cocoa?, etc) Charcoal burning sites/charcoal burners	
Primary processing of wood products - Wood industry sawmills such as plywood processing mills	Secondary forest biomass residue	1. Shavings and sawdust 2. Bark 3. Chips 4. Chunks 5. Offcuts 6. Slabs	Mulch, fuelwood, animal bedding, engineered wood products,	Point sources and generators of residues - Wood industry sawmills such as plywood processing mills and other licensed mills	

- Peeling industry mills - Pulp and paper industry mills - Others ????		7. Others????	raw materials for pulp industry	- Peeling industry mills - Pulp and paper industry mills	
				Users of the residues - Peri-urban and Urban areas nearby - Briquette manufacturers and consumers	
Secondary processing of wood products - Formal manufacturers and traders - Informal sector		1. Shavings and sawdust 2. Chips 3. Others	Mulch, fuelwood, animal bedding	Point sources and generators of residues - Formal (large scale) manufacturers and traders	
				Users of the residues - Major Peri-urban and Urban areas depending on residue near the formal manufacturers and traders firms - Briquette manufacturers and consumer, etc	

Form 1b. Forest Residues Quantification Data Collection Form

Country: X

Forest (area of analysis): X

Forest harvesting residues			
Type of data required		**Data**	**For French Translation**
1.Annual production of industrial roundwood and woodfuel	Year or period for the given data		
	Size in hectares		
	Species composition of focus area		
	Annual production of industrial roundwood (m3 /year)		
	Annual production of woodfuel (m3 /year)		
2. Rate of felling removal	For industrial roundwood (%)		
	For woodfuel (%)		
3. Predominant forest type in the country (area of analysis) and respective tree composition after felling	Ratio of stem and crown (Crown (%) and Stem+bark (%))		
	Foliage and crown, (Foliage, % of crown)		
	Bark and stem (Bark, % of stem)		
Wood processing residues (primary and secondary stages)			
1.Sawnwood production	Year or period for the given data		
	Annual volume of sawnwood production (m3 /year)		
	Data source on sawnwood production		
2. Average efficiency of sawmills in the country/area of analysis (recovery rate)	Volume ratio of sawnwood produced and roundwood input (%)		
	Volume ratio of sawdust and roundwood input (%)		
	Volume ratio of slabs and chips and roundwood input (%)		
	Volume reduction due to shrinkage and other losses (%)		
3.Current use of residues	Percentage of harvesting residues currently utilised for the production of other wood products,		

	construction, energy and so on		
4.Wood density species	Wood density species (t/m3)		

Definition:

Woodfuel**:** The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use

Industrial roundwood**:** The wood removed for the production of goods and services other than energy production (woodfuel)

Form 1c. Data to estimate costs of generating the different products and bi-products

1. *Production Costs of Charcoal by Kiln Technology*

- *Annual inputs cost : e.g quantity of feedstock, cost of feedstock, charcoal production (tonnes per year), Kiln efficiency (%).*
- *Feedstock collection cost;*
- *Annual labour cost ($/person-hour): the labour rate for unskilled and skilled workers ($ per employee per hour).*
- *Annual Transportation cost of feedstock ($/t/km): cost of transportation of feedstock from the collection point to the charcoal plant. There is a need to: Identify the current methods of transportation of moving wood forestry/plantation within the country. Define the current transportation prices associated with the transportation method.*
- *Transportation cost of charcoal ($/t/km): cost of transportation of charcoal from plant to market. The user will need to: Identify the current methods of transportation; define the current transportation prices associated with the transportation method identified above in unit of $ per tonne per km.*

- *Annual charcoal product storage cost ($/t)*
- *Fixed costs: consist of equipment costs, basic construction material costs for the kilnsand installation costs*
- *Other costs (%): The percentage of general and administrative costs, plant overhead and maintenance cost.*
- *Market price of charcoal ($/kg): Provide a current market price of charcoal ($ per kg) (price paid by consumers) in rural, urban and industrial markets.*

Financial data

- *Financial parameters (%): Include the following financial parameters if applicable: Discount rate, loan ratio and loan interest rate.*

The socio-economic benefits of charcoal production from selected feedstock

- *Total Number of Jobs*
- *Total Number of Consumers Supplied with Charcoal*

2. *Production cost for Briquettes*

- *Annual inputs cost ($ per year): Quantity of feedstock (tonne per year) , quantity of chemical binder (tonne per year), water consumption (m3 per year), electricity consumption (kWh per year), unit cost of feedstock (USD per tonne), unit cost of chemical binder (USD per tonne), unit cost of water (USD per m3), unit cost of electricity (USD per kWh).*
- *Annual labour cost (USD/person-hour): the labour rate for unskilled and skilled workers ($ per employee per hour).*
- *Feedstock collection: The user enters the hours of labour required for manual labour, hours of labour required for running the machinery and the price of diesel.*
- *Price of briquettes ($/kg):*
- *Transportation cost of feedstock ($/t/km): cost of transportation of feedstock from the collection point to the briquette plant. Identify the current methods of transportation of moving commodities within the country. Define the current transportation prices associated with the transportation method identified above in unit of USD per tonne per km.*

- *Transportation cost of briquettes (USD/t/km): cost of transportation of briquette from plant to market. Identify the current methods of transportation of moving commodities within the country. Define the current transportation prices associated with the transportation method identified above in unit of USD per tonne per km.*
- *Annual cost of storage ($/t);*
- *Fixed costs consist of equipment cost, building cost and installation cost*

- *Other Costs (%): The percentage of: Plant overhead, Maintenance, General and administrative and safety storage rate of briquette products.*

Financial data

- *Financial parameters: The user identifies the values for the following financial parameters: Discount rate (%), loan ratio (%), loan interest rate (%), loan term (years) and Plant Cost Index.*
- *The plant cost index data for equipment cost is obtained from technical literature and based on past technical and economic conditions.*

The socio-economic benefits of briquettes production from selected feedstock

- *Total Number of Jobs*
- *Total Number of Consumers Supplied with Charcoal*

<u>Other types of bio-energy products (if applicable)</u>

3. *Gasification: partial burning of biomass to generate a gas mixture that is subsequently combusted in gas engines to produce electricity.*
4. *Combustion: the burning of biomass to produce steam which drives a turbine to produce electricity.*
5. *Bioethanol and biodiesel*