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Outlook for Sustainable Forest Bioeconomy in Gabon, Kenya, Nigeria, South Africa and Tanzania

CIRCULAR BIOECONOMY ALLIANCE

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Contents

Executive summary **4**

1. Motivation and purpose of the report **9**

2. Background of the AF5 countries **18**

3. Gabon: The forest country **31**

4. Kenya: Small forest sector with untapped potential **40**

5. Nigeria: Population growth the major driving force for forest-based bioeconomy **54**

6. South Africa: Forest industry powerhouse **65**

7. Tanzania: Large forest resources and stable institutions **76**

8. The future of fuelwood: A critical question **91**

9. The way forward: Management and policy implications **97**

Key messages **114**

References **115**

Appendices **129**

Table A1. Societal, economic and forest sector indicators for AF5 129

Table A2. Forest products exports from AF5 countries in 2020 131

Executive summary

Africa is at a crossroads. The last 20 years have been marked by a profound turnaround in perceptions of the continent, both within its borders and internationally. This change has been driven primarily by exceptional economic growth in many parts of Africa, and expectations of its increasing global role in the coming decades.

Today, Africa's population is 1.34 billion and the UN medium variant projection expects it to be 2.08 billion by 2040. Renewed confidence among many African states is reflected in Agenda 2063 of the African Union, a blueprint and master plan for transforming Africa into the global powerhouse of the future. It puts an important focus on the rapid urbanisation of Africa – by 2030 more than one billion Africans are projected to be city dwellers.

However, as well as the expected development and potential future opportunities in Africa, there are many questions and challenges. African cities face challenges in terms of infrastructure, energy, housing, technology and mobility. Is it possible to manage an urbanisation wave in a sustainable manner, reducing the number of people living in informal settlements and slums? What are the impacts of the changing climate and opportunities to adapt and build resilience to it? What role do governments play, and what type of policies are most promising for a sustainable future?

In this study, we explore the role the **circular forest-based bioeconomy** could play in fulfilling African aspirations and answering many of these current and future challenges.

Why is the forest-based bioeconomy important?

Forests are central to circular bioeconomies because forests are the main source of non-food, non-feed renewable biological resources. Wood is the most versatile renewable material on Earth and is fundamental to making the circular bioeconomy work. The forest bioeconomy encompasses not only traditional forest sectors, such as forestry, sawnwood, paper and wood products, but also new wood-based industries, such as biotextiles or biochemicals, the services related to those products (for example, research and development, education), and other forest ecosystem services (such as non-wood products, carbon storage or recreation).

In the African context, the forest bioeconomy could generate large opportunities. Africa has huge potential to derive more value from its forests, even without producing more wood, while advancing environmental, economic and social sustainability. New and more resource-efficient uses of biological resources and waste could bring new business prospects, incomes and jobs, and also help to diversify economies.

Creating more wealth from African forests does not have to mean deforestation or forest degradation. In fact, it could mean exactly the opposite by creating more incentives to take care of forests, and adding more value to them through industrial processing that embraces the circular bioeconomy.

In this report, we ask the question: how could forest bioeconomy contribute more to the wellbeing of African countries while at the same time helping to address climate change and other sustainability challenges? We focus mainly on wood products; future studies on non-wood products and other forest ecosystem services are also needed.

One size does not fit all

Africa consists of 54 countries with vast differences between them and the forests they contain. Consequently, a successful forest bioeconomy and how it is implemented is likely to vary significantly between the countries – one size does not fit all. It is these differences that help us to illustrate how the forest bioeconomy could be an answer to the very different conditions in African countries, and how it needs to be tailored to local circumstances.

In this report, we study five African countries in detail:

1. Gabon: the forest country
2. Kenya: a small forest sector with untapped potential
3. Nigeria: population growth the major driving force for the forest-based bioeconomy
4. South Africa: the forest industry powerhouse
5. Tanzania: large forest resources and stable institutions

Fuelwood – a key common issue

One of the key factors that will determine forest bioeconomy development in each of the five countries will be what happens to fuelwood development in the future. In these countries, the total roundwood production in 2020 was 180 million cubic metres, of which 81% was used for wood fuels (bioenergy) and only 19% for industrial roundwood. The social, economic and environmental costs of a fuelwood-dominated cooking and heating energy system are immense, and there must be more efficient, sustainable and value-added use of forest resources if there is to be viable forest-based bioeconomy development.

What could advance the forest bioeconomy?

By leveraging their rich forest resources in a sustainable and circular way, the five countries we studied can transform into more value-adding, diversified and sustainable economies and societies. However, this will not be easy and will not take place without systemic changes. Part of these changes are factors outside the conventional forest sector (for example, economic transformation, public sector development, better infrastructure, social security). Moreover, especially in Kenya, Nigeria and Tanzania, where a large part of the population still live in rural areas, better rural-urban connectivity and developing infrastructure in both urban and rural areas is essential.

National level objectives

- **Good governance is a precondition.** Forest bioeconomy is not an entity separate from society, it is very much part of the environmental, economic, social and institutional setting. Successful forest bioeconomy requires the sustainable use of forests, well-functioning institutions and societal cohesion and governance.
- **Sustainability needs to be imposed and monitored.** One should not assume forest bioeconomy to be sustainable per se, but should address and design policies to support all dimensions of sustainability and monitor its development.
- **Sequencing actions**. Not all the necessary actions to boost forest bioeconomy can be implemented simultaneously, nor it is not wise to seek to do so. Some can be implemented in the short term, some in the medium term and some structural reforms are possible only in the long term.
- **Introduce a dedicated forest bioeconomy strategy.** This should set beacons that let countries navigate to more sustainable forest sectors and societies in general. An **action plan** for implementation, and a system to **monitor the progress made** towards meeting the strategy targets is also required.
- **Recognise the importance of narrative and social inclusiveness**. For forest bioeconomy development to succeed, it is necessary to tell an evidence-based narrative that is understandable and engages most of the people who are, in one way or another, part of the forest bioeconomy value chain, whether rural or urban.

Medium-term objectives

- Take actions to **reduce fuelwood consumption** by upgrading the technologies for producing and using wood energy (such as new/improved stoves, small- to medium-scale heat plants) and use alternative raw materials instead of charcoal, such as brickettes and pellets.
- Countries should seek to **process wood for more value-added products**, rather than exporting low-value roundwood.

- Given that biotechnology and innovation, especially from advanced life sciences, lies at the heart of the bioeconomy, synergies with general **research and innovation policy** have a crucial role. This requires a skilled workforce, R&D investment, a stable business environment, a strong system of knowledge creation and diffusion, policies that encourage entrepreneurial activities and a focus on governance and implementation.
- **Sustainable forest management** can be regarded as the basis of forest economy. Given that deforestation has continued in all five countries in the past decade, especially in Nigeria, South Africa and Tanzania, improving forest management is key.
- A **circular** forest bioeconomy aims to design forest products for a cycle of disassembly and reuse, and so increase resource efficiency. A circular economy and forest bioeconomy should be developed in parallel and combined.

Long-term objectives

- **Further reducing fuelwood consumption** is possible in the longer run by moving to alternative energy forms (such as solar panels, windmills, gas) and building the required infrastructure for these.
- **Infrastructure such as new engineered wood mills (CLT, LVL) and forest biorefineries, which could increase value-added wood products production,** would require the import of knowhow, capital, multi-actor cooperation and supporting policies.
- Given expectations of increasingly high urbanisation, **cities are key infrastructures where there is a need to advance climate mitigation measures and SDGs**. Reducing the fossil intensiveness of the sector is critical for reducing overall emissions, with building energy performance improvements, a decrease in building materials' fossil carbon footprint, and the introduction of policy and investment commitments for more resource-efficient low fossil-carbon buildings. **Wood construction** will play a key part in helping to achieve these goals.

Key messages

- Circular forest bioeconomy strategy will be a key tool in achieving the Agenda 2030 SDGs and Paris Climate Agreement in African countries. Therefore, launching a dedicated national bioeconomy strategy is an essential tool for forest bioeconomy development.
- Forest bioeconomy is not a separate entity in society. General good governance is a precondition for a flourishing forest bioeconomy.
- Circular bioeconomy can help to support biodiversity and climate mitigation, and biodiversity and climate mitigation considerations are necessary for a successful forest bioeconomy.

- There is an immediate need to stop subsidising fossil fuel production in those African countries in which subsidies are in place. This not only provides funding opportunities for the forest bioeconomy (and other societal needs), but drives the demand for non-fossil solutions, such as forest bioeconomy.
- Investment in research, development and innovation needs to increase to strengthen the foundations for a circular bioeconomy.
- Bioeconomy must also be seen as a key strategy for cities and urban areas, not only for rural areas, as has traditionally tended to be the case. To support societal engagement, an evidence-based *circular forest bioeconomy narrative,* and efficient communication of it, is needed.

1. Motivation and purpose of the report

1.1 Motivation

The last two decades have been marked by a profound turnaround in perceptions of Africa, both within the continent and internationally. This change has been driven primarily by the exceptional economic growth in many parts of Africa, and expectations of its increasing role in a global setting in the coming decades. Africa's population today is 1.34 billion and the UN medium variant projection expects it to be 2.08 billion in 2040. This is almost double the projections of the combined European and North American population (1.14 billion). Renewed confidence among many African states is reflected in the Africa 2063 Agenda of the African Union, which is a blueprint and master plan for transforming Africa into the global powerhouse of the future. The agenda puts an important focus on the rapid urbanisation of Africa, and in 2030 more than one billion Africans are projected to be city dwellers.

Clearly, in addition to the expected development and future opportunities in Africa, there are many questions and challenges. For example, there are challenges for African cities in terms of infrastructure, energy, housing, technology and mobility. Is it possible to manage this urbanisation wave in a sustainable manner, reducing the number of people living in informal settlements and slums? What are the impacts of the changing climate and opportunities to adapt and build resilience to it? What role do governments play, and what type of policies are most promising for a sustainable future?

These future African opportunities and challenges lead us to think about the role the circular bioeconomy could play in fulfilling African aspirations and tackling the challenges. In recent years, circular bioeconomy has received attention in the global and EU context (for example, German Bioeconomy Council 2018; European Commission 2018), and is seen as essential in countries seeking to fulfil economic aspirations while at the same time addressing climate change challenges. Some African countries have also expressed their interest in bioeconomy development (EAC Bio-economy Observatory 2020; Ecuru 2020; Gatune et al. 2021), with South Africa having been the pioneer in this front (DST, 2013). However, a recent review study found that there is limited research on the topic, with most addressing more traditional forest bioeconomy activities and a sizable amount looking at the development of value chains (Rosa and Martius 2021).

There are many definitions of bioeconomy as well as usage of similar terms, such as biobased-economy and green economy (D'Amato et al. 2017; Hetemäki et al. 2017). Hetemäki et al. (2022) state that bioeconomy has turned out to be a changing concept and adjustable for various purposes. One useful definition is from the Global Bioeconomy Summit from 2015 (German Bioeconomy Council 2015): "bio-

economy as the knowledge-based production and utilisation of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors". According to Ecuru (2020), in East Africa, "the term 'bioeconomy' is widely understood in the region as the use of scientific knowledge to add social and economic value to biological resources in a sustainable way. This added value is expressed in healthier foods, safer medicines, useful substances from biological waste and other environmentally friendly processes in manufacturing, distribution and consumption of goods and services." In short, a modern and sustainable bioeconomy relies on renewable resources and biological processes to produce food, energy, materials and services, and seeks to maximise the synergies with Sustainable Development Goals and minimising biodiversity loss and ecosystem degradation (El-Chichakli et al. 2016; Palahí et al. 2020; Hetemäki et al. 2022). As the Malabo Montpellier Panel (2022, p. 5) report states, "the bioeconomy combines innovations in the economy with ecology and knowledge to ensure a more sustainable use of biological resources."

Hetemäki et al. (2017) extended the Global Bioeconomy Summit 2015 definition to a circular bioeconomy. A circular bioeconomy builds on the mutual efforts of the circular economy and bioeconomy concepts, which are interlinked in many ways (see Box 1.2). Implementing the concepts of a bioeconomy and circular economy together as a systemic joint approach is seen to improve resource efficiency and help reduce environmental pressures. Although the circular and bioeconomy concepts are often considered separately, it is evident that there are significant synergies when they are applied as a hybrid approach, making simultaneous use of both, as in the concept of the circular bioeconomy. Hetemäki et al. (2017) and Palahí et al. (2020) also link the circular bioeconomy concept to the natural-capital concept, ie they also stress the need to pay attention to all the ecosystem services as part of the bioeconomy, such as fresh-water provision, flood and soil erosion control, recreation, tourism and the fact that biodiversity is the necessary condition for bioeconomy to exist at all. Box 1.1 offers clarification on the following concepts: forestry, forest sector, forest bioeconomy, circular forest bioeconomy and forest ecosystem services.

It is evident that, in the African context, forest bioeconomy could generate large opportunities. As Ecuru (2020) stated, "over 65% of the people in East Africa depend directly on biological resources for food, fuel, medicine and other uses. They use these biological resources in their raw form, and dispose of significant portions as biological waste. By adding value, numerous other uses of the biological resources can be found, eg biowaste can be turned into biofertilisers and energy, and high-value green chemicals can be recovered from the waste." Thus, these new and more resource-efficient uses of biological resources and waste could bring new business prospects, incomes and jobs, and also help to diversify economies. On the other hand, according to Oguntuase and Adu (2021), Africa is one of the hotspots of vulnerability to the adverse impacts of human-induced climate change (IPCC 2014), with multiple biophysical, political and socioeconomic stresses interacting to increase the susceptibility of the continent and constrain its adaptive ca-

pacity. Therefore, it is also essential to develop the circular bioeconomy so that it helps to build resilience to the changing African climate in the future.

Bioeconomy strategies tend to be overarching, covering all biomass forms (agriculture, forests, marine, waste). Clearly, all these can be important and have a role to play. However, in order to go more deeply into one of the important sectors of the bioeconomy value chain, and to an area that is our expertise, we focus in this report on forest bioeconomy. This focus on forests is also justified by the fact that bioeconomy discussions usually tend to address agriculture – as in Africa – and deal with the forest sector rather superficially, or not at all (for example, ATPSNET 2021; Fertahi et al. 2023). Consequently, we add to the literature by focusing specifically on the forest bioeconomy, rather than the agribioeconomy. However, especially in the African context, it is important to acknowledge the role of agro forestry, ie combining agriculture and forestry. Although we do not go into detail on this, we will take it up in relevant parts of this report.

Hetemäki et al. (2022) argue that *circular forest-based bioeconomy* can be viewed as a necessary part of the solution, although not sufficient alone, to tackle the grand challenges we are facing, including climate change and sustainable production and consumption (see also Hetemäki et al. 2017; Palahí et al. 2020). Indeed, forests are central to circular bioeconomies because forests are the main source of non-food, non-feed renewable biological resources. Wood is the most versatile renewable material on Earth and is fundamental to making the circular bioeconomy work. The forest bioeconomy encompasses the traditional forest sectors, such as forestry, sawnwood, plywood, paper and wood products, as well as emerging new wood-based industries, such as biotextiles, biochemicals, new packaging and building products, biopharma, and also the services related to those products (research and development, education, sales, marketing, extension, consulting, corporate governance, etc), and other forest ecosystem services (non-wood products, recreation, hunting, tourism, carbon storage, biodiversity, etc).

This report focuses mainly on wood products, and the important non-wood and forest services are touched on only superficially. This is mainly due to restricting the scope of the report to be manageable for the resources we have, as well as having better data sources for forest products. This is particularly important as we use the data-based trend projections as reflection points to discuss potential future developments. However, it would be very important to supplement this report with future studies on the non-wood products and other forest ecosystem services. All the forest ecosystem services (including the products) should also be addressed simultaneously, due to the many synergies and trade-offs that may exist between the different usages of forests.

To illustrate the potential opportunities that African forest bioeconomy products could bring in future, we refer to the following simple example by Hetemäki et al. (2021). They point out that, according to FAO data, Africa produced 54% more wood and had four times more forest area than the EU in 2019, yet the export value of EU forest products was 17 times greater than in Africa: USD 100 billion com-

pared with USD 6 billion. This big difference is mainly due to Africa exporting (in terms of volume) only a fraction of the value-added products, such as sawnwood and paper and paperboard, compared to the EU. This is just one example indicating how Africa has huge potential to derive more value from its forests, even without producing more wood, while advancing environmental, economic and social sustainability. But to realise this, Africa must develop its circular forest bioeconomy and supportive policies.

To add and elaborate a bit more on the lines of Hetemäki et al. (2021), consider the following facts. In 2015, Africa and North America had exactly the same area of forests with 657 million hectares apiece (FAOSTAT). However, Africa produced 36% or about 200 million m^3 more roundwood than North America that year. Yet, the North American forest sector's GDP contribution was over three times more than Africa's (FAO 2022c). North America exports in volume terms 10–20 times more higher-valued forest products than Africa does. Meanwhile, Europe with less than half the size of the forest area of Africa (and 80% of it in Russia with low utilisation rate) and producing a bit less roundwood than Africa in 2015, contributed nine times more to GDP than Africa did (FAO 2022b). Moreover, this wealth from forests in Europe and North America was created in a context in which their forest areas have been increasing or were stable (eg from 2000 to 2015), unlike in Africa where it has been declining continuously in this century (and earlier).

These simple figures illustrate that the full potential of Africa's forests is still very much untapped, and that creating more wealth from African forests does not have to mean deforestation or forest degradation. In fact, it could mean exactly the opposite by creating more incentives to take care of the forests, and adding more value to them through industrial processing that embraces circular bioeconomy.

1.2 Purpose of the report

In this report, we study five African countries in more detail. We ask the question: how could forest bioeconomy contribute more to the wellbeing of the countries while at the same time helping to address climate change and other sustainability challenges? The countries studied are *Gabon, Kenya, Nigeria, South Africa and Tanzania*. As we will show in this report, they have very different socio-economic and forest sector characteristics. Consequently, successful forest bioeconomy and how it is implemented is likely to vary significantly between the countries – *one size does not fit all*. It is these differences that help us illustrate how the forest bioeconomy could be an answer to very different conditions in African countries, and how it needs to be tailored to local circumstances.

This report is based on a desk review of relevant academic papers, documents from governments (Gabon, Kenya, Nigeria, South Africa and Tanzania, hereafter referred to as **AF5**) and international organisations (eg African Development Bank, World Bank, FAO, UNFCCC). In addition, it is based on data analyses and simple trend

projections that provide business-as-usual reflection points for more extensive "what-if"-type of analytical outlook discussion, and insights for non-trend development possibilities and their desirability and implications. The earlier version of the manuscript was commented on by several African bioeconomy experts, which helped to bring new insights and expertise beyond that of the authors of this report (see Acknowledgements). However, it is important to stress that we did not carry out any systematic key informant interviews or focus group discussions among the relevant stakeholders from the focus countries. This would be important for future studies to deepen the analysis of this report, getting new insights, and possibly also correct some misapprehensions from which all pure desktop studies may suffer.

The report is outlined as follows. First, we discuss the general background of the five African countries studied and why they were chosen. After that, we analyse each of the five countries in more detail in turn, including outlook analysis for the forest bioeconomy in these countries. This leads to discussion of some lessons learnt and comparison between the countries, why it would be natural to prioritise somewhat different areas and ways to tailor the forest bioeconomy for local circumstances. Energy, and especially wood energy, will be a decisive question for many African countries in the future, and it could have both direct and indirect implications for future forest bioeconomy development. Thus, we address this question in more detail. After that, we discuss sustainable forest bioeconomy *enabling factors* that are key for its development in the future. Finally, we conclude the report with policy and management implications.

Box 1.1. What do we mean by forestry, forest sector, forest bioeconomy, circular forest bioeconomy and forest ecosystem services?

The report uses several concepts related to forests, which can easily lead to confusion about what they mean and how they differ from each other. Here we define these concepts and clarify what they mean in this report.

Forestry

Forestry refers to the management of forests for different purposes or activities such as planting, cultivating, harvesting and managing forests for various purposes, including timber production, conservation, recreation and ecosystem protection. In terms of its economic meaning, forestry refers to the management and utilisation of forest resources for the production of wood, but it also encompasses a broader range of activities that could be, for example, non-timber forest products (such as valuable fruits, nuts, mushrooms, medical plants), tourism and recreation, carbon sequestration and water purification.

Forest sector

The forest sector encompasses all the activities related to the management, utilisation and processing of forest resources. This includes, in addition to forestry (see above), the industrial processing of roundwood or forest residues to forest products, such as sawnwood, pulp and paper, and packaging products. It also includes the production of other forest benefits, such as non-timber forest products, wildlife management and ecotourism. Thus, it is broader concept than "forestry" as it includes both forestry and forest-based industries.

Forest bioeconomy

The forest bioeconomy concept differs in two main respects from the "forest sector" concept. First, it has as its foundation a normative objective and need of mankind to gradually move away from the prevailing fossil-based economy, which is based on the use of fossil resource deposits such as coal, oil and natural gas. The idea of forest bioeconomy is that various human needs and desires can be – even if not totally – fulfilled by the sustainable use of renewable and sustainably managed forest resources, instead of non-renewable fossil resources. The second essential part of forest bioeconomy is to innovate and bring into markets new, more resource-efficient, circular and environmentally friendly forest-based products. Thus, forest bioeconomy

seeks to produce traditional products in a more resource efficient way and fossil-free, as well as extend these to a wider range of new products, such as bio-based materials, chemicals, engineered wood products and other innovative products derived from forest biomass. As Hetemäki et al. (2017), European Commission (2018) and Palahí et al. (2020) stress, the forest bioeconomy includes all the forest ecosystem services. For example, economic and social opportunities related to non-wood forest products and services, tourism and recreation, water supply and purification, carbon sequestration, etc. However, so far there has been a shortage of studies addressing these products and services related to forest bioeconomy.

Circular forest bioeconomy

The circular economy is an economic model that aims to minimise waste and make the most of resources by keeping them in use for as long as possible. It differs from the traditional linear economy, where resources are extracted, used and then disposed of. In a circular economy, products and materials are designed for durability, repairability, recyclability and reusability (remanufacturing). The goal is to reduce resource consumption, decrease waste generation and create a more sustainable and regenerative economic system. Forest bioeconomy and circular bioeconomy have many synergies and they should be developed simultaneously. Indeed, in this report we understand that forest bioeconomy per se seeks to increase circularity. For example, when new forest-based products are developed, it is essential that they are developed to be as circular as possible. Therefore, forest bioeconomy and circular forest bioeconomy may be used to mean the same thing, and it is sometimes difficult to separate them. However, circularity can be understood to imply that forest bioeconomy operators need to take more responsibility than simply creating new forest-based products. That is, it is the responsibility of governments, companies and funders investing in new forest bioeconomy products to also ensure that there are institutions that make it possible to recycle, reuse and remanufacture the new products. If such institutions do not yet exist, they should be established. A historical example demonstrating this trend is how, after the second world war, governments in many countries, together with companies, started recycling newsprint and took responsibility for setting up the necessary institutions that made recycling possible.

Forest ecosystem services

The Millennium Ecosystem Assessment (2005) in the early 2000s popularised the concept of ecosystem services. In line with this report, forest ecosystem services are understood to be the various benefits and functions that forests provide to both the environment and human society. These services can be categorised into four main types.

1. Provisioning services, including the tangible resources provided by forests, such as timber, food and non-timber forest products.
2. Regulating services, which refer to the role of forests in regulating environmental processes, such as water purification, carbon sequestration and climate regulation.
3. Cultural services, which encompasses the cultural, spiritual and recreational value of forests to humans, including opportunities for recreation, cultural practices and aesthetics.
4. Supporting services, which are the underlying ecological processes that enable other ecosystem services to function, such as nutrient cycling and soil formation.

It may be noted that *biodiversity* as such is not part of the ecosystem services. Biodiversity includes diversity within and among species and ecosystems. Changes in biodiversity can influence the supply of ecosystem services. In this sense, biodiversity is a necessary function for provision of ecosystem services.

The wellbeing of forest ecosystems, and the value of ecosystem goods and services they provide, is the foundation for forest bioeconomy. Without biodiversity, forest bioeconomy cannot exist. Moreover, it has been argued that, in a modern society, bioeconomy may also be necessary for biodiversity, even if indirectly (Hetemäki et al. 2017; Hetemäki et al. 2022; Palahí et al. 2020). For example, a sustainable forest bioeconomy may provide the necessary resources to maintain or increase biodiversity in forests by providing incentives and funding for measures enhancing forest resilience (such as climate adaptation), or by helping to mitigate climate change, which is one of the most critical factors impacting future biodiversity. Still, it is important to highlight that forest bioeconomy per se is not necessarily helping biodiversity, and it could be the opposite, and therefore forest bioeconomy must be managed and monitored in such a way that it generates positive synergies with biodiversity.

In addition to the above concepts, there is also the popular concept of **"sustainable forest management"** (SFM), which is related to all the above concepts. FAO (2023) defines SFM "as a dynamic and evolving concept, which aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations. Forests and trees, when sustainably managed, make vital contributions both to people and to the planet, bolstering livelihoods, providing clean air and water, conserving biodiversity and responding to climate change." Forest bioeconomy is built on sustainable forest management.

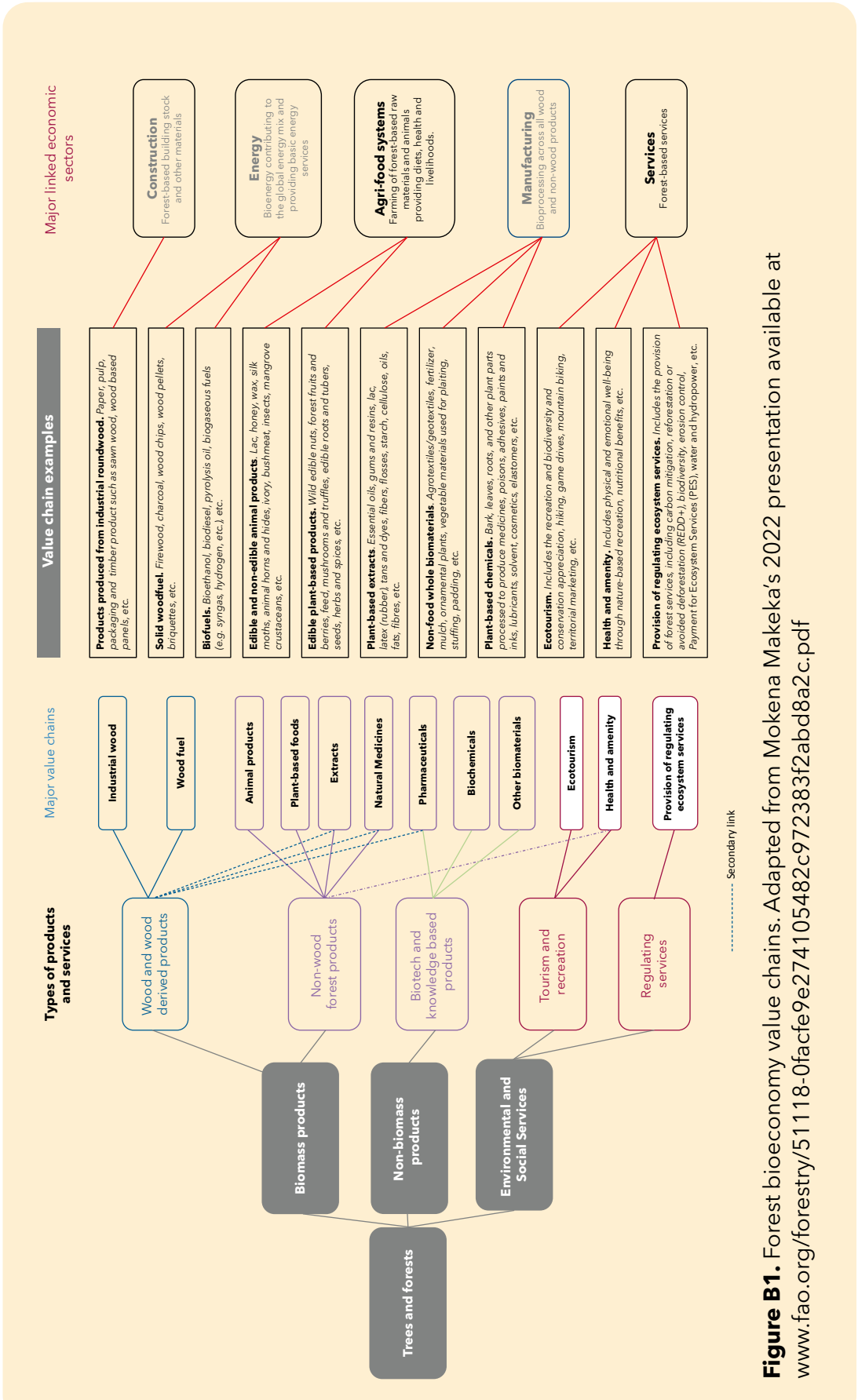


Figure B1. Forest bioeconomy value chains. Adapted from Mokena Makeka's 2022 presentation available at www.fao.org/forestry/51118-0facfe9e274105482c972383f2abd8a2c.pdf

2. Background of the AF5 countries

About 16% of the world's forest area (637 million hectares) is located in Africa (FAO 2022c). Yet, the estimated total share of economic contribution of the African forest sector to the world forest sector gross domestic product is only 3% (FAO 2022c). For comparison, for Asia this figure is 50% (FAO 2022c), which has slightly smaller forest area than Africa. These simple statistics indicate that there is a large untapped potential for African forests to generate wellbeing, even if the GDP figure is problematic in terms of being a good indicator of wellbeing.

In the last decade, Africa continued an upward trajectory of deforestation and degradation with a net annual forest loss of 3.94 million hectares from 2010–2020 (FAO 2022c). Indeed, in 2015 the African Forest Landscape Restoration Initiative (AFR100) was launched to restore 100 million hectares of degraded forest and land by 2030 (African Union Development Agency 2022). It is African initiated and led and seeks to accelerate restoration to enhance food security, increase climate change resilience and mitigation and combat rural poverty. To untap the potential Africa has, there is a need to address deforestation and forest degradation.

However, speaking of Africa as one unity hides the large differences between the countries in the continent, and this also relates to forests. Africa consists of 54 countries with vast differences between them. For example, just contrast Seychelles with a population of 99,000 people and land area of 459 km^2 compared to Nigeria with 206 million people and a land area of 923 769 km^2. Or contrast the forest area of 127 million hectares in Democratic Republic of the Congo (sixth in the world) to that of Lesotho with 34,000 hectares. The continent's countries also have large differences between them in other ways. Consequently, for the purpose of studying the circular forest bioeconomy, it is not very fruitful to analyse the continent as such, but rather its countries. Given the large number of countries, studying all of them would be a daunting – in fact impossible – task for the resources we have for this report. Therefore, we had to be selective and focus only on some countries.

We chose to study five countries that differ in many respects from each other in terms of their socio-economic and forest sector characteristics (see Table A1 in the appendix*): Gabon, Kenya, Nigeria, South Africa and Tanzania*. Before going into more detail about the differences, we point out why these differences are useful for the purpose of this study. Firstly, these differences help to highlight the fact that circular forest bioeconomy development, and the infrastructure and policies needed to advance it, are likely to differ in many respects from country to country depending on socio-economic and forest sector characteristics. There is unlikely to be a one-size-fits-all strategy for all of them. They face more or less different types of opportunities and challenges, and therefore strategies and policies also need to be tailored to local circumstances. Secondly, among the AF5 countries there are socio-economic and forest sector characteristics that correspond to some extent to many of the other African countries. Whether it is in terms of population size and growth, economic structure, forest cover and forest sector characteristics, there are important analogies in many of the other countries in the continent. Therefore,

perhaps the AF5 countries can help to highlight many of the opportunities and challenges that the other 49 African countries will also face when developing their circular forest bioeconomy.

Looking more closely at some of the socio-economic differences between the AF5 countries, the following seem obvious. In terms of population, you can divide these into a very small country (Gabon), medium-size countries (Kenya, South Africa and Tanzania) and a large-size country (Nigeria) (see Table A1 in the appendix). Besides the current size of the population, each country's growth rate in the future will be a key factor. Figure 1 illustrates that Nigeria and Tanzania are projected to face the most rapid population growth. The three others are projected to also have significant population growth, but not to the same degree. In terms of where the population lives, Gabon and South Africa differ from the rest, in that they are much more urbanised societies. Gabon is the most extreme with 90% living in urban areas, especially the capital Libreville where almost 40% of the country's population live. In contrast, the urban population share in Kenya is 28% and in Tanzania 35%.

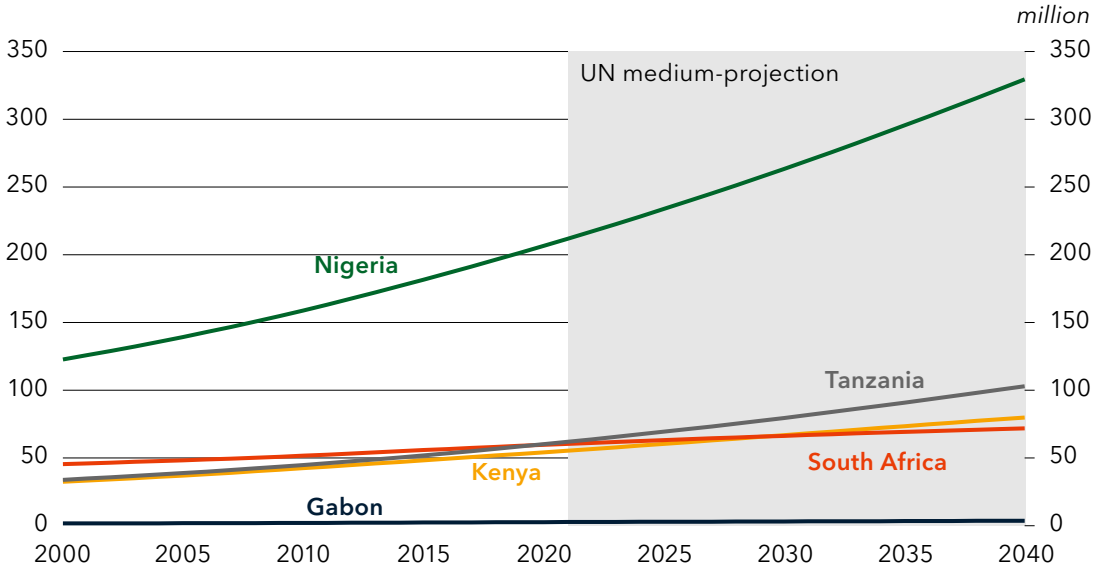


Figure 1. Population 2000–2020 and UN medium variant projection to 2040. Data source: https://population.un.org/wpp/; Figure: Lauri Hetemäki

The rural characteristics of Kenya and Tanzania are also indicated by the high share of the agriculture, forestry and fishing sectors (henceforth, agrisector) in the country's economy, with the value added of the sector in GDP around a quarter. Nigeria is also heavily agriculture-based; in 2020 its agrisector value added as percentage of GDP was 24%. In contrast, the agrisector value added in Gabon and South Africa is very low (Table A1). However, these figures may hide the fact that, for example, in Gabon and South Africa the bioeconomy sector is more developed and it is significant in the more value-added parts of the bioeconomy value chain. This is especially true in South Africa where forest industry, including the pulp and paper industry, plays a major role. The forest industry's share of South African manufacturing GDP is around 5%.

In terms of economic performance, measured by GDP per capita, Gabon and South Africa are at a much higher level than the other three AF5 countries. Based on this index, these two countries belong to the World Bank "upper middle income" group of countries, the same as Bulgaria and Mexico. However, this simple index hides the fact that the income distribution may be very skewed, with the bulk of the population having much lower incomes than the average (see the Gini index in Table A1).

Table A1 also shows the Climate Risk Index (CRI), see row number 10. The CRI index, developed by Germanwatch, analyses and quantifies the impacts of extreme weather events in terms of fatalities and the economic losses. CRI ranks the world's countries, and the ones ranking as highest risk countries have the lowest CRI index number. In 2019, CRI score varied between 2.67 (Mozambique) and 118 (several countries). It is not an all-encompassing indicator and should be seen as one measure of the vulnerability to climate-related risks.

According to the CRI, Kenya (33) and South Africa (32.5) rank as the highest risk countries among the AF5 (see Table A1, and Eckstein et al. 2021). In Kenya (CRI = 33) about 84% of the land is classified as arid and semi-arid, thus exposed to extreme droughts, locust invasion and flood (African Development Bank 2022). These disturbances can displace communities, induce social tension and affect livelihoods. South Africa has been especially vulnerable to flooding caused by heavy rains, which can lead to loss of lives and damaged property and infrastructure. For example, catastrophic floods and landslides hit the South African provinces of KwaZulu-Natal and Eastern Cape in 2021 following exceptionally heavy rainfall, with 443 people dead and more than 40,000 displaced, and the South African president declared a national state of disaster (Madondo et al. 2023)

We analyse via two indices how the five countries perform in terms of innovation and their forest biomass resources. The Global Innovation Index (GII), sometimes referred to as the WIPO indicator, is used to measure innovation at national level (World Intellectual Property Organisation 2022). The overall GII is an average of two sub-indices: the innovation input sub-index and the innovation output sub-index. The input-index captures elements of the economy that enable and facilitate innovative activities and the output-index captures innovation outputs that are the result of innovative activities within the economy. Both the input and output indices are composed of a large number of individual indices – for the 2022 index used here, a total of 81. In 2022, the highest ranked GII was Switzerland with a score of 64.6 and the lowest rank was Guinea with a score of 11.6. The scores for AF5 are: Gabon (not included), Kenya 22.7, Nigeria 16.9, South Africa 29.8; Tanzania 19.4.

For the forest biomass we use as the index the forest growing stock (million m^3 over bark) for 2020, ie a measure of the total wood volume in the country's forests: Gabon 5,529; Kenya 773; Nigeria 2,166; South Africa 898; Tanzania 3,314. If we map the forest biomass against GII, we can place the AF5 countries in the four-box table, shown as Table 1. To categorise the countries, we assumed that the forest biomass is low if the growing stock it is below 1000 million m^3, and high if it is above this. For the GII we assumed the low-high threshold to be 20. Note that since there is no GII index available for Gabon, there is a question mark over whether it has been

correctly placed in the right box in Table 1. We *assume* that Economic Complexity Index (ECI) measuring the relative knowledge intensity of an economy is correlated with GII index and, according to ECI, Gabon ranks very low. Therefore, we place it in the low GII category. Assuming this is a correct placement of Gabon in terms of the two indexes, we would have the results shown in Table 1.

According to the classification in Table 1, none of the AF5 countries is placed in the high forest biomass, high GII category, which could be seen to provide the best opportunities to develop forest-based bioeconomy. For Gabon, Nigeria and Tanzania, the priority would seem to be to develop the country's knowhow and innovation potential, whereas in Kenya and South Africa the priority is also increasing sustainably managed forest resources. However, one must bear in mind the simple and crude basis of making such a conclusion based only on two indicators. For example, among the AF5, the deforestation rate has been highest in Tanzania (see Table A1) and, clearly, reversing this trend is also a priority. However, for country comparison purposes, interesting insights may be gained by positioning the AF5 countries according to the two indices used here.

Table 1. Forest Biomass and Global Innovation Index (GII).

	Low Innovation GII	High Innovation GII
High Forest Biomass	*Gabon* Nigeria Tanzania	
Low Forest Biomass		Kenya South Africa

In terms of the forest sector characteristics of the AF5 countries, besides the forest biomass volume used above, another indicator is forest cover. The African Development Bank (2018a) has classified African countries into six different categories based on their forest cover. All the AF5 countries (in bold in Table 2) belong to different categories, and none of these belong to the first category, "Forest Crisis Countries". Despite belonging to different forest cover categories, each of the AF5 countries can embrace the potential of circular forest bioeconomy (CFB), but how it is implemented is likely to differ due to the regional characteristics.

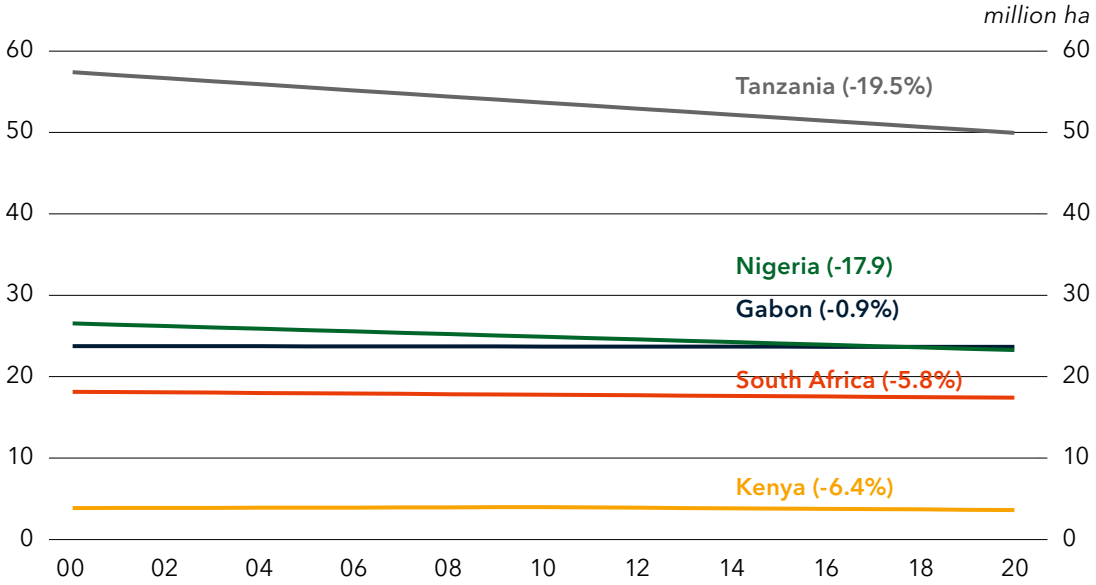
In terms of forest volume and share of forest area of the total land area, Gabon and Tanzania stand out as major forest countries (see Table A1). Over 90% of Gabon's land area is forests and it is 52% in Tanzania. The latter being a much bigger country than Gabon, its volume of forests is the highest of all the five countries at 46 million hectares. For comparison, this is almost equal to the size of total forest area in two of the most forested countries of the EU, Finland and Sweden. Nigeria is a large country in terms of land area (923,768 km2) and its forest area is also large at 21.6 million hectares. In South Africa, forest cover is only 14% of the land area, but

it has the largest amount of plantation forests – more than three million hectares – of the AF5 countries. This puts it in a good position in terms of developing CFB. Yet another type of CFB scenario can be visioned for Kenya. It has only 3.6 million hectares of forest covering around 6% of the land area. But with its large land area (580 367 km^2), there may be plenty of potential for planting trees for domestic and industrial use, and thereby increasing the future potential of CFB.

One striking fact Figure 2 highlights is that all the AF5 countries have experienced deforestation in the past decades. For Gabon, this has been very small, but for Tanzania and Nigeria, in particular, it is very high. This is clearly a factor that needs much attention when considering developing CFB. Indeed, it is important to plan measures for how CFB could turn around the situation, ie increase simultaneously both CFB and forest area.

Table 2. Forest cover categories of the AF5 countries. Source: African Development Bank Group (2018a).

Category	% of forest cover	Country	% of African land	% of African forest	% of African population
Category 1 **Forest crisis countries**	0–5%	Algeria, Burundi, Comoros, Djibouti, Egypt, Ethiopia, Lesotho, Libya, Mauritania, Niger, Tunisia, W. Sahara	30.4%	1.5%	25.7%
Category 2 **Low forest countries**	6–10%	Chad, Mauritius, Morocco, Namibia, **South Africa**, Togo	12.8%	5.1%	10.8%
Category 3 **Modest forest cover countries**	11–20%	Eritrea, Madagascar, Mali, **Nigeria**, Rwanda, Sierra Leone, Somalia	11.9%	7.5%	21%
Category 4 **Adequate forest cover countries**	21–30%	Benin, Botswana, Burkina Faso, Cape Verde, Côte d'Ivoire, Chana, Guines, **Kenya**, Malawi, Sao Tomo & Principe, Sudan, Swaziland, Uganda	16.8%	19.8%	20%
Category 5 **High forest cover countries**	31–50%	Central African Republic, Gambia, Liberia, Mozambique, Senegal, **Tanzania**, Zambia, Zimbabwe	12.5%	23.5%	11.7%
Category 6 **Very high forest cover countries**	Over 50%	Angola, Cameroon, Republic of Congo, DR of Congo, Equatorial Guinea, **Gabon**, Guinea Bissau, Seychelles	15.6%	42.6%	10.9%

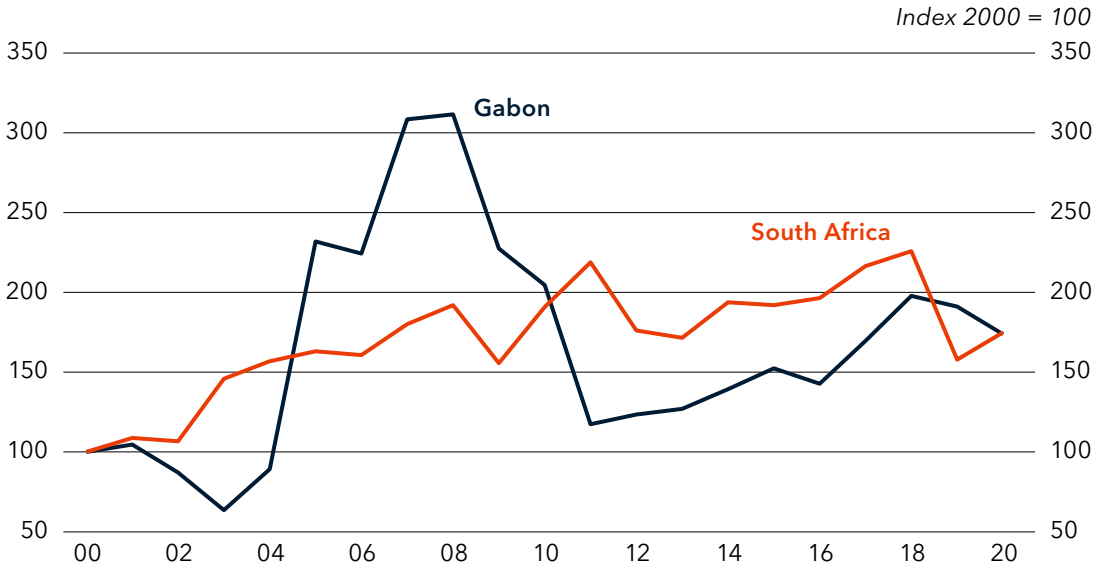


Data source: FAOSTAT

Figure 2. Forest area 1990 to 2020 and its percentage decline from 1990 to 2020 in parentheses. Figure: Lauri Hetemäki.

Among the AF5 countries, only Gabon and South Africa are significant in terms of the export value of forest products (see Table A1 and Figure 3). South Africa is the biggest exporter with about USD 600 million annual exports, and Gabon the second with about USD 400 million. The third biggest is Nigeria, but with a value of only about one-tenth of South Africa. Note that Gabon, Kenya, Nigeria and Tanzania do not have their own significant paper and paperboard production. They import these products and small part of it ends later to exports as well. For example, Tanzania imported 76,646 tonnes of paper and paperboard in 2020, and further exported 36,107 tonnes. Only South Africa is a significant paper and paperboard producer among the AF5 countries.

In Figure 3, we analyse in more detail how the export of forest products has developed in South Africa and Gabon, the two major exporting countries. The original data is from FAOSTAT and expressed in USD. Note that the cumulative rate of USD inflation from 2000 to 2020 has been about 50%, so when interpreting the Figure 3 data, one should take this into account when comparing the years 2020 to 2000. The Gabonese export value increased rapidly between 2004 and 2007 due to increasing sawnwood exports. After that, there was a significant drop due to the collapse in roundwood exports after its export ban. From 2010 onwards, there has been a significant and steady value-added increase of exports as exports have focused on sawnwood, rather than roundwood, as previously. Thus, based purely on these statistics, Gabon has succeeded in its policy of improving the value of its forest sector. Today, the export value is about a quarter higher in *real terms* than in year 2000. South African real export value is similarly about a quarter higher today than in year 2000, but it has followed much steadier development than Gabon. However, in the last two years it has declined, the reasons for which are unclear to the authors of this report.



Data source: FAOSTAT

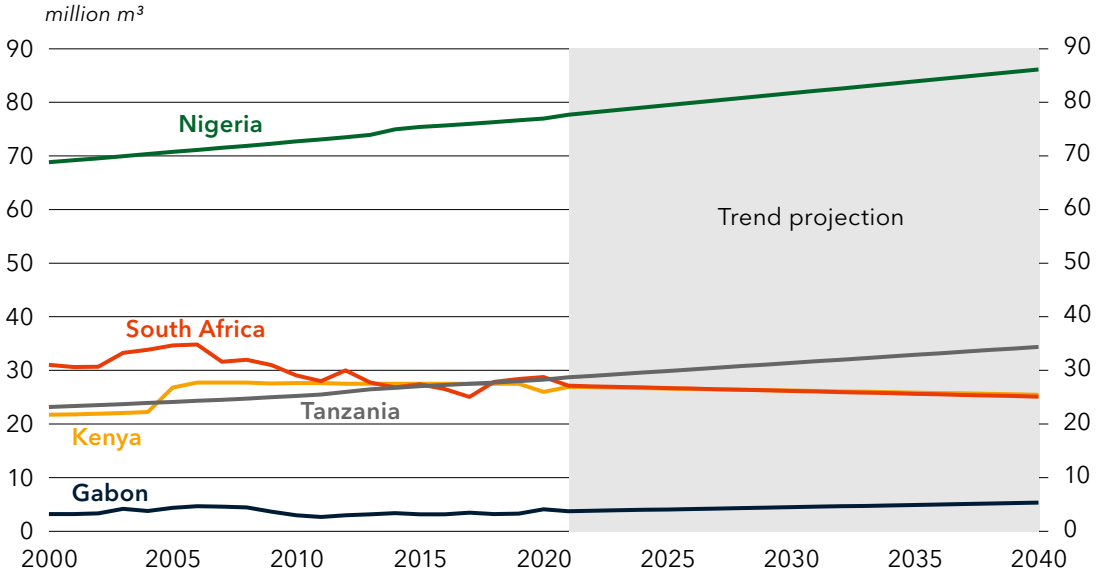
Figure 3. Gabon and South Africa forest products export value index (2000 = 100) from 2000 to 2020. Figure: Lauri Hetemäki.

The development of forest products export values from 2000 to 2020 for Kenya, Nigeria and Tanzania are much more erratic than for Gabon and South Africa, and the changes have been between 8 to 15 times relative to year 2000 for each of these countries. This could be due to the very low absolute level of export values, which means that changes from one year to another can be large. There may also be issues with the data quality.

Nigeria is Africa's biggest roundwood producer with around 77 million m^3 per annum according to FAO data (Figure 4), with almost 90% of this roundwood used for energy production (Figure 5). One challenge is how to change the energy infrastructure to satisfy energy demand in a sustainable way with the rapidly growing population (projected to about double by 2050). What role could CFB play in this?

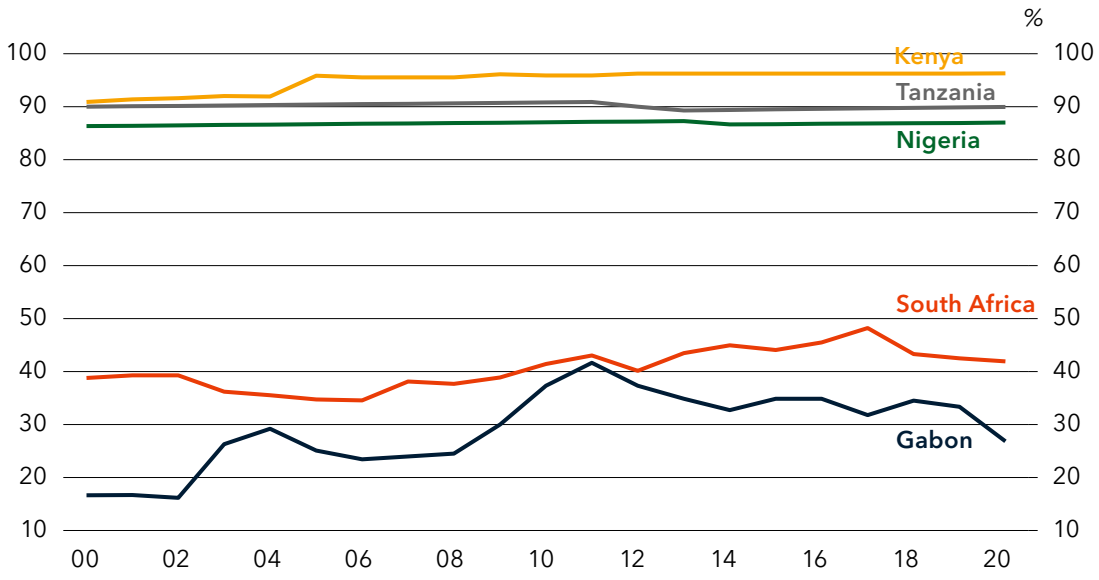
In contrast, Gabon is a small country with only 2.2 million people and annual roundwood production of only 4 million m^3. Yet, Gabon is an interesting CFB country as it has decided to significantly reduce its dependence on fossil resources and develop and invest in the forest bioeconomy. With its policymakers strongly backing this development, and being a small, very urbanised and "agile" country, change may also be relatively quick.

In terms of the forest products industry, South Africa is clearly the most advanced of the five countries. It is the only one with significant pulp and paper industry, and the value of its forest products exports (USD 1.6 billion in 2021) are about double that of the four other AF5 countries together.



Data source: FAOSTAT

Figure 4. Roundwood production 2000–2020 and trend projection (2010–2020 trend) to 2040. Figure: Lauri Hetemäki.



Data source: FAOSTAT

Figure 5. Share of wood fuel production of the total roundwood production, 2000–2020. Figure: Lauri Hetemäki.

A country's governance structure may also play an important role for CFB development. How committed are the policymakers to developing CFB and do they have CFB strategies? How easy is it to establish new capacity for CFB – what is the business environment for new domestic or foreign CFB investments? To what extent is the country's R&D and educational infrastructure helping this development?

According to Oguntuase and Adu (2021), South Africa and Kenya are first and second among African countries in terms of the bioeconomy readiness index. This is in line with the World Bank index of "Ease of doing business", based on which Kenya and South Africa rank the second and third highest in the Sub-Sharan African continent (Rwanda is first). Tanzania is at 11th place and Nigeria at 20th. Gabon is not in the list, but it is low in the World Bank index of "Ease of doing business" (see Appendix A). South Africa is the only country with a dedicated national bioeconomy strategy, which was approved in 2013. According to Oguntuase and Adu (2021),

> *"strategies to promote the bioeconomy in Africa must focus on targeted investments to support R&D activities; building efficient innovation system; improving the level of education, training, and skills of the populace; and supporting market development to enhance competitiveness. Furthermore, African countries must improve general governance, the quality of their infrastructure, and the rule of law, to attract foreign investment in the bioeconomy sectors." (p2530).*

The above discussion has indicated that the AF5 countries present a wide diversity regarding the potential and characteristics of how future circular forest bioeconomy could develop. However, there are also common elements and needs for all the AF5; namely, the need for forest bioeconomy strategies and supporting policies, investment in R&D, education and new forest bioeconomy production capacity. All these also require new capital (financing) and technological support within and outside the AF5 countries.

It is clear that the agriculture sector and forestry are linked in the AF5 countries in many ways. Thus, *agroforestry* is likely to also play an important role. However, the main focus of this report is the forest bioeconomy opportunities, and the agriculture sector is not systematically analysed. It would be important in other studies to have similar systematic analysis of the agriculture sector, as well as analysing the synergies and trade-offs between the two sectors. *In this respect, the current report is only a partial analysis of the AF5 countries' opportunities related to circular bioeconomy.*

Moreover, it is important to pay attention to the sustainability of future CFB development, especially regarding climate change and biodiversity and socially inclusivity. Clearly, the measures taken to develop CFB need to also help to mitigate climate change and adapt forests to changing climate, ie build their resilience. Biodiversity is also a necessary condition for CFB – without it there is no CFB. In this respect it may be noted that all the AF5 countries are signatories of the Convention on Biological Diversity. Aligned to this commitment, it is essential to find ways to maximise the synergies and minimise trade-offs between CFB and biodiversity development. In terms of social aspects, CFB needs to be developed in such a way that it also generates benefits (income, jobs) to the areas where the forest resources are located, ie rural areas.

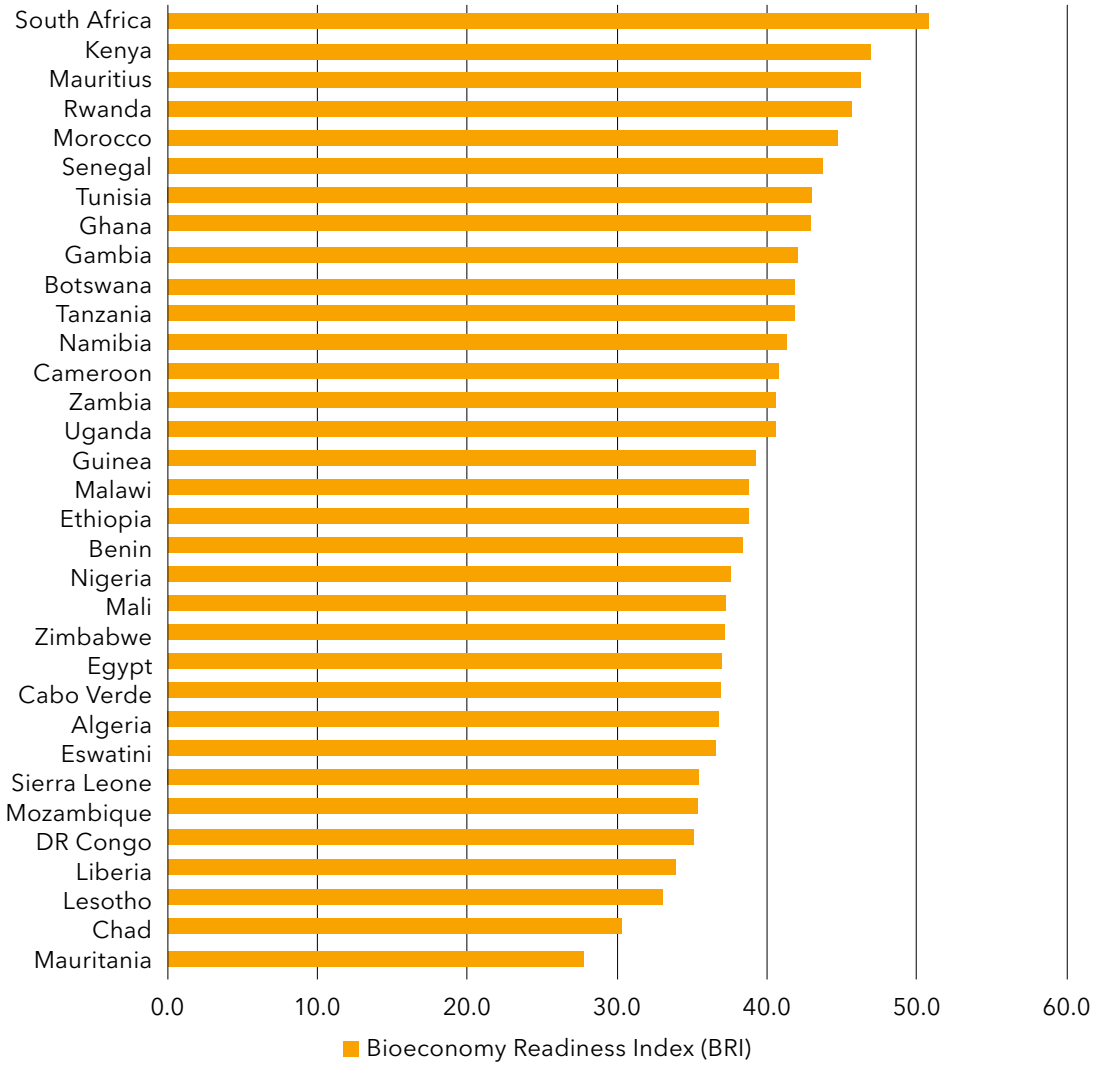


Figure 6. Bioeconomy readiness index of African countries. Adapted from Oguntuase and Adu (2021). Note that Gabon is not included in the figure, but would most likely be at a very high level of the index.

Next, we analyse each of the AF5 countries in more detail. The analysis will follow the same pattern for each country. First, we provide general socio-economic background, after which we outline the forest sector. Then we provide a simple business-as-usual trend projection to the next two decades, ie up to 2040. This can be regarded as a development pattern against which different structural changes and "what-if" assumptions or scenarios can be reflected. Two decades is long enough for major structural changes to take place, such as economic, social and infrastructure changes, and of course, increasingly, the changing climate. To some extent, past trends may still continue, especially the closer to the current times our foresight extends. However, it would be surprising if, in 2040, we observe that tomorrow was just another yesterday, ie the past trends had continued as such. *Consequently, the trend projections in this report should not be regarded as forecasts, but as useful reflection points for different assumptions and scenarios.* They also help to raise important points that may be necessary to change in the countries' forest sectors, if these are to be viable and sustainable.

Box 1.2. Circular economy perspective

There is a confusing supply of similar sustainability-related concepts, such as bioeconomy (BE), circular economy (CE) and green economy (GE). From policy and practical perspectives, having several different but closely related concepts addressing sustainable development is not optimal. This short introduction to the concept of the circular economy illustrates its specific features and how it relates to the bioeconomy concept.

A circular economy is an economic system designed to minimise waste and maximise the efficient use of resources. Unlike the traditional linear economy, which follows a "take-make-dispose" approach where resources are extracted, used and then discarded as waste, a circular economy aims to keep products, materials and resources in a continuous loop, thereby reducing resource depletion and environmental impact.

Key principles and features of a circular economy include:

1. Resource efficiency: the primary goal is to use resources more efficiently by reducing waste, reusing products and materials, and recycling. This involves designing products with longer lifespans and considering their end-of-life possibilities from the beginning.
2. Closed-loop systems: products and materials are designed to be reused, refurbished, remanufactured or recycled at the end of their life cycle, rather than being discarded as waste.
3. Product design: products are designed with durability, reparability and recyclability in mind. This often involves using modular components that can be easily replaced or upgraded.
4. Sharing and collaborative consumption: encouraging shared use of products and resources, such as car-sharing or tool libraries, reduces the overall demand for new products and can be more resource-efficient.
5. Waste reduction: minimising waste through better waste management practices, waste-to-energy processes, and by promoting the use of biodegradable materials.
6. Sustainable materials: using renewable and recyclable materials in production processes whenever possible to reduce the environmental impact of resource extraction.
7. Extended producer responsibility (EPR): producers are held responsible for the entire life cycle of their products, including their disposal. This incentivises manufacturers to design products that are easier to recycle or dispose of responsibly.

Digitalisation and innovation: using technology and data to optimise resource use, track products throughout their lifecycle, and enable new business models such as the sharing economy.

Following eg Hetemäki et al. (2017) we see a merit in merging the forest bioeconomy and circular economy concepts into the circular forest bioeconomy concept, not least due to the many synergies between the bioeconomy and circular economy . Moreover, in the African context, e.g. Ncube et al. (2022) see large potential for circular bioeconomy. However, they state that "Currently, most countries of the African Union lack well-defined policies, requisite infrastructure, and expertise for biowaste valorisation, thus limiting the potential development of the region. Against this background, it is necessary to deploy circular bioeconomy principles based on the awareness of the biocapacity of territories through the nexus of biowaste management and life cycle thinking" (Ncube et al. 2022).

As pointed out by D'Amato et al. (2017), in the literature, CE tends to focus on industrial urban processes and decoupling resource use and economic output, whereas BE focuses on biological resource-based innovation and land use practices in the context of rural development. Given this, one value added of the circular bioeconomy concept is that it can be seen as merging these two trends and linking urban and rural communities.

If the bioeconomy concept is seen in a narrow sense, ie it only focuses on developing bio-based materials and energy, and does not consider the circularity aspects, it will be at risk of becoming too much a 'business as usual' approach. As indicated above, circularity also requires addressing recycling, reusability and resource efficiency at the product or service design stage. By doing that, it also enhances thinking around lifecycle and value chains. One implication of this is that actors operating in bioeconomy businesses need to expand their thinking outside the traditional focus and find broader and more diverse cooperation with different actors. You cannot satisfy circularity by operating only in the business-to-business networks, but need to also consider consumers and how to help establish recycling and reuse of the products at the end of their first stage use. How would the lifecycle of a new bioproduct be optimally designed, and how is the recycling and reusing institutionally operationalised to satisfy the circularity requirements? Similarly, when designing policies, policymakers cannot just advance all possible bioeconomy developments, but rather those that also satisfy the circularity requirements.

Bioeconomy and circular economy concepts should be seen as being integrated, despite their somewhat different emphasis in terms of actions. This would also have practical policy implications. For example, in the African context, the merging of bioeconomy and circular economy concepts could also create administrative and resourcing synergies and help to decrease "silos" type of thinking and operation. Rural and urban areas, and the policies related to these, as well as bioeconomy and circularity, need to all be advanced simultaneously, and across economic and societal sectors. Therefore, the implementation of bioeconomy and circular economy requires collaboration between governments, businesses and consumers, as well as changes in consumer behaviour, industry practices and policy frameworks to be fully effective. For more details on the examples and opportunities of circular economy in Africa, see the Ellen MacArthur Foundation, one of the pioneers in circular economy.

Figure B2. African circular bioeconomy can minimize the environmental impacts of biowaste while simultaneously generating value-added bioproducts and bioenergy. Figure: Lauri Hetemäki.

3. Gabon: The forest country

3.1 Socio-economic context

Gabon is located on the west coast of Central Africa, and it is part of the Congo basin where some of the largest tropical rainforests in the world are located. It is sparsely populated with an estimated 2.2 million inhabitants, of which almost 90% live in urban areas (World Bank 2019). The capital, Libreville, and Port Gentil, the economic capital of the country, are home to 59% of the population (World Bank 2019). Although the population size is small, according to a UN projection to 2040 it is expected to increase by 1.1 million or by 50%. Clearly, this would set many challenges for housing and other infrastructure, as well as employment. Currently, Gabon's unemployment rate is high (22.3% in 2021) and about a third of the population lives below the national poverty line (World Bank 2019).

The country's large petroleum resources and foreign private investments have helped to make Gabon one of the most prosperous countries in Sub-Saharan Africa. Of the AF5 countries, it has the highest gross domestic product (GDP) per capita. The oil sector has accounted for 80% of exports, 45% of GDP and 60% of fiscal revenue on average over the past five years (World Bank 2019). However, one of the socio-economic challenges in Gabon is to generate more inclusive and equitable growth. Although GDP per capita is among the highest in Africa, the country has not been able to ensure equitable development and social welfare among the population (World Bank 2019). It is ranked 112 in the world according to the Human Development Index of 2021. According to World Bank (2019), oil wealth has brought benefits to the urban elite and public servants, which were further shared through family networks, but have not reached an important share of the population, which has remained poor. Inequalities plague the current social service delivery system, and access by the poor to services remains low.

Given that Gabon is facing a decline in its oil reserves, and the world is seeking to move away from using fossil resources, the Gabonese government has decided to diversify its economy. In 2009, the Government launched the Emerging Gabon 2025 strategic plan to pursue sustainable development and diversify its economy. Besides economic diversification, it aims at an efficient public administration, basic infrastructures, a fair judicial system, and poverty and inequality reduction. The Emergent Gabon roadmap is based on three pillars (Gabonese Republic 2021).

1. Industrial Gabon (optimising oil and mining, construction and agro-industrial processing).
2. Green Gabon (sustainable forest management, certified timber production, agriculture and livestock development and sustainable fisheries).
3. Gabon Services (development of financial services for ecotourism, education, health, and information technologies).

Since the launch of the Emerging Gabon plan, the country has unveiled measures to try to reduce its dependency on the oil sector (FAO 2022c). The nation's sovereign wealth fund, the Gabonese Strategic Investment Fund, is one means by which the government is seeking to do that. The fund's objectives include supporting the growth of small and medium-sized local enterprises through direct investment; increasing the capture of revenue from the country's natural resources; diversifying government revenues and mitigating risk; and broadly supporting the government's strategic economic policy objectives. One of the primary sector industries that has been identified as a priority in this transition is the wood products industry.

It appears that, in the African context, Gabon can be regarded as a somewhat special case in terms of its determination to develop its forest sector to a more value added and extensive industry. Although South Africa is the forest industry powerhouse in Africa (see Chapter 6), in recent years Gabon has started a systematic strategy to develop and increase its forest-based industry value add creation, and with visible results already (more on this below). Moreover, Gabon has a very small population, but has vast forest resources. Unlike most African countries, it is not very dependent on fuelwood production for cooking and heating. This partly also explains why the deforestation rate is very small in Gabon. In terms of demographics, ethnic boundaries are less sharply drawn in Gabon than elsewhere in Africa, and there is little ethnic tension. The bulk of the different ethnic groups are spread throughout Gabon, leading to constant contact and interaction among the groups. Because of this and the small population size, it is probably easier to govern than many other African countries.

Presumably because of the above facts, among the AF5 countries of this report (or Africa in general), Gabon is well placed to develop its forest bioeconomy systematically and relatively quickly. According to the African Natural Resources Centre (2021), "experience from recent policy changes in the forestry sector in Gabon shows that opportunities for developing the natural resources sector in Africa rely heavily on the power of government policy." However, it remains to be seen how the military coup and political turmoil that took place in August 2023 will impact future forest bioeconomy development in Gabon.

3.2 Forest sector and its goals

With 88% forest cover, Gabon has the second-highest percentage forest cover in the world (after Suriname). It holds a special status as a High-Forest, Low-Deforestation country.[1] All forests are owned by the state and are divided into: (i) the permanent forest estate, including production forests, which are managed by private logging concession holders under the supervision of the Ministry of Water and Forests (MINEF), and protection forests and community forests; and (ii) the rural do-

1 High Forest, Low Deforestation (HFLD) developing countries and jurisdictions are those with very extensive, ecologically intact forests and low past rates of deforestation. See: www.un-redd.org/news/recognizing-role-high-forest-cover-low-deforestation-developing-countries

main consisting of agricultural landscapes, including young and mature secondary forests, traditional shifting cultivation agriculture and villages (Gabonese Republic 2021). Deforestation rates have historically been very low in Gabon with an annual rate persistently lower than 0.05% since 1990, although more recently this figure has increased to about 0.1% (Gabonese Republic 2021). About 99.9% of the Gabonese forest is naturally regenerating, while forest plantations are estimated at only 30,000 hectares. About 63% of the forest is under forest concession management (African Natural Resources Centre 2021).

According to the most recent FAO statistics, the total forest area for Gabon was estimated at 23.62 million hectares in 2010 and 23.5 million hectares in 2020 with a modest net annual change between 2010 and 2020 of 11,900 hectares or a deforestation rate of 0.05%. About 99.9% of the Gabonese forest is naturally regenerating, while forest plantations are estimated at only 30,000 hectares, and together they cover over 85% of the national territory. About 63% of the forest is under forest concession management (African Natural Resources Centre 2021).

The forestry sector is the second largest employer after public services with more than 10,000 permanent jobs in forestry and a further 10,000 jobs in forest industries (African Natural Resources Centre 2021). Employment has increased, driven by the number of wood processing industries established in the Gabon Special Economic Zone between 2009 and 2018. These industries have grown from 80 in 2009 to 155 in 2018 (African Natural Resources Centre 2021). Despite the emergence of the oil industry, forestry remains a major foreign exchange earner, contributing 3–5% to national GDP (African Natural Resources Centre 2021).

Gabon adopted its first forest policy in 1996, to increase the forestry sector's contribution to economic and social development. In 2001, a new Forest Code was signed into law requiring logging companies to undertake sustainable management of their concessions, employ low impact harvesting techniques, lengthen harvest rotation to at least 20 years, submit 30-year management plans for forest concessions, and prescribing that by 2009 75% of raw logs would be processed in Gabon prior to export (Gabonese Republic 2021). By late 2009, Gabon was still far from reaching its wood processing goal, so the President ordered the halting of all export of raw logs and required that 100% of timber be processed in the country (Gabonese Republic 2021). These restrictions started to come into effect in 2010 and were fully implemented in 2011. This policy was intended to generate more value-add and jobs on national territory, but also contributed to professionalising the sector and to a significant drop in total wood production, thereby reducing emissions (Gabonese Republic 2021).

Forest Stewardship Council (FSC) certification was first awarded in Gabon in 2008 but has only risen recently in response to Gabon's recent announcement that all concessions will require FSC certification by 2022 (Gabonese Republic 2021). Yet, illegal logging is still considered to be widespread in Gabon (Gabonese Republic 2021). According to the Gabonese Republic (2021), "unpublished national studies (conducted by law enforcement departments) indicate that up until 2019 about 30% exploitation involves some form of illegal practices, such as over-harvest or some

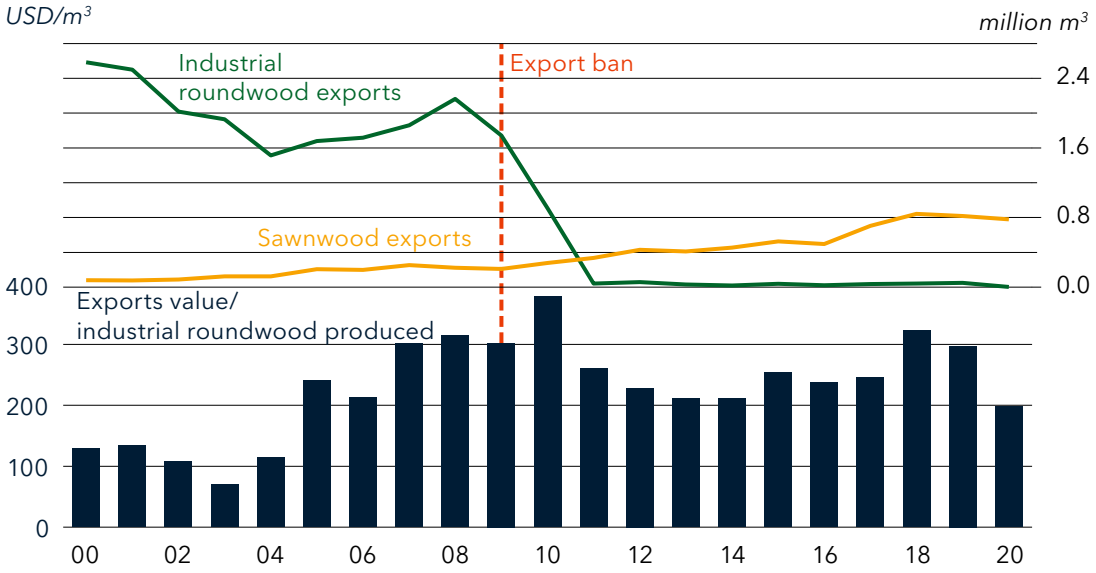
other non-respect of management plans or logging of protected species within legal concessions, or illegal logging." In 2014, a new "Sustainable Development" law, which authorises companies to compensate for the destruction they cause in forests or traditional lands by buying offset credits, was approved (Gabonese Republic 2021). There are four different kinds of credits: carbon credits, biodiversity credits, ecosystem credits and community capital. The latter is defined as "the sum of natural and cultural assets belonging to a community" (Gabonese Republic 2021).

The above discussion indicates that, for over a decade, the government of Gabon has made systematic efforts to develop and enhance its forests and forest industry, while paying attention to environmental sustainability. According to Lee White, the Gabonese minister of Water, Forest, the Sea and Environment, the country "had earned mere pennies from each dollar's worth of wood that its people harvested and exported in the past. That distorted attitudes and led to deforestation and loss of ecosystem services. Part of the solution lies in convincing the people of Gabon that their wood is much more valuable and therefore worth conserving, paradoxically by creating substantive jobs in the timber industry within the country" (Cordon 2021). "If we can create sustainable forestry industries, we can create hundreds of thousands of jobs that gives us a constituency of people who are vested in maintaining the forest," said White, describing this as an "industrial ecosystem," a synonym for the circular economy. "That's how we get the Gabonese people to become the protectors of forests that we need them to be" (Cordon 2021).

3.3 Forest bioeconomy outlook

It seems clear that at least some of the Gabonese forest sector policies have had the desired impacts. In Figure 7, the development of forest products export value per cubic metre of industrial roundwood produced (in USD), industrial roundwood exports and sawnwood exports in the past two decades are shown. The roundwood export ban was imposed in 2009, it started to come into effect in 2010 and was fully implemented in 2011. Most of the companies whose main activity was in exporting unprocessed logs were faced with the choice of either establishing sawmill units to their operations or ceasing their activities (World Bank 2019). The top part of Figure 7 shows that industrial roundwood exports collapsed in this period. On the other hand, the more value added sawnwood exports started to increase after the ban. Thus, the export ban policy seemed to have had the impact it was designed for.

The bottom of the Figure 7 shows the forest products export value in US dollars divided by the cubic metres of industrial roundwood produced in Gabon. It reveals that it was at its highest in 2010 at USD 378, after which it started to decline until 2014, and then again started gradually to increase, reaching USD 328 in 2018 (nominal values). This development can be considered satisfactory, but not yet very good. The Gabonese government has set the target to increase significantly the value added of its forest production and exports, and also create a significant number of jobs in the sector. Several policies and processes for this have been set, but it takes time for these to have impact (see below for more details). Moving from investment planning to actual production also takes time.



Data: FAOSTAT

Figure 7. Gabon's forest products export value (USD) per m^3 industrial roundwood produced, and industrial roundwood and sawnwood exports from 2000 to 2020. Figure: Lauri Hetemäki.

Besides the forest bioeconomy related policies discussed above, Gabon has other policies and actions aimed at increasing and developing its value-added wood processing. First, it launched the Gabon Special Economic Zone (GSEZ) in 2010 as a joint venture between Olam International Ltd, the Republic of Gabon, and Africa Finance Corporation with a mandate to develop infrastructure, enhance industrial competitiveness and build a business-friendly ecosystem in Gabon (GSEZ 2022). GSEZ is a multi-sectoral industrial park located 27 km from Libreville and it brings together 144 companies from 19 countries operating in 22 industrial sectors (GSEZ 2022). One key cluster in GSEZ is wood processing, which brings together 84 companies. It was ranked the best industrial zone in the world for wood sector by FDI Intelligence-Financial Times in 2020 (GSEZ 2022).

Secondly, as part of the Strategic Plan for an Emerging Gabon, the country intends to process all its wood locally by drawing on native artisans and industry. For example, according to African Natural Resources Centre (2021), it is estimated that small-scale forest enterprises based on furniture and carpentry have the potential to add value of USD 44–271/m^3 of sawnwood processed to finished products and increase job creation by a factor of 4 to 12 times. These figures would imply that, for the estimated 500,000 m^3 of sawnwood exported each year from Gabon, the potential value-addition for processing this volume to fine furniture could be in the range of USD 22 million to USD 1.56 billion (African Natural Resources Centre 2021).

To achieve the above objectives, incentives for industrial investment have been put in place and investment support and preferential tax treatment for processed goods have been introduced (African Natural Resources Centre 2021). For example, the government has introduced new tax laws aimed at encouraging further

wood processing for export and incentivising local value addition (law came into effect in 2021). Products that have undergone first processing will be subjected to an export duty of 9%, but where products have undergone secondary processing, it decreases to 3%, and drops further for products that have undergone third processing where the export duty will be levied at only 1.5% (African Natural Resources Centre 2021). In addition, a 20 billion CFA franc support fund to accelerate industrialisation in the wood sector has been established (African Natural Resources Centre, 2021). Given the target to expand the forest industry, it requires simultaneous actions to secure the sustainability of roundwood supply. Gabon wants to generate more income from its forests as well as preserve them. According to the Minister for Water, Forests, Sea and Environment: "we're trying to come up with a new development model for a high rainforest country that preserves the forest but allows us to develop" (Tan 2021).

For forest protection purposes, the government has introduced several measures to enhance sustainable forest management. In 2018, Gabon required all operators of forest concessions to FSC-certify their forest areas by 2022. The country has also adopted measures to minimise forest degradation, for example, timber companies are required to harvest on a 25-year cycle to allow regrowth. In addition, the government introduced a comprehensive Natural Resources Monitoring and Observation System (NNRFOS). It is expected to include observations from space and ground measurements to allow the identification and mitigation of changes in forest cover, as well as to monitor the biodiversity and carbon sequestration capacity associated with various land use decisions and practices (World Bank 2019).

Gabon is also receiving foreign support for its forestry conservation. In 2019, Norway committed to pay USD 150 million to Gabon to protect its forests under the Central African Forest Initiative (CAFI), and recently Gabon received its first USD 17 million payment for this, making it the first African country to receive a results-based payment for reducing emissions from deforestation and forest degradation (REDD+) (Tan 2021). CAFI's payments to Gabon focus on reducing CO2 emissions from degradation through sustainable forestry practices. CAFI will also pay for Gabon's natural forests carbon sequestration, giving standing forests a value beyond wood production. Denis Sonwa, senior scientist for the Center for International Forestry Research (CIFOR), commented that, "it shows that REDD+ is technically possible, but for it to become a reality we need some sort of dynamic domestic policy" (Tan 2021). Gabon has also adopted other forest conservation measures, as discussed in, for example, World Bank (2019).

The government has acknowledged that increasing wood processing also requires expansion of forest plantations. According to FAOSTAT data, the area of forest plantations in Gabon has been stable for the past two decades, at 30,000 hectares. However, recently the government announced establishment of an additional 200,000 hectares of forest plantation by 2025 (African Natural Resources Centre 2021).

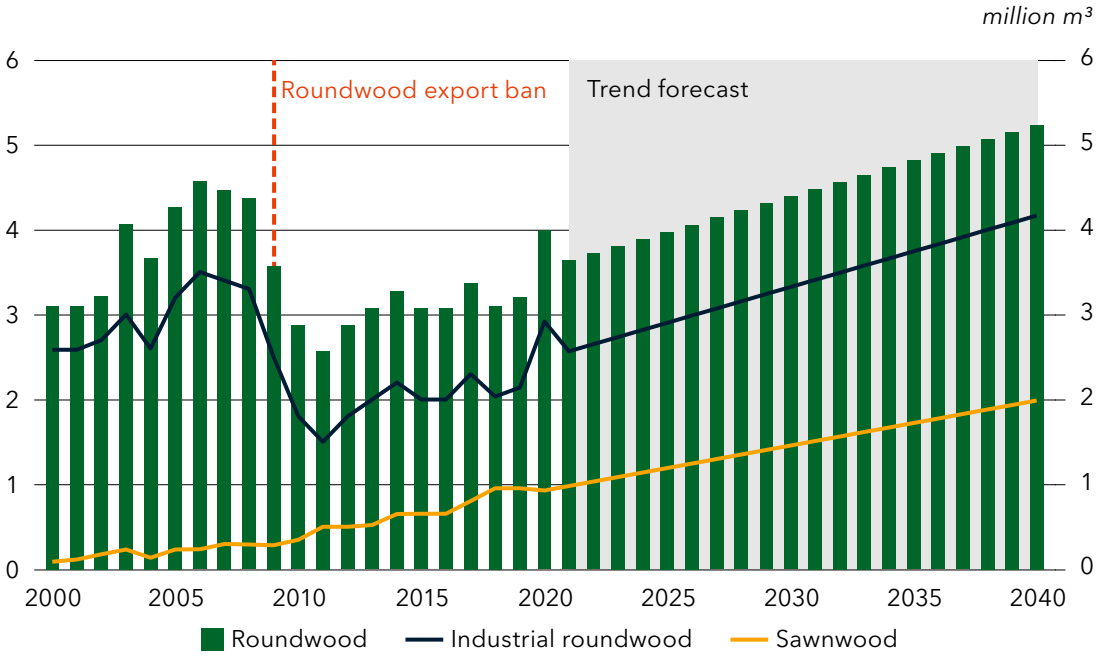
The above discussion indicates that Gabon's government has launched systematic and wide-ranging policy measures to develop the forest bioeconomy sector. These actions are expected to help diversify the country's economy, increase state

revenues and create more jobs, besides the direct economic impacts. Significant numbers of new jobs are expected in both urban and rural areas (here, mainly forestry and logistics). Moreover, these actions are required to be implemented by sustainable forestry and in a way that the country's forests and their rich biodiversity are preserved and the forests remain a major carbon sink.

Given these efforts, what can be expected for the future of forest bioeconomy development in Gabon? Are there still some opportunities and challenges that have not yet received enough attention, but which would be necessary for successful forest bioeconomy development? Next, we approach these questions via some simple data analysis and trend projections.

Figure 8 shows the roundwood, industrial roundwood and sawnwood production for 2000 to 2020 and the trend projections to 2040. Note that in Gabon only about 27% of the total roundwood production goes to fuelwood (energy), as the bulk ends up in industrial processing. In the four other AF5 countries (and Africa in general) it is the opposite, as fuelwood shares in these countries are between 63% and 96%.

The projections to 2040 are based on 2010 to 2020 trends. That is, the next two decades are assumed to develop along the trends that have been taking place in the past decade. This is, of course, very simplistic and becomes increasingly unlikely the further from the present day the projection extends. Yet, it provides a useful business-as-usual scenario against which one can reflect other "what-if" type of assumptions and scenarios.



Data: FAOSTAT

Figure 8. Gabon's roundwood, industrial roundwood and sawnwood production 2000–2020 and trend forecast to 2040 (trend from 2010 to 2020). Figure: Lauri Hetemäki.

Figure 8 shows that, if the current trends were to continue, roundwood production would increase by about 24% and sawnwood production would more than double by 2040 compared to the current levels. The large increase in sawnwood production would naturally help to achieve the value-added targets set by Gabonese government. However, the Gabonese targets have been set to process the roundwood to even more valuable products than sawnwood. The 24% increase in roundwood production would equal 1.24 million m^3 more wood. If the Gabonese government were to succeed in its plan to increase plantation forests by 200,000 hectares by 2025 (or at least before 2040), this could provide the roundwood for the projected increase of sawnwood production by 2040.

Moreover, according to FAOSTAT, Gabon still produced around one million cubic metres of fuelwood in 2021 (27% of total roundwood). However, one should view this data critically as, according to FAOSTAT, fuelwood production has stayed at exactly the same amount of 1.07 million m^3 during the last two decades. The figure is most likely an estimate, and it may be difficult to know precisely how big fuelwood production is. Most of its use is in rural areas where it is used for cooking and heating. Despite the uncertainties, one would expect there still to be ample possibilities in future to move to more efficient energy uses than fuelwood and conserve the forests or use the wood for industrial purposes.

The Figure 8 does not include data and projections on so-called *engineering wood products*, such as cross laminated timber (CLT) or laminated veneer lumber (LVL), plywood, etc. These are more processed and value-added products than sawnwood. The strategy in Gabon is to also reduce greenhouse-gas emissions by wood construction, encourage the sustainable use of forest products and tap into emerging markets. For example, the country has set the target to advance CLT production. Indeed, the government has launched an initiative to construct the country's first CLT building, the Gabon Sovereign Wealth Tower. It would have roughly 9,000 square metres of floor space over more than six floors. As FAO (2020c) states, "this project aims to maximise the use of locally sourced wood materials; achieve design excellence for mass-timber-based mixed-use development and zero-carbon construction; anchor the development of mass-timber value chains in sustainable forest management; and enhance the transfer of skills in timber value chains and the construction sector." According to initial calculations, the tower has the potential to remove about 1.5 million kg of carbon dioxide from the atmosphere.

Given the projected population growth in Gabon by 50% (1.1 million) by 2040, it will be necessary to design innovative and low emission buildings and construction solutions. Here, CLT and other engineered wood products promise to offer at least part of the solution. Yet, other large-scale sectors with high CO_2 emission footprints also include the textile, chemicals, and transport and packaging sectors. In future, Gabon will consume increasing amounts of products from these sectors. Therefore, it will be important to assess to what extent at least some of these could be produced domestically and with a low carbon footprint. Basically, wood-based biorefinery and other products provide opportunities to substitute fossil-based products in all these sectors. However, these products require a very different kind of knowhow, processes and investment than wood products, in which Gabon already has

competence. Yet, it would be important to analyse more closely if any or some of these sectors could offer potential opportunities for Gabon. However, most likely this would require foreign capital investment and knowhow, and probably foreign companies alone, or joint ventures with Gabonese companies. To pave way for this type of development, it would be important for Gabonese government to address the hurdles that may hinder attracting foreign investments. For example, according to the World Bank, the poor quality of Gabon's business climate is a major barrier to the diversification of its economy. Gabon ranked 169 out of 190 countries in the Doing Business 2018 report.[2] However, as this is in Gabon's own hands, if there is will to do so, it should also be a realistic goal to improve the business climate.

2 https://www.worldbank.org/en/country/gabon/overview#1

4. Kenya: Small forest sector with untapped potential

4.1 Socio-economic context

The Republic of Kenya is located in East Africa and borders the Indian Ocean. It is one of the largest economies and populous countries in Africa, ranking in the top 10 on both indicators. Kenya's population is projected to grow by almost 26 million (48%) from 2020 to 2040 (UN medium variant, Table A1). The rapidly expanding population will clearly be a major challenge in the future, as in so many other African countries. The bulk of the population (72%) live in rural areas and the agriculture sector accounts for almost a quarter of the GDP (Table A1). According to the World Bank, "Kenya has made significant political and economic reforms that have contributed to sustained economic growth, social development, and political stability gains over the past decade."[3] Indeed, among the AF5 countries, Kenya is ranked as the most business friendly (Table A1). "However, its key development challenges still include poverty, inequality, transparency and accountability, climate change, continued weak private sector investment and the vulnerability of the economy to internal and external shocks" (African Development Bank 2018c).

The World Bank (2022) classifies Kenya as lower-middle-income,[4] but, even so, over 60% of the total workforce is in agriculture, and the country has a relatively small urban population (~26%), of which ~56% live in slums (African Development Bank, 2018c). The geography of Kenya includes a diverse range of climates, and the country is prone to climate-related hazards, including both floods and drought. The CRI index of 33 is low (see Table A1), indicating this high vulnerability to climate change impacts. Kenya has the 12th highest GINI coefficient in Africa (48.5), a gender inequality index of 55.2 and a human development index of 0.56, indicating wide disparities in wellbeing, income and access to opportunity between different social and gender groups (African Development Bank, 2018c). In summary, Kenya is vulnerable to impacts of climate change and other global challenges and there is a need to increase resilience, investment and innovation to improve welfare and adapt to changing climate.

4.2 Importance of forests and the forest sector

From Kenya's total land area, over 80% is classified as arid and semi-arid land and is considered as being at risk of desertification. Forest cover is just over 6% of the Kenyan land area and was 3.6 million hectares in 2020 (FAOSTAT, Table A1). Forests are classified into four types (Republic of Kenya 2019), of which the first three

3 www.worldbank.org/en/country/kenya/overview
4 https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

are based on forest ecozones, defined by altitude and climate: 1. Dryland forests; 2. Montane and western rainforests; 3. Coastal and mangrove forests; and 4. Commercial plantation forests managed by Kenya Forest Service (KFS), which spread across the three ecozones.

According to the World Bank (2018), land degradation is severe in Kenya because of deforestation and land use cover change, which replaced high value biomes with low-value biomes. Due to the increased use of forests for firewood and charcoal production, illegal harvesting and agricultural and infrastructure expansion, Kenya lost 12,400 hectares of forest between 1990 and 2015. The closed canopy forest – which covered approximately 12% of the land area – has been reduced to only 1.7% of its original size (World Bank 2018). However, noting that the forest area in Kenya declined by 6.4% from 2000 to 2020 (see Figure 2), but only 0.1% from 2010 to 2020 (Table A1), suggests that the measures aimed at cutting deforestation have started to work.

Forests are managed under three tenure systems: public, community and private. Public forests are managed by both national government agencies, mainly Kenya Forest Service (KFS) and Kenya Wildlife Service and County Governments (Republic of Kenya 2019). These forests are mainly managed for provision of environmental goods and services, but they also contain a belt that is managed for timber, poles and fuelwood. In forests that are owned by communities, or held in trust by county governments, forest management rights and responsibilities are transferred from the public administration to local communities through long-term leases or management agreements (Republic of Kenya 2019). Private forests are owned or managed by individuals, institutions or corporate entities as freehold or leasehold.

The forest sector is a critical asset for economic growth, environmental sustainability, and provision of social and cultural values. For instance, the latest available figures from FAO (FAO 2015) show that about 50,000 people were directly employed in the forest sector while about 300,000–600,000 were indirectly employed. Further, over two million households within five kilometres from forest edges have significant dependency on the forest services and products, which include cultivation, grazing, fishing, fuel, food, honey, herbal medicines, water and other benefits. Excluding charcoal and other subsistence uses, Kenya's forest sector accounts for 3.6% of Kenya's GDP and supports agriculture, livestock, energy, trade and other industries – which cumulatively contribute about 39% of the GDP. Conversion of grasslands and shrublands to cropland has also occurred in many regions of Kenya – leading to 16% of cropland expansion from 1990–2015 (World Bank 2018).

Wood-based industries in Kenya consist of about 450 sawmills, two integrated panel mills that manufacture plywood, particleboard and hardboard (one of which also manufactures sawnwood). Most of these mills procure their raw materials from government plantation forests for which harvesting and utilisation levels are established by KFS. Farmlands and woodlands outside state forests supply the bulk of wood for transmission poles, wood fuel and sawlogs for small-scale sawmills spread across many regions in the country (Republic of Kenya 2019). Kenya's annual supply and consumption of its main wood products in 2020 are shown in Table 1.

About 96% of the wood production is fuelwood (energy wood), and only 4% goes to industrial purposes, mainly sawnwood and wood panels. Kenya is a net importer of forest products (Table 1). Pulpwood supply has declined due to the closure of Pan African Paper Mills in 2009, which was the largest consumer of pulpwood. In summary, Kenya has rather scarce forest resource (compared to the size of the country or the other AF5 countries) and a small forest industry, which serves mainly the domestic market.

According to Republic of Kenya (2019), the forest sector is the backbone of Kenya's *tourism* since forests provide habitats for wild animals, offer dry season grazing grounds and protect catchments that provide water downstream. Forests maintain water catchments that support agriculture, industry, horticulture and energy sectors. In some rural areas, forests contribute over 75% of the cash income and provide virtually all a household's energy requirements. It is estimated that the economic benefits of forest ecosystem services exceed the short-term gains of deforestation and forest degradation and therefore justify the need to conserve the forests (Republic of Kenya 2019).

Ecotourism – which is very much forest related – plays a significant role in Kenya's economy and has the potential to support conservation efforts and improve local livelihoods. Kenya is known for its diverse and abundant wildlife and is home to several national parks, wildlife reserves and other protected areas, which attract tourists from all over the world. Ecotourism provides an alternative source of income for communities living near protected areas, which can help reduce pressure on natural resources and encourage conservation. Ecotourism is a significant contributor to the economy of Kenya, generating significant income and employment opportunities. According to the World Travel and Tourism Council, the travel and tourism industry contributed an estimated KES 206 billion (approximately USD 1.9 billion) to Kenya's GDP in 2019. The tourism sector is a major source of income and employment in Kenya's economy, accounting for 10.4% of Kenya's GDP, and 5.5% of formal employment (KIPPRA 2023). Ecotourism (also related to forest resources) plays a major role in in tourism, and provides jobs in a range of sectors, including accommodation, transportation, tourism services and local businesses that cater to tourists. It is estimated that the travel and tourism industry employed approximately 1.6 million people in Kenya in 2019, with a significant portion of these jobs being in the ecotourism sector. Thus, ecotourism remains an important source of income and employment and has the potential to contribute even more if managed sustainably and responsibly.

4.3 Forest policy goals and needs

To advance sustainable forest management, Kenya has developed several policies, laws and regulations. The Constitution of Kenya 2010 requires the state to work to achieve and maintain tree cover of at least 10% of the land area in Kenya. The forest policy goals, objectives and guiding principles are described in "The Forest Policy 2014" document (Republic of Kenya 2014). Moreover, the forestry governance is based on the Kenyan Forest Conservation and Management Act (FCMA) 2016. The

aim of Kenya Forest Policy is the sustainable development, management, utilisation and conservation of forest resources and equitable sharing of accrued benefits for the present and future generations of the people of Kenya. Various efforts have been put in place by the government to achieve this. For example, under the African Forest and Landscape and Restoration Initiative (AFR 100), Kenya aims to plant 5.1 million hectares of trees in deforested and degraded forests by 2030 (AECOM 2021). Kenya has also joined in global programmes for enhanced management of forests. The country is participating in REDD+, and has set the following priorities (Republic of Kenya 2019, pp. 4–5): 1. Reducing pressure to clear forests for agriculture, settlements and other land uses; 2. Promoting sustainable utilisation of forests by promoting efficiency and energy conservation; 3. Improving governance in the forest sector by strengthening national capacity for Forest Law Enforcement, Governance (FLEG) – advocacy and awareness; and 4. Enhancement of carbon stocks through afforestation/reforestation, and fire prevention and control.

The FMCA 2016 also seeks to engage the private sector for forestry development. As one key measure to advance this, it outlines forest concessions as a means of involving the private sector in sustainable public forest management. This could provide access to private sector financial capital and benefits from the transfer of technological and operational efficiencies from the private sector into public sector forest management (Kagombe 2023). It would also help to boost employment and income generation and alleviate poverty.

The most recent policy document regarding the forest policy objectives is the draft for a strategic plan regarding the environment, climate change and forestry for the period 2023–2027 (Republic of Kenya 2023). The strategy identifies five key results areas: 1. Conservation; 2. Protection and management of environment and forestry resources; 3. Climate change adaptation and mitigation; 4. Agro-forestry and commercial forestry management; and 5. Resource mobilisation and partnerships. One of the key targets of forest policy has been to increase the forest cover to 10% of the country's land area by 2030 ("Vision 2030 target"). However, the recent strategic plan extends this ambition to 30% by 2050 (Republic of Kenya 2023).

Kagombe (2023) provides an assessment of the forest policies and legislative frameworks for commercial forestry management in Kenya. The study highlights gaps and opportunities to be addressed in future policy formulation and implementation of commercial forestry in Kenya. The paper shows that the FMCA from 2016 contains most of the requirements outlined in the FAO voluntary guidelines on forest concessions. However, according to Kagombe (2023), there is a need to address gaps such as: the harvesting value of an area, forest revenue collection, management of rescinded concessions, evaluation of the concession process, the mode of bidding, gender inclusion and independent observation. Forest certification could also play a major role in the adoption of sustainable forest management practices in forest concessions. According to Kagombe (2023), in order to promote willingness to invest in commercial forestry, "there is need for secure land tenure, respect for private ownership, reliable economic guidelines and standards, transparent governance, effective measures for tackling corruption, and efficient conflict resolution mechanism."

4.4 Challenges and opportunities

Despite the existence of the above policies, laws and programmes, the Kenyan forestry sector continues to face many challenges. Kenya's government summaries *problems related to forestry* as follows: "Past attempts to increase forest cover and address the problem of deforestation and forest degradation in the country have not been very successful. This can be attributed to among other factors; increasing demand for land for agriculture, urbanisation and other developments, high energy demand and inadequate funding to support investments in the forestry sector. Unresponsive policy and poor governance in the forestry sector have often in the past compounded these problems" (Republic of Kenya 2019, p. 4).

During 2002–2018, the average deforestation rate in Kenya was 0.58% of the total land area, which implied that 9.3% of the total land area was deforested. On the other hand, afforestation in 8.8% of the total land area took place at the same time. Thus, in effect a net area of 0.44% of Kenya's total land area was deforested in this period. Factors contributing to the deforestation include illegal conversion of forests into other uses (mainly agriculture), logging and over-exploitation of forests for fuelwood, timber and poles.

The primary management objective for *public natural forests* is mainly for watershed protection and biodiversity conservation. The *community forests,* which are also used for commercial forestry, are the largest in terms of area (24.5 million hectares) followed by farm and private forests located in agricultural landscapes (~10.4 million hectares) and public forests (3.5 million hectares) with forest plantations accounting for 107,000 hectares (Cheboiwo et al. 2018).

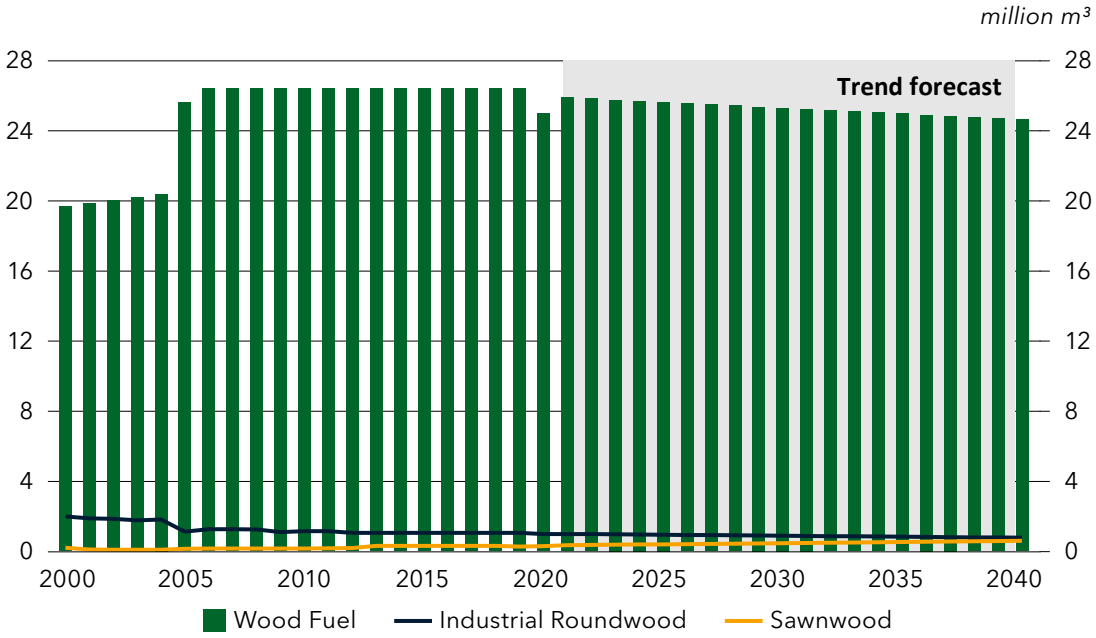
The *state-owned forest plantations* are approximately 136,000 hectares, and *other publicly owned plantations* (for example, local governments, municipalities) account for an additional 86,000 hectares (Ototo and Vlosky 2018). The predominant species are pines and cypress (86%), eucalyptus (10%), and the rest are indigenous hardwood and softwood plantations (Ototo and Vlosky 2018). These forests are managed by the Kenyan Forest Service to produce sawlogs, pulpwood and poles. Plantations are also the main source of roundwood for sawnwood and plywood industries.[5] *Private forest plantations* are estimated to cover about 100,000 hectares (Ototo and Vlosky 2018). They are predominately eucalyptus species grown to provide posts, transmission and building poles, sawn timber, fuelwood and charcoal. The tea and tobacco industries are among the leading investors in fuelwood plantations for fuel to dry their products.

According to Ototo and Vlosky (2018), investment in private plantation forestry faces some key challenges, which include limited access to extension services for establishing, managing and harvesting forest plantation, lack of quality planting seedlings from local tree nurseries, lack of organisation and information systems related to end markets, and the requirement that independent growers obtain licenses to harvest trees on their land and transport tree products between administrative are-

5 https://www.fao.org/faostat/en/#data

as. The Kenyan Forest Service has tried to address these barriers to promote private plantation forestry as an effective economic activity for both small-scale and large-scale growers. In general, there is a need for efforts to encourage private investment in forest production by bringing more land under forest production, providing extension/outreach services and planting fast-growing, high-yield tree species.

One of the biggest challenges of the Kenyan forest sector is the very high consumption of *wood fuel (or fuelwood)*. Figure 9 shows that the wood fuel share of the total roundwood production is around 96%, and there has been no major change in that (for more detailed discussion on this topic, see below).



Data: FAOSTAT

Figure 9. Kenya's wood fuel, industrial roundwood and sawnwood production 2000–2020 and trend forecast to 2040. Figure: Lauri Hetemäki.

Besides the wood fuel sector, the *small-scale sawmilling and plywood industries* also suffer from low efficiency. The utilisation efficiency of roundwood by small sawmills is estimated to average 28% (Gatsby Foundation 2022). In contrast, the country's only large-scale integrated mill that produces lumber, plywood, particleboard and hardboard achieves about 80% recovery. The mill uses waste material for combined heat and power to fuel its operations. However, most other sawmills in the country have smaller capacities and produce single products – mainly lumber – using inefficient technologies that result in low recovery rates. This remains a key challenge in the utilisation of available roundwood resources in the country. The third challenge facing Kenya's forest sector is overcoming a supply deficit of industrial raw materials because of the unsustainable management of its forests in the last three decades. Restocking harvested industrial plantations by KFS has been lagging behind schedule with an estimated 3,000 hectares being replanted versus more than 6,000 hectares of mature plantations harvested annually (FAO 2015).

Finally, increasing population pressure and associated demand for agricultural land and wood products poses a great challenge to the forestry sector in Kenya. As Table 1A indicates, the Kenyan population is projected to increase by around 25 million in the coming two decades. Moreover, Kenya and its forest are especially vulnerable to the impacts of climate change in the future. Therefore, better adapting forests to changing climate will be key.

Despite the challenges, the forestry sector continues to play an important role in Kenya and has great potential to grow. There is a sizable local market for forest products as well as in the greater East African and global markets. Efforts should be tailored toward increasing forest production and improving conversion recoveries at wood processing facilities. At the end of the day, adoption of innovation throughout the forest supply chain coupled with strong enforceable government policy will move Kenya's forest sector forward. Thus, it is necessary to address the challenges described above. The solutions to these relate to "the usual suspects": policies, investment, technology, capacity building and education, research, etc. All these require increasing funding and new funding mechanisms. We argue later that the forest-based bioeconomy could provide opportunities to attract these funds and interest to develop the forest-based sector in Kenya.

Climate change

According to African Development Bank (2018c), the largest source of GHG emissions in Kenya is agriculture, ie the land use change and forestry sector has negative emissions. The emissions from Agrisector (AFOLU) in 2014–2016 were 63% of total emissions and almost four times bigger than from oil combustion (AfDB 2018c). Livestock production and forestry are the largest contributors to AFOLU emissions. Table 3 illustrates that Kenya had an average annual emission from forests of 52 Mt of CO_2 during 2014–2018, and the emissions have increased relative to periods 2006–2010 and 2010–2014.

Table 3. Historical annual CO_2 net emissions classified by forest strata. Source: Republic of Kenya (2019).

Forest strata	Emissions, tonnes of CO_2				
	2002–2006	2006–2010	2010–2014	2014–2018	Average
Montane and Western rainforest	44,644,932	26,587,270	29,212,476	31,226,464	32,917,786
Coastal and mangrove forest	4,824,805	2,025,054	5,196,054	9,712,5288	5,437,247
Dryland forest	10,631,166	7,666,989	14,132,878	12,239,340	11,167,593
Public plantations	2,732,682	1,829,312	1,887,435	4,276,302	2,681,433
Total	62,833,585	38,099,174	50,428,843	57,454,634	52,204,059

As a result of the forestry problems, and Kenya's participation in REDD+, it has set the following priorities (Republic of Kenya 2019, pp. 4–5):

- reducing pressure to clear forests for agriculture, settlements and other land uses
- promoting sustainable use of forests by promoting efficiency and energy conservation
- improving governance in the forest sector by strengthening national capacity for Forest Law Enforcement, Governance (FLEG)- advocacy and awareness
- enhancement of carbon stocks through afforestation/reforestation, and fire prevention and control.

To what extent the above priorities are achieved depends on the actions implemented. For example, reducing forest clearing for agricultural purposes will probably not happen without new or additional policy measures.

Charcoal and firewood: How to transfer to more sustainable energy and wood utilisation?

Among the Kenyan government, international organisations and scientists there is wide agreement on the need to decrease firewood and charcoal consumption by increasing efficiency and using alternative energy sources, as well as better management of forests used for wood fuel in order to increase sustainable forestry in Kenya (Drigo et al. 2015; Ototo and Vlosky 2018; World Bank 2018; African Development Bank 2018c; Cheboiwo et al. 2018; Republic of Kenya 2019; IEA 2019; Chisika et al. 2021; Ndegwa et al. 2021; AECOM 2021; Gatsby Foundation 2022; KIPPRA 2023).

Moving to more efficient and sustainable cooking and heating will play a key role in attempts to reduce forest deforestation and degradation, as well as better enabling value-added forest bioeconomy development in Kenya. This is simply due to fact that 96% of the wood consumption in Kenya is used for cooking or heating purposes, and only 4% for forest products industry and poles. As Figure 10 shows, there has been no big change in this respect during this century – the historic trend continues.

The wood used for firewood or charcoal may not be suitable for many value-added forest bioeconomy products due to quality reasons (shape of the wood trunk, wood material properties), such as for sawnwood or engineered wood products. However, they could be suitable for wood cellulose, hemicellulose or lignin-based products (for example, for various biochemicals, packaging products and for textile raw materials).

Fuelwood use is substantial in Kenya and may not be sustainable in the long run, eg given the demands of growing population and low annual productivity of dryland forests, which could also worsen in future due to climate change. According to IEA (2019), 83% of the population depends on biomass (mainly firewood and

charcoal) for cooking. In rural areas, where the bulk of the population lives, 84% of households use firewood as main source of cooking fuel, and 7.7% is based on mainly wood charcoal (AECOM 2021). In urban areas, charcoal also represents a major part of cooking fuel – almost one fifth.

The wood used for energy is often harvested/collected in ways that are inefficient and result in forest degradation, and the wood is transferred to energy form with low efficiency and with technologies that can create health problems and pollution. According to Ototo and Vlosky (2018), the greatest driver of degradation of dryland forests is charcoal production, owing to the high demand for charcoal in rural and urban settlements across the country. Charcoal producers use especially high-density species, such as Balanites, Acacia and Terminalia, which have low regeneration capacity. Most wood used for charcoal production is sourced from trees on farms. Drigo et al. (2015) estimate that around 40% of wood fuel, which includes both charcoal and firewood, is unsustainably harvested, causing negative impacts on Kenya's biodiverse forests.

In 2018, World Agroforestry (ICRAF) conducted a household survey across Kenyan Baringo county, and found a prevalence of unsustainable practices in charcoal production – one of the main economic activities in the region (Njenga 2020). First, the survey revealed that most landowners who source wood for charcoal did not carry out any kind of tree management. For example, they did not thin or cut down stems or branches to promote growth, reduce formation of thickets (in the case of Prosopis) or replant when they cut native species. Second, it showed that all charcoal producers used traditional earth mound kilns (TEK) which produce low yields and result in wood waste and cutting down more trees than necessary. The use of inefficient technologies is a significant indirect driver of forest degradation, as more fuelwood/charcoal is required to deliver the same outcome, further increasing the pressure on forests.

In general, the use of traditional 'three-stone' fires and kilns is still common in Kenya, especially in rural communities. These cookstoves do not fully combust the biomass, with up to 75% of the heat being lost. In addition, the burning process releases substances hazardous to human health, including carbon monoxide, nitrous oxides, particulate matter and black carbon (Natural Capital Partners 2019). Encouraging the uptake of, and providing opportunities for, clean/improved cookstoves with higher thermal capacities would reduce the demand for energy wood per capita and improve the health impacts on the user. It has been estimated that this could lead to savings of close to one million cubic metres of wood fuel per year (UNEP 2017). The gradual transfer to alternative energy forms, such as natural gas, solar and wind energy, etc, would also be very important. For example, if we assumed that increasing wood energy efficiency and transferring to alternative energy forms would reduce current energy wood use by 30%, this would imply 7.5 million m^3 wood saving, or 7.5 times more than current industrial roundwood production in Kenya.

IEA (2019) analysed different scenarios for fuel and cooking technologies in Kenya and what these could mean for the future. The scenarios reflect the degree to

which the government policies can shape investment flows and the availability and affordability of modern energy sources. The first scenario, named "The Stated Policies Scenario", reflects IEA's assessment of current policy frameworks and plans, taking into account the regulatory, institutional, infrastructure and financial circumstances that shape the prospects for their implementation. The second scenario, "The Africa Case", is built on the premise of Agenda 2063, the continent's inclusive and sustainable vision for accelerated economic and industrial development.[6] The scenario results are shown in Figure 10. For example, the current policy framework could deliver by reducing the share of charcoal and solid biomass for cooking purposes from 83% in 2018 to 53% in 2030.

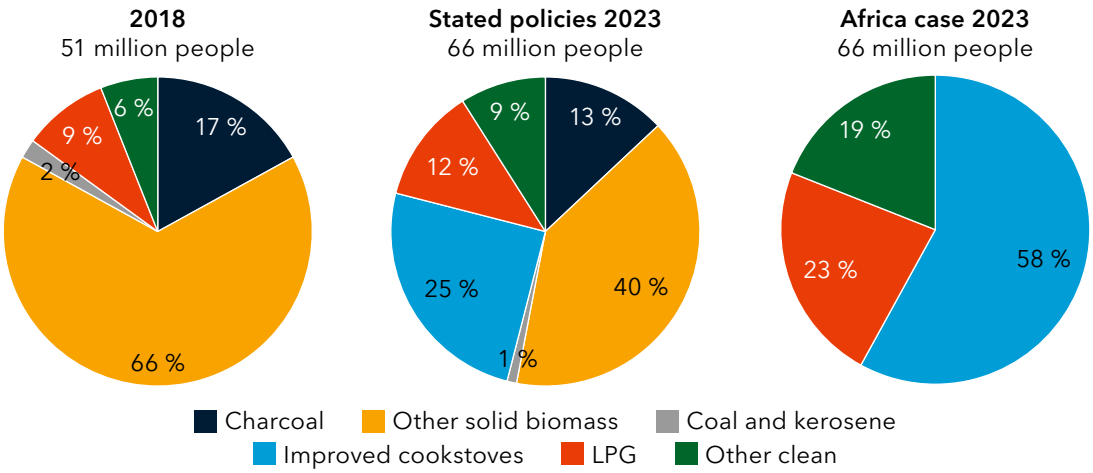


Figure 10. Kenya fuels and technologies used for cooking. Adapted from IEA (2019).

The efforts to reduce wood energy consumption in Kenya need to tackle the whole charcoal and firewood value chain and the socio-economic issues involved. A report produced in 2013 by the Kenya Forest Service (2013) shows that the charcoal industry employs more than one million people across the value chain. The charcoal industry creates jobs and income for wood producers, charcoal producers and vendors. However, the sector remains informal in the economy. Wood harvesting, charcoal burning, transport and trade are still largely unregulated. The report also revealed that most trees used for charcoal production are sourced from rangelands that are under various forms of ownerships including freehold, group ownership and trust lands. Moreover, local charcoal producers often lack the skills, raw materials and investment capacities to adopt more efficient technologies. Thus, trying to reduce wood energy consumption will involve many parties and it will be a complex endeavour.

Among the main challenges affecting firewood and charcoal use are low energy access, awareness and affordability-related issues (KIPPRA 2023). Compared

6 Agenda 2063 was adopted in 2015 by the heads of state and governments of the African Union.

to other energy sources, firewood and charcoal are often cheaper and more accessible. Several initiatives have been set up by government and non-government stakeholders to address these challenges. For example, the Kenya Country Action Plan (CAP) (2013) for Clean Cookstoves and Fuels looked into raising awareness to promote the use of clean fuels to address knowledge barriers. For example, according to KIPPRA (2023), the government zero-rated VAT on LPG led to significant uptake of LPG by more than 50% between 2016 and 2020. In 2021, the government reinstated VAT exemptions on renewable energy products, including clean cooking solutions and solar and wind generation equipment through the Finance Act, 2021 (KIPPRA 2023). This and other types of incentives to promote alternative energy forms for wood fuel are essential to speed up the use of forests as an energy source. Moreover, the role of non-governmental organisations and national and multilateral development organisations to promote and support clean cooking, increased public advocacy and other initiatives, is essential.

4.5 Forest bioeconomy outlook

The basis of forest bioeconomy is forests and sustainable forest management. Currently, Kenya faces a growing wood supply deficit and urgently needs to develop new plantation resources (Gatsby Foundation 2022; Republic of Kenya 2023). On the other hand, if the wood production trends of the past decade were to continue in the future (see Figure 9), in 2040 wood fuel production would still amount to 96%, and industrial roundwood only 4% of the total roundwood production. Clearly, reducing the wood going for firewood and charcoal is also key to more value-added forest bioeconomy development in Kenya, such as providing raw material for biochemicals, packaging and textiles.

Scanning the recent Kenyan government strategies, policy documents and policy briefs reveals that the bioeconomy concept is missing from these (Republic of Kenya 2022, 2023; KIPPRA 2022, 2023). For example, the strategy for environment, climate change and forestry set a strategic objective to mainstream the *circular economy* in national development but does not mention bioeconomy at all (Republic of Kenya 2023). Moreover, when the Kenyan Medium-Term Plan for 2023–2027 (Republic of Kenya 2022) or KIPPRA (2023, 2023) policy briefs focus on land use or the rural sectors, the focus is almost exclusively on agriculture. Although the documents acknowledge and discuss commercial forestry and agroforestry, there is a lack of discussion of the opportunities the forest value chain and forest bioeconomy can provide in terms of incomes, jobs and addressing sustainability challenges, such as replacing fossil materials. The outlook for future development also tends to neglect the opportunities the forest sector could provide. For example, in discussion of the opportunities that biotechnology development can bring, the focus is on agriculture and food-related issues, with no discussion of forest-related biotechnologies (KIPPRA 2022).

One gets the impression that if something is relatively small in terms of economic significance (eg compared to agriculture) and underdeveloped today, so it will be

also in the future. Simply put, Kenya has yet to open its eyes to the opportunities that the forest-based value chain and forest bioeconomy can bring to the country. It is essential to acknowledge these opportunities at the national level and in government strategies and resource allocations, so that appropriate policies and measures could be directed to forest bioeconomy development.

Yet, the Kenyan forest bioeconomy outlook is not as bleak as one might conclude from the above. Although the forest bioeconomy concept is missing, and the government does not have forest bioeconomy strategies and policies, many of the enabling factors that help forest bioeconomy development have still received attention.

One key enabling factor for forest bioeconomy development is to strengthen the commercial forestry sector. Currently, the commercial forest sector is underdeveloped, and it is thought that offering long-term concessions on publicly owned forest reserves could attract private sector investment (The Daily Nation 2023; Republic of Kenya 2023). One policy that could attract major investment into new planting would be to offer long-term concessions/leases in some of Kenya's state Forest Reserves (Alonso and Jacovelli 2022). Kenya has legislation in place for this to happen but has been reluctant to launch such a scheme. If the conditions were right, the private sector could take on the main role of investing in commercial timber plantations in Kenya. Benchmarking should also be carried out from other countries. For example, valuable lessons could be learned from Uganda where a variety of incentives have led to over 85,000 hectares of new timber plantations since 2004 (Alonso and Jacovelli 2022; Gatsby Foundation 2022). Its success is said to be due to a combination of concessions on public land and financial and technical support from Sawlog Production Grant Scheme (SPGS), a government agency.

Moreover, to advance forest bioeconomy, it would also be essential to develop smallholder farm forestry and wood value chains in Kenya (The Daily Nation 2023). This would offer incentives for forest management as well as provide income, jobs and improve rural livelihoods. Indeed, Kenya has already organised private forestry associations such as the Farm Forestry Smallholder Producers Association (FFSPAK) as an umbrella organisation based in Nairobi and working with smallholder farmers to promote farm forestry and improve the livelihood of its members (FAO 2019). The association provides advisory services such as market information and trends, silviculture, weather forecast, finding input suppliers, financial partners, research collaborations. However, there remains a huge need for more capacity building, improved governance and transparency (to reduce investment risks) and better access to finance for smallholders (FAO 2019).

At the national level, well-coordinated and implemented bioeconomy strategies and policies are important. In this respect, there is a need to ensure coherence of the existing policies, legislation and regulatory frameworks. Effective and efficient sectoral coordination between relevant regulatory institutions involved in biomass use is therefore a necessity. In essence, there is a need for explicit legal, regulatory and institutional frameworks on biomass generation, production, distribution and supply.

ATPSNET (2021) outlines the general background for Kenya's bioeconomy development. It indicates that the country has had specific bioeconomy-related strategies and policies for some parts of the bioeconomy value chain, such as biodiesel and biotechnology, but not an overarching national bioeconomy strategy. For example, Kenya has had a strategy for developing the biodiesel industry and the National Biotechnology and Development Policy, among others. According to the interviews and desk analysis, the perspective summarising the view of bioeconomy in Kenya context is the following (ATPSNET 2021): "processes and activities that lead to sustainable use of biological resources to create value in form of products, services and knowledge, through science, technology and innovation." In terms of bioeconomy, the focus of the report is very much on agriculture, and there is no mention of the opportunities related to the forest sector.

The report identifies that a "glaring gap that has posed a challenge to utilisation of new innovations and could be a bottleneck to bioeconomy development is poor linkages between the academia, research institutions and industrial applications of bioinnovations. This is further aggravated by lack of a well-functioning innovation system to ensure enhanced competitiveness and links with the education and research system, the business system, the intermediate organisations, ST&I infrastructure and framework conditions in which they operate to interact dynamically" (ATPSNET 2021. p. 57).

Research, development and innovation (RDI) expenditure is key to advancing bioeconomy development. Being a member of the African Union (AU), Kenya has a mandate to meet the set standard of 1% of GDP to be investment in research by the AU's executive council (ATPSNET 2021). In fact, Kenya has a target of 2% of GDP to be spent on research activities. However, despite such commitments, the country's expenditure on research is still below target, averaging at 0.79% of GDP (Hanlin 2017). However, according to ASTP (2021, p. 58) Kenya has the highest density of researchers per million inhabitants in east and central Africa and this has been attributed to a rise in the number of both public and private universities. Yet, according to ASTP (2021) there is a disconnect between education and training and industry needs that are technologically aligned.

For future forest bioeconomy development, modernising wood energy consumption could provide many opportunities. First, by introducing more efficient cooking and heating technologies, the wood utilisation per capita could be reduced. This in turn would help take the pressure off forest lands and also provide opportunities for more value-added use of wood. This trend should also be enhanced by moving to alternative energy forms, such as solar, wind and gas (IEA 2019), which could save wood resources for higher value material products, such as wood construction.

On the other hand, there is a growing need to replace oil by biofuels (bioethanol and biodiesel) to meet transportation needs, reduce vehicle emissions, save on foreign exchange required for petroleum importation, improve the balance of trade, create employment and contribute to the overall green economy. This could be achieved through the establishment of facilities for biofuel blending and identify-

ing and using the forest biomass (and, for example, jatropha) feedstock for these purposes.

When discussing the Kenyan forest sector development and bioeconomy, it is important to highlight that it is much more than wood for energy and products. For example, forests in Kenya are also particularly important in terms of *tourism*. Services, such as ecotourism, should be understood to be part of the bioeconomy (Hetemäki et al. 2017; Ronzon et al. 2017; Rinn et al. 2023). According to Rinn et al. (2023), "bioeconomy-based tourism is a concept that considers the approach of BE in the field of tourism. It focuses above all on a sustainable level of tourism in the connection of economic and environmental pillars, where the main emphasis is placed on the effective use of natural resources and a maximum effort not to waste these resources, as well as to ensure their subsequent renewal."

The tourism sector is a major source of income and employment in Kenya's economy, accounting for 10.4% of Kenya's GDP, and 5.5% of formal employment (KIPPRA 2023). As Ototo and Vlosky (2018) state, "the country is one of the world's most popular tourist destinations where a myriad of big game mammals can be seen …" The large number of national parks and game reserves help to bring tourist employment and income. According to KIPPRA (2023), protected areas with high ecotourism potential tend to lack comprehensive management plans. The establishment of management plans for the country's national parks and wildlife conservancies in forests would be critical to develop ecotourism. Also, the national parks and most community conservancies do not often provide the necessary infrastructure for ecotourism, such as roads and accommodation.

Finally, when developing the forest bioeconomy, it is essential to bear in mind that Kenya's forests provide a wide range of ecosystem goods and services that support Kenya's economy and wellbeing. For example, montane forests regulate more than 75% of the country's renewable water resources, which is critical for the sustainable development of many sectors such as agriculture, forestry, fisheries, electricity, water, hotels and other tourist accommodation, public administration and defence (Ototo and Vlosky 2018). Forests also prevent soil erosion and provide biodiversity. Thus, it is key to design strategies, policies and measures that make it possible to maximise synergies and minimise trade-offs between bioeconomy development and the other ecosystem services that Kenyan forests provide.

5. Nigeria: Population growth the major driving force for forest-based bioeconomy

5.1 Socio-economic context

Nigeria is situated in the West African Region and is often referred to as "the giant of Africa" due to its population, which is almost twice that of the second most populous country (Ethiopia).[7] The country's population is estimated at 222 million and is projected to reach about 401 million by the end of the year 2050.[8] The majority of Nigerians live in urban areas (53%) which also experience a higher population growth rate (3.9%) relative to the national population growth rate of 2.4% (World Bank 2023). This high population and its growth rate present immense challenges to socio-economic infrastructure and amenities as well being a direct cause of the high employment rate experienced in the country. According to the KPMG 2023 Global Economic Outlook report, the unemployment rate in Nigeria was 37.7% in 2022 and is projected to increase to 40.6% in 2023.[9] An even higher percentage of Nigeria's citizens are living in poverty. According to the 2022 Multidimensional Poverty Index (MPI) survey, about 63% of persons living within Nigeria (133 million people) are multidimensionally poor (NBS 2022).

The country has also had a history of conflicts and violence that in the past have caused political instability such as military coups, electoral crises, religious/ethnic crises, ethnic militant uprisings, kidnapping and the ongoing Boko Haram insurgency (Raji and Wahab 2016). This instability has the potential to constrain the socio-economic development of the country. For instance, insecurity coupled with low oil production is projected to decelerate the country's economic growth to an average of 3.2% during the 2022–2023 period (AfDB 2022). However, the 2023 elections and peaceful transfer over the last year offers optimism that the country can surmount such problems.

Nigeria is the biggest economy of the continent and GDP was USD 440 billion in 2021 (World Bank 2023b). Four sectors in particular have contributed to Nigeria's economy: agriculture, trade, information and communication and manufacturing. Agriculture is the largest sector in the economy, contributing 25.9% to the real GDP with an estimated value of around USD 41 billion in 2021. The agricultural sector has four components – crop production, livestock, forestry and fishing, with respective values of around USD 37 billion, USD 2683 billion, USD 418 million, and USD 832 million. The manufacturing sector contributed 9% to the country's real GDP with a value of around USD 14 billion. The sector's contribution was largely driven by the food, beverages and tobacco sub-sectors, its share being 23% of the total sector value.

7 https://worldpopulationreview.com/continents/africa-population accessed November 18, 2022.
8 https://worldpopulationreview.com/continents/africa-population accessed November 18, 2022.
9 https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2023/03/kpmg-global-economic-outlook-h1-2023-report.pdf

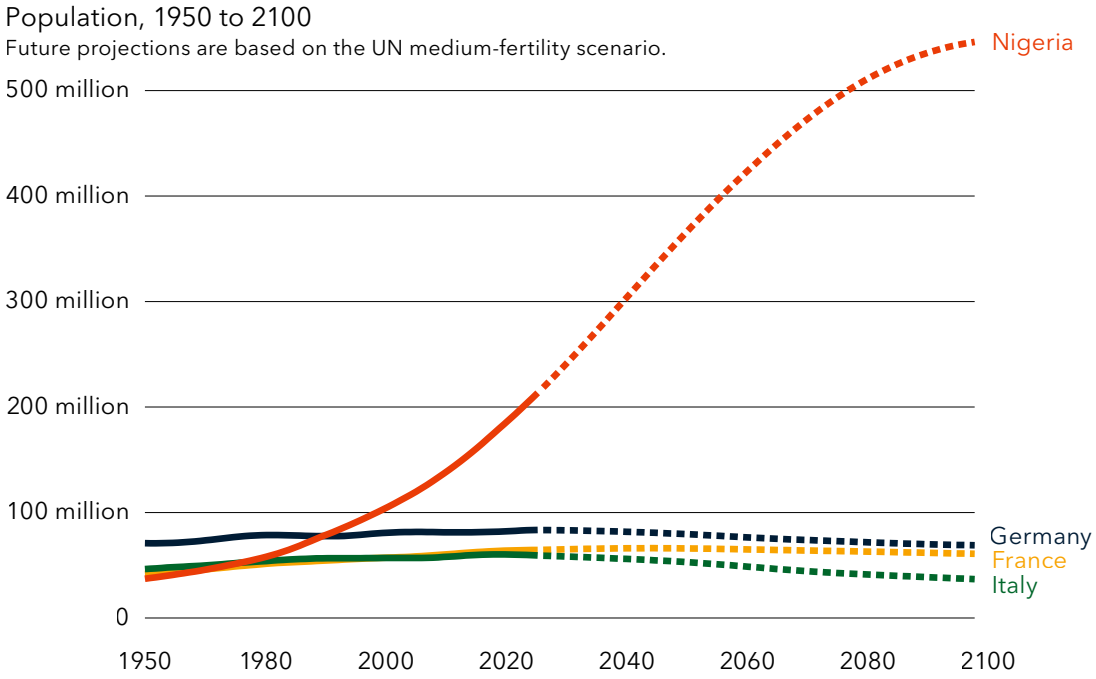


Figure 11. Nigeria's population is expected to more than double by 2100. Adapted from https://ourworldindata.org/grapher/UN-population-projection-medium-variant?time=earliest..2050&country=NGA~ITA~DEU~FRA

The country continues to face massive developmental challenges, including the need to reduce dependency on oil and diversify the economy, address insufficient infrastructure, build strong and effective institutions, as well as address governance issues and public financial management systems. Inequality, in terms of income and opportunities, remains high and has adversely affected poverty reduction. The lack of job opportunities is at the core of the high poverty levels, regional inequality, and social and political unrest. High inflation has also taken a toll on households' welfare (World Bank 2022b). Human capital is at the centre of economic development. However, the country has performed dismally in human capital to drive its economic growth. According to the World Bank, Nigeria ranked 150 out of 157 countries in the 2020 Human Capital Index (World Bank 2020). Nigeria is highly culturally diverse, with more than 250 ethnic groups speaking about 500 distinct languages. While harnessing this diversity for national development is obviously a daunting task (Ojo 2016), the government of Nigeria has affirmed its readiness to tap into the huge asset provided by its population towards its development process (Kozah 2022).

Poor infrastructure development has also been a major contributor to the slow economic development. The World Economic Forum's 2016–17 Global Competitiveness Index ranks Nigeria's infrastructure at the bottom – 132 out of 138 countries (Schwab 2016). According to Bello-Schünemann and Porter (2017), "currently only 16% of Nigeria's roads are paved, compared on average to half of the roads in the world's lower middle-income countries. Similarly, in 2016, only about 30% of

Nigeria's population had access to improved sanitation facilities compared to, on average, more than half of the population in the country's global income peers." The report also stated that Nigeria's substantive deficit in basic physical infrastructure severely compromises human development.

Heavy reliance on fossil resources has exposed the country to external shocks, such as the recent Covid pandemic which resulted in a sharp decline in oil prices. Moreover, industrialisation and over-exploitation of natural resources, including forest resources, have led to environmental degradation (Federal Ministry of Finance, Budget and National Planning 2021). To address these myriad challenges and spur economic growth and development, the country has developed the National Development Plan 2021–25, which aims to lay the foundation for transitioning to a green economy by 2025 by implementing, among other targets, the following:

- upscaling investments in renewable energy and energy efficiency for productivity, competitiveness and job creation
- setting Nigeria on the path towards a green economy by building a circular economy and improving the bioeconomy
- reversing deforestation trends towards vulnerable communities, for example through increasing forest plantations from 5.9 million hectares to 12 million hectares in 2023 and restoring degraded lands from 4,979 hectares to 13,892 hectares (2023) (Federal Ministry of Finance, Budget and National Planning 2021).

The above policy targets indicate that the country has started to demonstrate some level of commitment to develop its forest bioeconomy as a tool for socio-economic development. However, more efforts need to be put into developing a robust legal and policy framework to catalyse this transition, including developing and implementing a (forest) bioeconomy policy.

5.2 Forest sector and its goals

Nigeria has about 23% forest cover, which is largely found within the following vegetative zones: Mangrove Swamp (3.57 million hectares), Lowland Rainforest (7.4 million hectares), Montane Forest (1.05 million hectares), Derived Savanna (3.8 million hectares), Guinea Savanna (5.4 million hectares) and Sudan Sahel (0.99 million hectares) (FAO 2020). About 98.9% of the Nigerian forest is naturally regenerating, while forest plantations are estimated at only 216,270 hectares (FAO 2020a). In terms of ownership, the majority of the forests (68%) are owned by institutions and local, tribal and indigenous communities; 30% are publicly owned and the rest are privately owned.

Deforestation remains one of the major challenges facing Nigerian forests. About 13% of the country's forests have been lost since the beginning of this century (Oyetunji et al. 2020). The FAO FRA 2020 estimates that the country lost about 163,310 hectares of forest between 2015 and 2020. The combination of high population growth and poverty rates have increased the demand for wood fuel and

the associated increase in its prices. For example, charcoal production, firewood harvesting and selling and lumbering are a main source of income for rural households in Southwest Nigeria (Fasona et al. 2020). Exploitation of forests and woodlands for these resources has resulted in increased deforestation and forest degradation in Nigeria.

According to FAO, Nigeria's forest resources contribute about 2.5% to the GDP, and provide employment for over five million people through supply of timber and non-timber products (FAO 2020a). The timber processing industry in Nigeria also plays a big role in the country's export. Over the last five years it has contributed an average of USD 1 billion in export revenue each year (Wigmore Trading 2021), with over 800,000 people working in the log processing industry.

Besides timber, the forests also provide a wide range of non-wood products and environmental functions, though these are not adequately quantified and are underestimated in national accounting. These products include bush meat, medicines, leaves, herbs, fibres, gum, etc and environmental services such as watershed protection, stabilisation of the hydrological regimes and carbon sequestration. In Nigeria, biomass – in the form of firewood and charcoal – is the largest source of total primary energy, with about 40 million people, or one-fifth of the population, directly engaged in fuelwood collection and charcoal production. The fuelwood sector provides an estimated 530,000 full-time equivalent direct jobs. An additional 200,000 people – mostly also full-time – provide transport services for retail and wholesale trade of wood charcoal (FAO 2020a). However, the forest sector in Nigeria, as in the larger Sub-Saharan Africa, is mainly informal and quantitative figures regarding the sector have to rely to a great extent on estimates rather than official statistics (Rosa and Martius 2021).

Nigeria recognises the multifunctional purpose of its forest resources and it is contributing to various international treaties and policies relating to forests, such as the Aichi Biodiversity Targets (Akindele et al. 2021) and has thus developed policies and laws to regulate the sector. The Nigerian Forest Law has been in existence to preserve the country's forest resources for over seven decades now. The Act, which was already promulgated as far back as 1958, provides for the preservation of forests and the setting up of forest reserves. It outlaws, and prescribes punishments for, offences related to cutting down trees over six feet in girth or setting fire to the forest except under special circumstances (Omon and Ilobekemen 2018, p. 33). The National Parks Decree (Decree No 36 of 1991) was adopted to provide a protective sanctuary for wildlife species as well as to promote and preserve the beauty and conservation of the country's natural vegetation. The Act established six national parks in which hunting, fishing and the destruction of trees, and the setting of fires in and around those spaces, are restricted. This Act was succeeded by the National Parks Act of 1999, which created two additional national parks (Salami et al. 2018).

As regards forest policy, the National Agricultural policy of 1988, which also governed the forestry sector, provides for: (a) consolidation and expansion of the forest estate in Nigeria and its environment for sustained yield; (b) regeneration of the

forests at rates higher than exploitation; (c) consolidation and protection of the environment vis a vis forest, soil, water, flora and fauna and the protection of forest resources from fire, cattle grazing and illegal encroachment; and (d) development of the forestry industry through the harvesting and utilisation of timber, its derivatives and the reduction of waste (Omon and Ilobekemen, 2018, p38).

However, as deforestation and forest degradation has continued in Nigeria in the past decades, the implementation of the above laws and policies have not been sufficiently extensive or effective to secure sustainable forest development. Thus, challenges still remain. These include deforestation, widespread and increasing land and vegetation degradation; growing debilitating effects of land degradation on communities; escalating real supply deficits for forest products; absence of credible forest databases and statistics to guide policy formulation; ineffective management of forest reserves; negligible private investment in forestry; neglect of biodiversity with a low level of protection of existing reserves; and low capability of forestry staff (both at the federal and state levels, especially at the latter) to manage forest resources (FAO, nd).[10]

To address the foregoing challenges, a new policy was adopted in 2006. The 2006 forest policy sought to spearhead sustainable forest management that would ensure sustainable increases in the economic, social and environmental benefits from forests and trees for the present and future generation, including the poor and the vulnerable groups. The policy highlighted four key strategies for achieving sustainable forest management, including: (i) promotion of partnership with all stakeholders including the private sector, communities and civil society organisations; (ii) decentralisation of forest management; (iii) promotion of community participation in forest resources management; and (iv) encouraging the active participation of all women and men, young people and elderly and the vulnerable in forest resources development (Federal Republic of Nigeria, 2006). However, the 2006 policy did not live up to its billing as loss of the country's forests remained one of the highest in Africa, mainly caused by illegal logging, agriculture expansion into forest areas and development of infrastructure (DGB Group 2021).

To finance its forestry development, Nigeria established the National Forestry Trust Fund (NFTF) in 2017 to support reforestation and sustainable management of forests in degraded forest estates, reserves and production landscapes (Essen 2018). The Fund was formed with the knowledge that state level funds would be inadequate to deal with the myriad problems plaguing the forest sector, hence the need for a nationwide funding approach (Essen 2018).

Nigeria is also implementing the Great Green Wall as part of an ambitious African Union-led Great Green Wall Initiative that aims to restore the continent's degraded landscapes, revitalise thousands of communities, boost food security and strengthen climate resilience in the Sahel. The government established a National Great Green Wall Agency (NAGGW) in 2015 to coordinate tree planting activities,

10 FAO (n.d). https://www.fao.org/3/ac918e/AC918E04.htm#TopOfPage

management and installation of support services, and provision of infrastructure such as solar systems and water for herders and farming communities. Some of the achievements so far include the establishment and fencing of 300km of shelterbelt in Borno, Jigawa, Katsina, Sokoto and Yobe states, in addition to setting up and fencing an estimated 170 hectares of woodlots in Adamawa, Bauchi, Gombe, Jigawa and Kano states; restoration of 560 hectares of degraded ecosystem in Bauchi, Jigawa and Sokoto and adoption of seeds of indigenous trees and herbaceous fodder species with 150,000 seedlings raised in five community nurseries. The agency has also been involved in building the capacity of farmers to improve climate resilience as well as the provision of solar home systems and livelihood empowerment such as balanites oil extraction, honey production and micro-gardens for vegetable production (Abdullahi 2022).

In order to reduce CO_2 emissions, Nigeria has set as priorities to increase energy efficiency through measures such as the use of more efficient generators, a reduction in gas flaring, the implementation of better transport systems and better technology, as well as implementing climate smart agriculture and reforestation while reducing household reliance on biomass fuels such as charcoal.

In terms of developing the Nigerian sustainable future and forest bioeconomy, a key focus is how wood energy consumption could be reduced. Nigeria's energy sector is characterised by a split between a well-developed and economically important fossil fuel industry, and a large "informal" rural energy infrastructure largely reliant on forest biomass for domestic energy needs (African Development Bank 2018b). Figure 12 shows the large role of biofuels (mainly wood energy) in consumption in Nigeria.

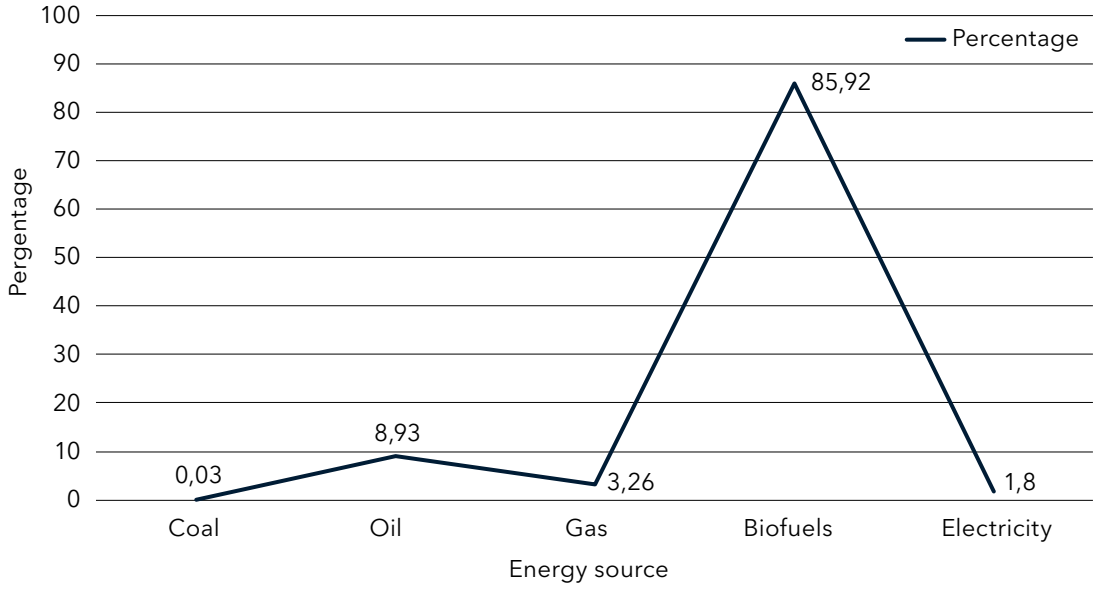


Figure 12. Proportional distribution of Nigeria's national energy consumption by major energy carriers (2014–2016). Data African Development Bank (2018).

The above policy and legal framework and government initiatives have not been effective in slowing down the rates of deforestation in the country. About 13% of Nigeria's forests have been lost in the country since the beginning of this century due in part to the nation's high population growth as well overreliance on fuelwood by mostly poor households who have incentives to harvest fuelwood and often use unsustainable fuelwood harvesting practices (Bashir et al. 2017). On the other hand, the continuous urban population growth has led to increases in human activities in forests, leading to depletion of forest reserves. In summary, if population growth continues as predicted, deforestation and forest degradation is likely to continue (Edeme and Chibuzo 2018) with adverse consequences for forest-dependent communities and the timber and fuelwood industry.

While forest reserves were established to promote biodiversity conservation in Nigeria, this has not hindered forest overexploitation and degradation. For example, Mmom and Mbee (2014) found that the steady growth of the population of the communities around the Gele-Gele Forest reserve led to the rapid decline and depletion of the forest stock in the reserve because of overdependence on the forest resources in the reserve. Similar trends also take place in other forest reserves in Nigeria, despite their richness in biodiversity and biological resources and provision of livelihood opportunities to the people who live around them (Mmom and Mbee 2014). Not only have these concerns been reported by scientists but the news media is also contributing to a campaign that promotes family planning as a way of curbing unabated population growth, as it has consequences on the natural environment. For example, an article headlined *"High population eats up Nigeria's forests"*, reported that Nigeria had 95 million people in 1990 and 216 million people by 2022 and the country produces about 1 million tons of charcoal annually of which 80% is consumed in the cities (Muolokwu 2019).

Nigeria faces serious environmental problems such as loss of biodiversity, dusty weather conditions, flood, droughts, etc because of unabated deforestation and forest degradation. Various recommendations have been made towards solving this menace, such as the enactment of policies aimed at reducing population growth and increasing awareness to protect the available forest resources in Nigeria. The significance of medicinal plants to rural livelihood in the provision of affordable healthcare in Nigeria has been emphasised by scientific studies (Ojekunle et al. 2020). Scientists, researchers and governments have also been providing guidance and advice on how Africa can use fuelwood sustainably, including propagating methods of making charcoal efficiently (Mononen and Pitkänen 2016). International research organisations are also contributing to the circular economy in Sub-Saharan Africa (Feleke et al. 2021).

While Nigerian forest policy has been in existence for decades and has sought to ensure sustainable forest management, the above discussion indicates that the country is still grappling with deforestation and forest degradation. Most of these challenges stem from high population rates, hence high demands for forest resources (especially for fuelwood), high levels of poverty, illegal harvesting of forest resources and unsuitable forest resources harvesting technologies. Cognisant of the above realities of the Nigerian forestry sector, in the next section we look into how its future could evolve and what opportunities the bioeconomy could bring.

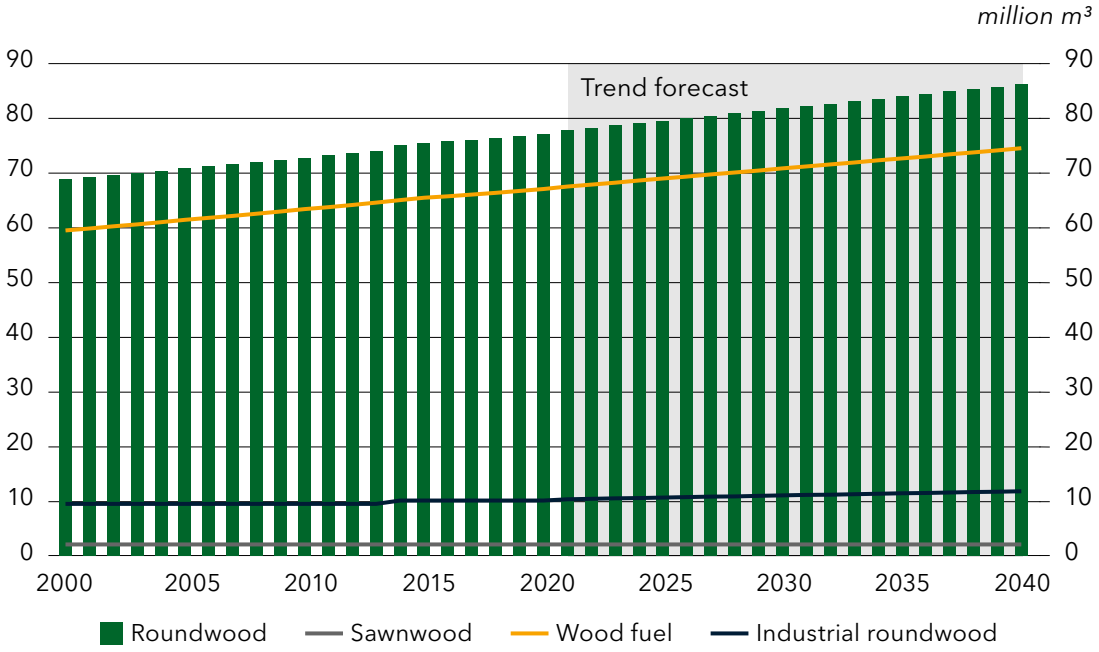
5.3 Forest bioeconomy outlook

Nigeria has shown its intention to advance the sustainable development and management of its forests and forest resources by adopting policies and laws to govern the sector. Some of the priorities of the policy and legal frameworks include inter alia the development of a funding mechanism for the sector and protection of forest resources through establishment of forest protected areas. However, the country still faces high deforestation and forest degradation due in part to high population rates and heavy dependence on fuelwood. The country's transition to a forest bioeconomy is therefore one which is replete with socio-economic challenges. Nigeria currently lacks a bioeconomy policy (Oguntuase 2017); nor does it have a forest bioeconomy policy. In addition, in the Nigerian context, the use of circular economy often refers only to waste recycling (Rajput et al. 2020).

Figure 13 shows the development of major forest products in the past two decades and the 2010–2020 trend projection to 2040. If this "business-as-usual" trend was to materialise, wood fuel production would be 86% of the total roundwood production in 2040, and industrial roundwood would still constitute only 14%. Sawnwood production would continue to be at a very low level, meaning there would hardly be any change in value addition. In terms of value-added product development and diversification of the forest bioeconomy, the "business-as-usual" case could be regarded as an undesirable future development. Clearly, the major issue would be that such a high share of the roundwood potential would still be going to low value-added wood fuel. To develop the forest bioeconomy, Nigeria should seek to divert its energy base away from wood energy and explore development, commercialisation and investment in modern cooking technologies, and alternative energy forms besides wood. Policies, R&D, investment and new income and employment opportunities should support this development.

The slow transition to the forest bioeconomy can also be seen in the trade of the country's value-added forest products. In 2020, Nigeria exported forest products amounting to nearly USD 104 million. Most of the products were roundwood and sawn wood, amounting to roughly USD 41 million and USD 18 million respectively. The high value of roundwood exports and very small amount of value-added forest product production indicates the weakness of forest bioeconomy in the country. For example, in 2017, Nigeria exported forest products to the value of USD 620 million, of which the share of roundwood was 95% and sawnwood 4% (FAOSTAT).

Given the above situation, it is clear that developing a more extensive and value-added forest bioeconomy in Nigeria cannot be based on the existing forest sector and industry structure. There is a need for transformation, which will require focusing attention on investment and funding, RD&I, forest biomass expansion, human capital development, and enhancing forest management as key ingredients to unlock and scale up development of the forest bioeconomy in Nigeria. For Nigeria to fully harness the power of the forest bioeconomy, it can take lessons from other countries (Jankovský et al. 2017). The Nigerian green jobs assessment report also provides a number of ideas that can contribute to a forest bioeconomy from clean cookstoves to forest restoration, among other initiatives that the country has already committed to and plans to invest in (Wiebe et al. 2021).



Data: FAOSTAT

Figure 13. Nigeria's roundwood, wood fuel, industrial roundwood and sawnwood production 2000–2020 and trend forecast to 2040. Figure: Lauri Hetemäki.

Funding is key in the transition to forest bioeconomy. The country has already made a bold step in establishing the National Forestry Trust Fund (NFTF) to improve funding for the forest sector, address the high rates of deforestation and improve forest sector development to support the high rate of industrialisation required in the country (Essen 2023). This fund should generate additional and complementary sources of funding to supplement government budgetary provisions to adequately support the country's forest bioeconomy processes. Nigeria is already a part of several internationally funded and supported initiatives aimed at increasing the forest base of the country through massive afforestation projects such as the Great Green Wall and the AFR 100 restoration projects (Mansourian 2020). The country needs to build on these initiatives and partnerships to mobilise additional and sufficient resources to support forest bioeconomy development.

The government has already embarked on an expansion of forest plantations to support the ever-growing demand for forests and forest resources. For instance, the government is supporting afforestation in 11 northern states to combat drought and improve the livelihoods of rural citizens. Ever since the Nigerian component of the Great Green Wall project was launched, a 1,500 km long belt has been established. The endeavour focuses on the worst-affected states, which include Adamawa, Borno, Yobe, Bauchi and Gombe in the north-east and Kano, Katsina, Kebbi, Jigawa, Sokoto and Zamfara in the north-west. However, insurgency in north-eastern Nigeria, and lack of technical knowledge, which has resulted in planting trees that are inappropriate for the soil and climate of the area, have been some of the barriers to the afforestation project (Geidam and Mohamad 2022), and these could be addressed through RDI and technical capacity development.

Urban areas also provide spaces where tree growing could be undertaken to enhance the proportion of green spaces in urban settings and improve ecological conditions in such areas. Urban forest development in Nigeria is under serious threat due to rapid urban population growth, human activities, limited land area and poor implementation of government policies (Ezeabasili et al. 2015). There is a need for robust policies and laws to provide a framework for sustainable urban forest development and management integrating human, social, political, cultural and economic priorities.

Despite Nigeria's enormous wealth in energy resources, wood fuel is still the main source of energy for cooking and heating for the majority of the population, with nearly 30 million households and more than 100 million Nigerians depending on wood as a source of fuel for cooking (Remteng et al. 2021). Weak government policies, weak supply chains, poor stove quality, limited stove choices, insufficient access to finance and a lack of awareness of the policies and available technologies are some of the factors accounting for the low adoption of more efficient technologies. There are strategies the country could implement to increase adoption of these clean cooking and heating technologies. These include developing national level policies integrating clean cooking into national interventions, developing additional test centres, such as the Ebonyi State-Nigeria, to ensure quality and production of improved cookstoves, and increased awareness and education about new and improved cookstoves (Remteng et al. 2021). This should be complemented by investment in the development and commercialisation of other modern biomass burning and cooking technologies such as improved charcoal kilns, solar heaters and cookers as well as investment in fuelwood plantation/woodlot development at household, institutional and commercial levels.

In terms of human capital development in the forest sector, Nigeria is home to thousands of forestry students in more than 40 universities. However, most graduates of forestry degrees either take a long time to find job in the sector or do not find one at all (Adeyanju et al. 2022). Yet, if this knowhow among these students could be harnessed in the various fields of forest bioeconomy (wood and wood products processing, non-wood forest development, biomass and biomass burning technologies, etc), it could also provide a boost to forest bioeconomy development (Adeyanju et al. 2022; Rekola et al. 2019). Amid these challenges, Nigeria youths have also been involved in different activities that promote agroforestry, reforestation and environmental awareness (Ahmed et al. 2021; Onatunji et al. 2021). These efforts need to be nurtured through business incubation, support to start up, and training on process, value addition and market linkages.

The publisher of this report, Circular Bioeconomy Alliance, has established a Living Lab – a two-year project which aims to put trees and their countless benefits back at the heart of farmers' daily lives.[11] The project aims to develop agroforestry in 10 states in the north central region of Nigeria. Nigeria lost 60 million hectares of primary tropical forest during the 20th century and continues to lose more than 5% of its forest area each year due to deforestation. This Living Lab will showcase how to

11 https://circularbioeconomyalliance.org/a-living-lab-for-nature-and-people-developing-agroforestry-with-local-producers-in-nigeria/

restore degraded land using agroforestry systems that integrate trees around and within farmers' fields. The planted trees will provide multiple ecosystem services, including the enrichment and restoration of the fertility of cultivated soils and the provision of a protective canopy to the underlying crops. The benefits are also economic, with fruit trees enabling diversification of production and the generation of additional income through the sale of fruit in local markets. Ultimately, the integration of trees in farmers' fields will not only develop and sustain these new agroforestry systems, but also increase the productivity of the main crops, which will be sold to local agribusinesses for export or domestic use (EFI, nd).

The slow adoption of forest bioeconomy in Nigeria can partly be attributed to the lack of an overarching and cohesive policy framework to guide the transition. A robust forest bioeconomy strategy to provide a pathway for the transition needs to be developed. The private sector plays a critical role in forestry bioeconomy transformation by providing the financial and technological investment necessary for the sector. However, the country has low private investment in the forest sector, which further slows down the bioeconomic transition. The forest bioeconomy strategy – as and when developed – should provide deliberate incentives to scale private sector involvement in forest bioeconomy value chains. Strategies should include providing long-term concessions on public forests to increase private sector involvement in commercial timber development and processing, and facilitating the development of private or communal forest ownership and management to supply wood for the industry. Development of communal and private forest plantations will also provide an alternative for those rural households that are currently dependent on fuelwood collection.

Nigeria has barely scratched the surface of forest bioeconomy. One necessary step to boost this sector would be to develop a government-led forest bioeconomy strategy that would also provide a pathway for catalysing the sector for it. The strategy should also set targets and means to achieve research and development in the sector, including funding RDI from varied sources, and organising and participating in knowledge sharing forums to showcase forest bioeconomy-focused RDI knowledge products to promote public understanding of forest bioeconomy.

In conclusion, Nigeria's forest bioeconomy potential can be harnessed with the right policies, actions and cooperation between the government, the private sector and society at large. Nigeria must work towards increasing its forest cover to meet the demands of its high population and high forest resources consumption trajectory and develop and maintain a vibrant forest industry capable of supplying forest products locally and internationally. In this regard, it is also crucial for Nigeria to develop and facilitate investment in high value-added forest industries, just like Gabon is doing. This will require enhanced investment in research, development and innovation (RDI) as well in capacity building to develop technically trained professionals to work in those industries. The country should also urgently but effectively implement its National Policy on Population for Sustainable Development to slow down the high rate of population increase through, for example, family planning and healthy reproductive practices. Investment in improved/modern cooking technologies, expansion of forest plantations and restoration of degraded lands, as well as investment in forest products value chains, will play a significant role in creating jobs and building the economy in Nigeria.

6. South Africa: Forest industry powerhouse

6.1. Socio-economic context

South Africa is one of the most diverse countries in the world and one of the most populous in Africa with over 59 million people, a majority (68%) of whom live in urban areas (World Bank 2021). The passage of the new constitution in 1996 restructured the country into nine provinces. Gauteng and KwaZulu-Natal are the two most populous provinces, with 15.9 million and 11.68 million people respectively (Statista 2022), making up 47% of the country's total population. The high population in urban areas presents immense challenges to and pressure on the country's socio-economic infrastructure, including housing, energy for cooking and heating, water resources, and health and education facilities. The country has experienced high unemployment rates in the last two decades – standing at around 20% – and the outlook looks grim with the country expected to see the highest unemployment rate globally (35.6%) by 2023 due to slow economic growth and stringent labour laws (World Economic Forum 2023).

Despite its bleak employment outlook, South Africa is the most industrialised country in Africa. The country had a gross domestic product (GDP) of USD 419 billion in 2021, only behind Nigeria in the AF5 countries and a GDP per capita of USD 7,055, which was only behind Gabon in the AF5 countries (World Bank 2023a).[12] The country's economy has largely anchored on the services sector, which contributed 63% of the GDP, followed by the industrial sector (24.5%), manufacturing (11.8%) and agriculture (2.4%). The country's top industries include mining (platinum, gold and chromium); automobile assembly; metalwork; and machinery (Michigan State University, nd).[13] The country's Human Development Index (HDI) has increased over the years from 0.627 in 1990 to 0.713 in 2021, which puts the country in the high human development category, positioning it at 109 out of the 191 countries and territories (UNDP 2022). The high GDP per capita and high HDI value notwithstanding, South Africa is the most unequal country in the world, with race playing a determining factor in a society where 10% of the population owns approximately 70% of the country's wealth (World Bank 2022a).

South Africa is one of the most carbon-intensive economies owing to its coal-based electricity generation, carbon-intensive transport systems and energy-intensive industries. In its National Development Plan 2030, the country has prioritised the transition to a green economy, leveraging its significant renewable energy resources. In 2022, South Africa's cabinet endorsed an investment plan to help the country transition away from the use of coal, a key step in securing USD 8.5 billion in climate finance on offer from the world's richest nations. The plan envisages the closure

12 World Bank (2023a). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?view=chart
13 Michigan State University (nd). South Africa: Economy. https://globaledge.msu.edu/countries/south-africa/economy#source_1

and repurposing of coal-fired power plants owned by Eskom Holdings SOC Ltd, to allow for production of additional renewable energy (Sguazzin and Dlouhy 2022). To support the transition, the World Bank approved USD 497 million in financing to reduce greenhouse gas emissions in South Africa and support a just transition (AFP 2022).

As in most countries, the Covid pandemic dealt the country's socio-economic structures and productivity a major blow. The country launched the Economic Reconstruction and Recovery Plan in 2020 to catalyse the country's economic recovery following the pandemic and its associated impacts. The plan seeks to unlock an economic growth rate of 3% on average over the next 10 years by focusing on the following areas (Republic of South Africa 2020):

1. A rollout of infrastructure development to stimulate investments and growth and develop other economic sectors and enhance employment creation.
2. Rapidly expand energy generation capacity through renewable energy, battery storage and gas technology.
3. Develop employment stimulus to create jobs and support livelihoods.
4. Drive industrial growth by supporting growth in local production to counter the steady decline of the manufacturing base over the past years and make South African exports much more competitive.

6.2. The forest sector and its goals

South African forests cover 14.1% of the total land area. About 82% of the existing forests are naturally regenerating while the rest – estimated at 3.14 million hectares – are planted forests (FAO 2020b). The planted forests consist of commercial timber plantations, which account for about 1% of the total land area of South Africa. In 2020, about 1.19 million hectares of the plantations were commercial plantations (DFFE 2020), making South Africa the country with the largest commercial forest plantations in Africa. In 2019, these commercial plantations produced 14.3 million m^3 of roundwood, which was about half of the total roundwood production in the country. The main planted tree species are eucalyptus and Pinus species. In terms of ownership, 82% of the commercial plantations are privately owned while the rest are under public ownership (DFFE 2020).

Despite the large forest plantation base, the total forest area in South Africa declined from 17.4 million hectares in 2010 to 17.05 million hectares in 2020, ie by 2.1% (Table A1, FAO 2020). The rate of new afforestation in the country has also declined considerably due to factors such as decreasing availability of land suitable for forest plantation development and a tightening of procedures for the granting of the necessary water licences (plantations can consume significant amount of the scarce water resources) (DFFE 2020).

The forest sector employs around 165,900 workers and provides about 62,700 direct jobs and 30,000 indirect jobs. The pulp and paper industry provides about

13,200 direct and 11,000 indirect employment opportunities. Some 20,000 workers are employed in sawmilling, 6,000 in the timber board and 2,200 in the mining timber industries, while a further 11,000 workers are employed in miscellaneous jobs in forestry (South Africa, nd).[14] The forest sector (forestry and forest products) contributes about 1% to the GDP. In terms of regional GDP, the forest sector in KwaZulu-Natal contributes 4.4%; in Mpumalanga 3.7%; in the Eastern Cape 0.6%; and in Limpopo about 0.6% (AutoTrader Commercial 2019).

Forest products in South Africa are one of the top five manufacturing sectors, contributing at least 4.5% to overall manufacturing (DTIC 2020). However, according to FAOSTAT (see Figure 14), the export value of SA forest products has been declining marginally in nominal and real terms over the last decade. Whereas in 2011 the export value stood at USD 1.785 billion – the highest in the country over the last decade – in 2017 it was USD 1.664 billion in nominal terms. This can be attributed to the stagnation in paper and paperboard production as well as the decline in wood pulp production over the past decade. Notice that while the less value added sawnwood production has been increasing in the past decade, its impact on the total export value is largely small since 75% of the total value is accounted by wood pulp and paper and paperboard.

While the forest sector contributes only 1% to the GDP, it is 25% of the agricultural GDP. Forestry operations are largely based in rural areas, making it a major contributor to rural economies and social welfare. The sector is thought to provide livelihoods for 700,000 people in rural areas and especially to the small-scale and new tree growers who currently supply 3.8% of all production volume (Starke et al. 2020).

South Africa developed a white paper on Sustainable Forest Development in 1997, following the end of apartheid in 1994. This forest policy's overall objective is to promote a thriving and sustainable forest sector, encompassing all components of forestry, not just commercial forestry. The policy specifically requires the government to withdraw from the ownership and management of plantation forests under its control and assume the role of regulator and facilitator, rather than participant in the forest sector (Dlomo and Pitcher 2002).

To implement the forest policy, the country developed its forest law in 1998 (Republic of South Africa 1998). The law promotes sustainable forest management based on the principles of sustainable development, which integrates ecological, social and economic values, in consultation with local communities and other stakeholders. The Act outlines measures to protect trees and establish protected areas, measures to control and remedy deforestation and provides for community participation in forest management (Republic of South Africa 1998).

14 Republic of South Africa (nd). Forestry. https://www.gov.za/about-sa/forestry#:~:text=The%20Department%20of%20Agriculture%2C%20Forestry,the%20country's%20land%20surface%20area.

In 2009, the country adopted a 20-year forest strategy. Its key strategic objectives include expanding the forest estate; improving people's quality of life through forestry; conserving forest biological diversity; improving skills, awareness raising and information sharing; enhancing and streamlining the regulatory environment; securing timber supply; establishing institutional and financial arrangements; establishing a knowledge-based forest enterprise; and international relations (Republic of South Africa 2009). The country's industrial strategy – the Re-imagined Industrial Strategy of 2018 – also identifies and prioritises the forest sector as one of the sectors to drive industrial development in South Africa.

To further implement the policy, South Africa developed the Master Plan for the Commercial Forestry Sector (2020–2025), which is aligned with and supportive of the Re-imagined Industrial Strategy. The objective of the Masterplan is to increase investment, jobs and competitiveness, underpinned by greater inclusivity in the forest sector. The plan sets two broad targets: an investment target and a jobs target. On investment, the plan aimed for an investment of USD 1.26 billion in the sector. USD 452 million had already been invested in the sector by 2020, and a further USD 757 million was to follow pending the removal of some inhibitors, which would bring the total investment to R38.9 billion.

On jobs, the Master Plan targeted the creation of 100,549 additional jobs, the bulk of which was to come from new afforestation (a projected 60,265 jobs). Another goal is to improve competitiveness in the sector through improvement in cost of production and in the ratio of logistic cost to total cost of production, improvement in timber yields in the primary sector for various tree species, improvement in the recovery rate in processing, and investment in RDI. The plan also aimed for inclusivity by increasing the share of procurement by SMEs that are part of the forestry value chain, increasing both black-owned company participation and overall SME performance, ensuring majority black ownership of commercial forestry plantations as well as the percentage of commercial forestry planted area that is in production by black-owned timber growers (DTIC 2020).

The importance of the forest sector is also recognised under the Public Private Growth Initiative (PPGI – a partnership between the National Government and the private sector) to stimulate investment. Forestry, specifically establishing new plantations and recapitalising existing damaged/degraded plantations, is among the top 10 projects that have remained immediate priorities for implementation under PPGI.[15]

South Africa has also embraced certification to promote sustainable forest management and development. The first Forest Stewardship Council (FSC) certificate was over two decades ago and the country has one of highest degrees of forest certification in the world, with some 80% of its timber plantations certified by the FSC (DEFE 2020). There has also been an increase in the number of non-corporate growers who have become certified in the recent past, a situation that has been

15 www.intransformation.org.za/wp-content/uploads/2022/04/PPGI-Case-Study.pdf

attributed in part to FSC's acceptance of group-certification schemes and the availability of local FSC auditors, both of which have considerably reduced the cost of certification (South Africa Yearbook 2020/2021). Overall, about 1,403,598 hectares of forests have been certified, and some 20 FSC forest management certificates and 120 chain of custody certificates have been awarded to date (FSC 2022a).

Besides the forest-specific policy above, South Africa has also developed climate policies that recognise the forest sector's potential to contribute to building climate resilience and mitigating climate change impacts on humans and ecosystems. The proposed interventions include carbon sequestration through sustainable forest management and conservation for avoidance of deforestation and degradation; landscape approaches; materials substitution with wood products, which entail substituting energy-intensive materials with products in construction; forest bioenergy, which involves substituting fossil fuels in energy generation; technological approaches, which involve the use of genetics and biotechnology for developing resilient tree species; and sustainable consumption, which entails change in in traditional consumption patterns through recycling and reuse, among others (Ofoegbu and Speranza 2021).

However, critics opine that the South Africa climate policy does not provide guidelines for adapting forest management to meet both conventional forest management and climate protection goals (Ofoegbu and Speranza 2021). They also observe that the degree to which the climate policy provides for the implementation of the prioritised forest-based interventions has not been specified. While forest management can support climate protection and sustainable livelihoods, South African climate policies tend to favour carbon sequestrations and landscape approaches, which overlooks other forest sector contributions to national climate change mitigation and adaptation targets. Though climate policies recognise that forests can protect the climate by replacing energy-intensive materials with wood products in construction and fossil fuels with wood pellets for bioelectricity production, little is being done to achieve these goals. The critics also argue that the climate policy is less strong on social inclusiveness, equitable benefit sharing and inclusive development of forests and forest-based communities. Yet, the ongoing social inclusivity discourse is changing ownership structures, transferring forest plantations and industries from corporations to private individuals and groups (Tshidzumba et al. 2018), with consequences for carbon sequestration and landscape approaches to climate mitigation in the country. There is a need for the forest sector and climate policymakers to consider how the changing ownership structure may affect forest industry and climate-protective forest management objectives. Weak institutional capacity has been identified as a factor derailing implementation of South Africa's Forest and allied policies (Shackleton et al. 2013).

The above discussion indicates that the government of South Africa has made policy and legal efforts for sustainable forest development approaches that embrace participation and integrate ecological, social and economic values in forest management. The government specifically aims to achieve greater industrialisation and job creation through investment in forest planation development and forest products processing and value addition. The policy goals also include conservation of

forest resources for biodiversity and the realisation of climate adaptation and mitigation. The section below reflects on how the South African forest products market have developed recently, and how the future of forest bioeconomy could evolve.

6.3. Forest bioeconomy outlook

South Africa stands out among African countries for having a dedicated bioeconomy strategy since 2013 (Department of Science and Technology 2013). South Africa, as a country endowed with natural resources and one of the highest levels of biodiversity in the world, focused early on bioeconomy and included health and biomedical, agriculture and industry aspects in its strategy in a unique way. The bioeconomy strategy seeks to guide bioscience research and innovation investments, as well as decision-making, within a high-level framework, based on the experiences of two previous initiatives, the "National Biotechnology Strategy" (2001) and the "Ten-Year Innovation Plan" (2008). South Africa's bioeconomy strategy was officially launched in 2014, effectively replacing the 2001 National Biotechnology Strategy. The bioeconomy strategy was interconnected with the National Development Plan (NDP). Agriculture, health and industry/the environment are identified as three priority areas for research and development in the Bioeconomy Strategy (Teitelbaum et al. 2020).

Besides the forest bioeconomy-related policy discussed above, South Africa is also implementing a number of forest bioeconomy-related projects. The country has made progress in maintaining the forest area. According to data by the FAO, the extent of planted forest has remained steady at 3.144 million hectares.[16] These plantations provide raw materials for pulp and paper mills, sawmills, treated poles and mining timber production, and wattle tannin production. The diversity of sites and markets necessitates the planting of a variety of pine, eucalypt and wattle species (Morris 2022). According to Morris (2022), a similar number of species are now planted (15) as in the 1950s, though only six of the earlier species are still in use. In the last 30 years, there have been changes with 40% of planted area in 2019 using species that were not available before 1990, thanks to advances in bioengineering and plant breeding. Since the 1990s, eucalypt hybrids and E. grandis have largely replaced *eucalyptus grandis*. *P. caribaea var. dunnii* and *P. elliottii var. hondurensis* have emerged as a viable pine planting option in South Africa (Morris 2022). Today, South Africa is a major supplier of eucalyptus clones across the continent, bringing in income for the country.

While the timber plantations produce between 15 and 18 million tons (17 to 20 million cubic metres) of timber every year (Research and Markets 2020), there is a growing timber shortage in the country and the industry is struggling to secure enough suitable land to plant new forests (Ministry of Water Affairs and Forestry

16 See https://fra-data.fao.org/assessments/fra/2020/ZAF/sections/forestCharacteristics

1997; Department of Trade, Industry and Competition 2020). Moreover, there is also an invasion of natural forests by alien plants, which is a national threat that jeopardises the stability of South African ecosystems. The ongoing reforestation project on the banks of the Breede and Berg rivers, which involves planting endemic species, aims to counter the invasion of the ecosystem by exotics. The invasion has negatively affected the water cycle, promoted fires, competed with and led to the disappearance of the local vegetation such as the Breede River Yellow Wood, wild olive and wild almond. The project, which is supported by Reforest'Action, works with the local communities to recreate a forest cover composed of diverse and endemic plant species, combats water stress by regulating the water cycle, educates local farmers and schoolchildren on reforestation benefits and provides employment opportunities to the local community (Avril 2021). The roundwood supply deficit presents an opportunity to expand plantations to meet the growing demand and is one of the areas that holds great potential for bioeconomy development in the forest sector.

For forest protection purposes, the country has made significant progress in pursuit of sustainable forest management through FSC certification. As already noted, South Africa has one of highest levels of forest certification in the world with some 80% of the country's timber plantations certified by the Forest Stewardship Council. Enhanced forest certification presents an opportunity for bioeconomy development in South Africa as it speaks directly to the desire outlined in the Bioeconomy Strategy, namely industrial development in a sustainable environment.

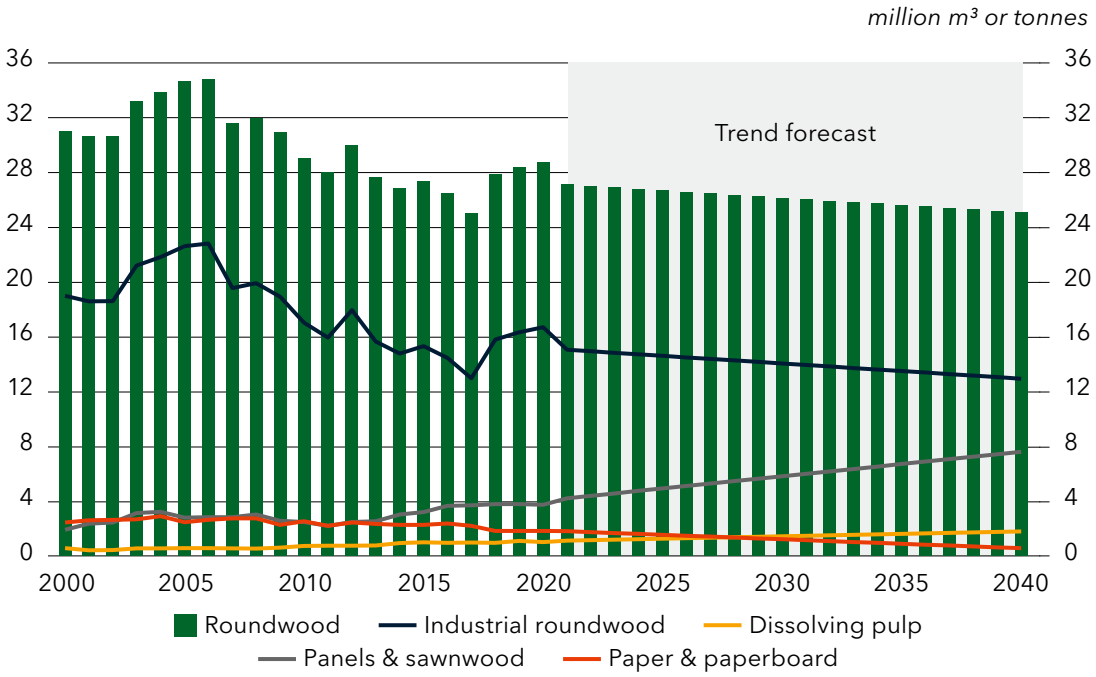
The above discussion indicates that South Africa's government has developed policies and projects to develop the country's forest bioeconomy in a sustainable manner that integrates ecological, social and economic values. Below, we reflect on simple data and trend projections to assess whether the country still has some opportunities and challenges that have not yet received enough attention, but which would be necessary for successful forest bioeconomy development.

South Africa is a significant exporter of forest-related products, with the main exports being pulp, paper and solid wood. China and India are the two biggest and almost equal export destinations for South African forest products. In 2017, South Africa exported forest products worth USD 529 million to these countries, ie 32% of total exports (FAOSTAT). Other major export destinations are Indonesia and Thailand. Together, the four countries account for almost half the export value (USD 1.66 billion) of South African forest products. With the growing population, consumer demands and environmental awareness in these destinations, there exists the potential to grow and expand the export of forest products to these countries.

Figure 14 shows the development of the major forest products in the past two decades and the 2010–2020 trend projection to 2040. If this business-as-usual was to hold, roundwood production would continue a downward trajectory with industrial roundwood and paper and paperboard also projected to drop over the next two decades. Panel and sawnwood production is projected to rise to about eight million m^3 by 2040 (see Figure 14). Dissolving pulp is mostly used as a raw material for viscose (textiles) and in a smaller degree for cosmetics, pharmaceuticals, as a filter in cigarettes, etc. It is more valuable in markets than pulp used for paper and

paperboard. It has promising growth prospects, especially in the textile industry where it helps to replace cotton and synthetic fibres. South Africa has increased its dissolving pulp production from about 700,000 tonnes in 2010 to one million tonnes in 2021. All of it is exported to other countries, mainly to Asia. According to the trend forecast, it will increase to 1.8 million by 2040.

The trend outlook for forest products is thus a mixed one, with some increasing and some decreasing. However, it is not realistic to expect the trend forecast to be realised exactly as outlined. It should rather be interpreted as a baseline against which it is fruitful to reflect different "what-if " type scenarios. For example, if South Africa can further invest in and sustain the expansion of forest cover to provide the necessary raw materials for the industry, as well as catalyse private sector investment in the forest industry to enhance production of more value-added products, such as engineered wood products or pulp for textile industry, the forest bioeconomy could expand.



Data: FAOSTAT; Forecasts: Lauri Hetemäki

Figure 14. South Africa's roundwood, industrial roundwood, panels and sawnwood, dissolving pulp and paper and paperboard production 2000–2020 and trend forecast to 2040. Figure: Lauri Hetemäki.

Indeed, developing emerging forest bioproducts – for example, engineered wood products, such as cross laminated timber (CLT) and laminated veneer lumber (LVL), and new types of pulp-based raw materials for textile industry – would be important to generate more value added as well as to help to meet sustainability requirements in the construction and textile industry. Specifically, the country's high population calls for the design and development of innovative and low emission

buildings and construction solutions. South Africa is already doing some work to pioneer CLT use for building and construction. Specifically, the Nelson Mandela University is piloting a CLT building to influence a new direction for design and construction in South Africa. The University intends to use the development to advance knowledge, research and skills about CLT and mass timber construction and create a community of practice between different faculties within the University, other educational institutions and role players from industry such as Forestry South Africa, Sawmilling South Africa, South African Wood Preservers Association, Institute for Timber Construction, National Home Builders Registration Council (NHBRC) and the Department of Trade and Industry (Nelson Mandela University 2021).

South Africa is also venturing into biorefineries based on wood. The Council for Scientific and Industrial Research (CSIR) has partnered with the University of KwaZulu-Natal to pioneer biorefinery in the country. A Biorefinery Industry Development Facility has been established in Durban to develop technologies to collect lignin from kraft mill black liquor. The facility has already developed a procedure for the rapid and accurate measurement of chromophores in dissolved pulp wood. South African pulp and paper mills currently use only 40% of a tree in the production process. The Biorefinery Facility aims to pioneer a new technique to use the tree to its maximum potential – up to 90% – to produce chemicals and other high-value products that would contribute to the evolution of current South African pulp and paper mills into forest biorefineries. The development will enable paper mills to develop biorefinery activities alongside their traditional paper and paperboard productions, become suppliers of diversified speciality papers, raw materials for textiles, pharmaceuticals, cellophane, fibre composites for automotive parts, furniture and audio speakers, nanocellulose (reinforcing agent, control release agent, viscosity modifier), xylitol and other chemicals from sugars (low calorie sweetener, toothpaste, recyclable plastics) and chemicals from lignin (binding agent, dispersion agent, emulsion stabiliser). This will further spur the development of forest bioeconomy in the country leading to more value addition, creation of new forest bio-product lines, creation of new jobs and enhanced revenues for the government.

The South African government has prioritised plantation expansion in areas where it is economically, environmentally and socially feasible. According to the Forest Masterplan, the total plantation opportunity is almost 200,000 hectares. The first focus area encompasses new afforestation, the return of currently unproductive plantation land back to production, the protection of the plantation resource from pests and diseases, and the initiation of agroforestry as a tool for the overall sustainability of small and community-based growers. To meet the current and future need, the following two critical aspects are required. Firstly, the afforestation of new areas identified in the Eastern Cape and KwaZulu Natal, which will yield more than 100,000 hectares of additional productive plantation land. Secondly, the return of previously afforested land to its full productive potential. This includes areas such the DEFF category B and C plantations (63,000 hectares), the Western Cape exit areas (22,000 hectares) and other unproductive or poorly performing plantations such as those belonging to municipalities or damage (DTIC 2020). By 2026, 151,000 hectares of productive new plantations will be established, and 68,820

DEFF-owned plantations will be returned to production. Also, by 2026, the pest and fire-affected areas are to be returned to production (DTIC 2020).

Afforestation and forest expansion is taking place in a major way in rural areas where there are few other viable opportunities for job creation and economic activity. As such, the development of these new plantations offers opportunities for job creation in rural areas. Development of these additional sources of raw material for the wood industry will attract greater processing capacity in the form of sawmills, board mills, chipping plants and treatment plants, which will lead to broader socio-economic growth. An additional R500 million (USD 27 million) a year could be generated from such plantations. South Africa's forestry programme also includes greening and tree-planting projects. The programme prioritises work on fire-fighting programmes such as the Working on Fire Programme and encourages the establishment of fire-protection associations (FPAs), which will create additional jobs around addressing the forest fire menace and enhancing forest protection and conservation.

In South Africa, over 85% of national energy production and about 93% of electricity generation is derived from coal. Thus, unlike in Kenya, Nigeria and Tanzania, in South Africa wood energy plays a relatively small role, as it does in Gabon (see Table A1). However, fuelwood is still used to some extent by 96% of rural households and 69% of low-income urban dwellers. It is estimated that the use of fuelwood by rural households alone is valued at approximately ZAR 10.5 billion (approx USD 700 million) annually, with the probability of an equally high value to low-income urban households (Shackleton et al. 2022). There is an opportunity for the country to transition to modern energy cooking and solutions so that this wood can go into more value-added forest products and further job creation. Private sector involvement in modern cooking technologies can help generate new products while creating additional jobs in the forest bioeconomy sector. There is also an opportunity for smallholders to invest further in short-rotation fuelwood species to ensure enhanced supply of fuelwood to the market while generating new sources of incomes and revenues for the government.

RDI is critical to the protection and sustainability of forest resources. The South African forest sector is based on a long history of research and development practices. However, the industry is currently faced with several challenges related to existing levels of investment in RDI, as well as the development and retention of the necessary expertise and skills (MNRT 2018). Funding for RDI has especially decreased over the past five years with most of the country's resources repurposed for Covid-19 related interventions (Forest South Africa 2020). Specifically, there is insufficient funding of research in timber processing, timber construction and the bioeconomy sub sectors (MNRT 2018).

There is therefore an urgent need to ensure that RDI priorities are identified appropriately and funded accordingly. In particular, the government should maintain funding for critical research areas such as pests and diseases control, which cause annual industry losses of approximately 11.5% (MNRT 2018). In addition, new funding opportunities should be explored to complement the existing funding. Funding

should also target RDI for the downstream value chain processes including improving efficiency of biomass feedstock processing through biorefineries approaches, diversifying into new bio-based products market opportunities and creating and supporting new business start-ups linked to new biomass product opportunities (MNRT 2018:21).

7. Tanzania: Large forest resources and stable institutions

7.1 Socio-economic context

Tanzania is one of the largest countries in East Africa with a surface area of 947,300 square kilometres (World Bank 2009). The population in 2020 was 59.7 million and it is forecasted to grow by 42.9 million by 2040 according to UN projections. The country has the lowest unemployment rate among the AF5 countries at 2.8% of the total labour force and well below the global unemployment rate of 5.8% (ILO 2023). The poverty rate in 2019 stood at 26.2% but increased to 27% in 2021 due to Covid-19 (World Bank 2023c). Certainly, as with other countries in Africa, the high population growth rate in Tanzania presents immense challenges to housing and other socio-economic infrastructure and the supply of wood and wood products. For instance, the market for forest products is growing rapidly because of this population dynamic, particularly in the construction sector where forests provide over 75% of all construction materials. However, Tanzania's production of sawnwood and wood panels, and imports and consumption, is still at a very low level and has not grown much over the past decade. For comparison purposes, Gabon, with a population only 3.6% that of Tanzania, produces 2.5 times more wood products (sawnwood and wood panels) than Tanzania. Italy, which has the same population as Tanzania, produces 12 times more wood products than Tanzania.

One-third of the population lives in urban areas characterised by high population densities, resulting in inadequate housing and access to other social services. There is an increasing pressure on the already dwindling natural resources as well an increase in GHG emissions. The environmental degradation is increasing the country's vulnerability to the impacts of climate change while also endangering livelihoods and food security due to dependence on rain-fed agriculture and natural resources, including forests.

Tanzania's GDP at current prices reached USD 75.5 billion in 2022. The country's GDP growth rate is projected to reach 5.1% in 2023 and to attain its potential growth rate of 6% in 2025 (TanzaniaInvest 2023). Agriculture (agriculture, forestry and fishing), industry and construction and services were the major economic industries, having accounted for 27%, 31% and 42% of the 2021 GDP respectively (TanzaniaInvest 2023). The main sectors of the Tanzanian economy in terms of their contribution to the GDP are construction (16%), crops (14%), manufacturing (9%), wholesale and retail trade (9%), transport (8%), livestock (8%), and mining and quarrying (5%). Tourism is also a key contributor to the economy, having contributed 10.6% of the GDP in 2019 before dropping to 5.3% in 2020 due to the impact of the Covid-19 pandemic (TanzaniaInvest 2023). However, the country remains poor and is classified as a lower middle-income country in the World Bank's list of countries, and as a least developed country at 159th out of 177 countries in the United Nations Development Programme's (UNDP's) 2007–08 Human Development Index.

Tanzania has great potential for future development. The country has rich and diverse natural resources which can contribute to current and future economic development and improve people's livelihoods. It is well situated to expand as a regional hub because out of the eight countries it borders, six are landlocked. The country is also one of the most peaceful nations in East Africa with very few conflicts being witnessed in decades (World Bank 2017).

The country has anchored its development vision on the mobilisation and effective utilisation of domestic resources (natural, financial and human) to promote economic activities that enjoy comparative and competitive advantages with a view to minimise the impact of external economic shifts and shocks (Tandari 2004). The National Five-Year Development Plan (2021–2026) provides for sustainable use, protection and wellbeing of its natural resources, including forests and lands. Some of the key forestry related interventions outlined in the national development plan include promoting renewable green energy technologies; combating illegal harvesting and trade of forest resources; improving infrastructure in forestry institutions; and promoting stakeholder engagement in the development and management of plantation forest resources for conservation and economic growth (United Republic of Tanzania 2021)

By prioritising sustainable development, management and utilisation of forest and forest resources in the national development plans, coupled with the country's socio-political stability, and strategic geographical location, the country stands a higher chance of succeeding in the development of its forest-based industry, enhancing the contribution of the forest industry to rural livelihoods and job creation within the forest bioeconomy framework.

7.2 Forest sector and its goals

Forest land in Tanzania is divided into forest reserves, which are gazetted because of their special values or for sustainable timber production, and unreserved land (general land, public land) (MNRT 2021). Forests and woodland cover about 55% of the total land area of 88.3 million hectares (Manyanda and Kashaigili 2022). The existing forest tenure arrangements are central government (16.6 million hectares or 34.5%), local government authorities (3.1 million hectares or 6.5%), village governments (21.9 million hectares or 45.7%), private owners (3.5 million hectares or 7.3%), and general land (unreserved forest) (2.9 million hectares or 6.0%) (TFRI 2021). However, the country has experienced remarkable loss of its forest cover over the past two decades. With a net annual forest cover change of -0.9% (FAO 2020c), Tanzania is among the top 10 countries with high net annual forest cover loss. This high rate of deforestation has been attributed to the following factors: high population growth and the associated increase in demand for food, settlements, infrastructure development, fuelwood, furniture, building materials and other products; high rates of poverty and the increased pressure on forest to meet basic needs; high rates of urbanisation, mainly due to high rates of rural-urban migration; agricultural expansion into forest lands; and high incidences of wild

fires from honey collection, charcoal burning and opening of new lands for farming (Kidegheso 2015; Doggart et al. 2020).

The country's four main forest types include closed forests, which are divided into montane/submontane closed forests and lowland closed forests found in Mt Kilimanjaro, Mt Meru, and in the Usambara, Uluguru and Uzungwa mountains. Mangrove forests occur along the coast of the Indian Ocean, on the islands and in river deltas such as the Rufiji delta and cover about 150,000 hectares. Savanna woodlands occupy more than 90% of the forested area and are mostly open and often degraded with undergrowth of grass and shrubs. Plantation forests, which also comprise small-scale woodlots, cover approximately 700,000 hectares and are mostly for industrial use. The central government owns and manages about 500,000 hectares, which translates to 24 plantations, while private companies and individuals own the remaining 200,000 hectares (Tanzania Forest Service Agency (TFS)). Forest plantations are dominated by pine (65%) and eucalyptus (20%) species while the rest are teak and black wattle species (World Bank 2017).

Tanzania has a long tradition of participatory forest management, which exist at different levels: direct village level forest management (village land forest reserves), community forest management in forests on village lands (community forest reserves) and joint forest management of national and local authority forest reserves (village forest management areas). Different parts of a national and local forest reserve and different activities within the reserve can be managed by different people or organisations (United Republic of Tanzania 2002).

The forest sector contributes 3.5% of Tanzania's GDP and 11% of the total export trade. However, the GDP figure does not include the value of the non-marketable forest products, which are not captured in official trade data. For example, forest-related tourism (eg in national parks), which depends on having viable forest resources, is significant in Tanzania but this contribution is not captured in official statistics. Thus, the contribution of the forest sector to national and social wellbeing is higher than the traditional forest sector statistics would indicate. The sector employs about three million people (MNRT 2021). Its share in the subsistence economy has been estimated to be over 20%.

Tanzania's demand for industrial wood is projected to rise to about 3.7 million m^3, but the current plantations can only supply about 1.1 million m^3. Timber demand is expected to grow strongly to 5.2 million m^3 by 2035, almost doubling from the 2.8 million m^3 in 2021 and driven primarily by the construction sector and paper consumption. When compared to the supply forecast of 3.2 million m^3 by 2035, there remains a supply deficit in the market. The supply-demand gap is mainly constituted by large diameter saw logs for sawntimber and veneer production (1.4 million m^3) and wood fibre for pulp and particle/fibre board (1 million m^3) (Held et al. 2017).

Tanzania faces a difficult task in bridging the supply deficit. First, the country has few of its own pulp and paper mills. According to FAOSTAT, the country's own wood pulp production has been 56,000 tonnes per annum for the last three decades, which requires about 0.28 million m^3 roundwood. Tanzania's own paper and

paperboard production is 40,000 tonnes per annum, which is negligible. Establishing a significant new industry within a decade to increase production is highly unlikely given the high-capital intensive nature of the industry and lack of supporting infrastructure, such as plantations, to supply the required pulp wood. For example, a modern pulp mill of the scale 700,000–1,000,000 tonnes of pulp per annum requires 3.5–5 million m^3 of wood every year and the pulp mill construction would cost around USD 1–1.5 billion investment. However, as a long-term forest bioeconomy strategy and policy, establishing domestic pulp industry to supply paperboard, textile and chemical industries would be important.

Forests provide about 85% of all the energy consumed in the country (United Republic of Tanzania 2021). About two million tonnes of charcoal are consumed annually in Tanzania (Leonard 2021). To reduce over reliance on wood energy consumption, the country seeks to enhance rural electrification, as well as the development of micro and mini-grid renewable generation in rural areas and promoting alternative and affordable energy sources to reduce charcoal consumption in urban and rural areas through regulation of charcoal production and use. Non-wood forest products (NWFPs) and forest-related tourism offer significant contribution to livelihoods through the use and sale of the products, nutritional benefits and safety net during periods of famine (United Republic of Tanzania 2021).

Tanzania's commercial forest sector is undergoing transition with the supply base moving from large private and government plantations towards small- and medium-scale tree growers. Smallholder forestry in Tanzania is unique compared to many other developing countries because the licensed processors and wood traders are the ones who carry the administrative burden after the wood sales and not the smallholder tree growers. The land ownership in the village land system is considered secure enough for longer-term investments, such as tree growing, in as much as the smallholder farmers lack a formal land title (Arvola et al. 2019; United Republic of Tanzania 2020). This shift from large private and government plantations towards small- and medium-scale tree growers is causing the sector to perform below its potential. This is due to the local low-quality seed the growers use, poor silvicultural practices and short rotations. The result is woodlots that are less productive, poorer quality and produce smaller diameter trees compared to large private plantations. In addition, the small tree growers are disaggregated and dispersed, making it challenging to service them with cost-effective processing solutions to improve the quality.

However, the growth in the supply base driven by small- and medium-scale growers is not a direct substitute for large plantation supply that is of higher quality, more cost effective to process (for most value chains) and has a more reliable supply flow. There is a need to increase productivity and the quality of the woodlots among small and medium tree growers who continue to be key players in the sector. If well trained and resourced with the right information, the smallholders can become major suppliers of roundwood for industrial processing as well as fuelwood in the country. Investment in better processing technology is needed, especially with the expected increase in the productivity and quality of small tree grower woodlots in the near future and provision of suitable infrastructure for a wood-based industry.

To make up for the deficit in the demand, new forest resources should be created to reduce pressure on natural forests (MNRT 2015). The overall volume of standing timber is also low and of poor quality, creating the need to improve the productivity and quality of woodlots for better harvests, quality and returns. The deficit, in particular, presents opportunities for the smallholders and the forest authorities to expand forest plantations in the country. There are also opportunities for investment in forest management practices, forest extension and in wood processing for enhanced value addition and job creation as well as increased investments in forest education and research.

The country has developed policies and laws to govern the forest sector. The 1998 forest policy sought to enhance the contribution of the forest sector to the sustainable development of Tanzania by focusing on four areas; forest-based industry and products; forest land management; ecosystem conservation; and institutions and human resources. The objective of the forest-based industry and product policy area is to increase employment and foreign exchange earnings through the sustainable development of forest-based industries and trade (TNBC 2021). For its part, the Sustainable Industrial Development Policy (SIDP 1996–2020) prioritised promotion of streams of industries around a single resource based on a zero-waste strategy. The SIDP's emphasis was on creation of an enabling environment for industrialisation by supporting existing and new industries (TNBC 2021).

The forest policy also aimed to increase the effective management and utilisation of forest and tree resources for the sustainable supply of products and services to meet local, national and global needs. In addition, it aimed to address the unregulated exploitation and declining quality of forest produce, which is due to the low capacity of forest institutions, parallel and fragmented management of forest and forest resources, the rising rate of deforestation and forest degradation. It also sought to align the country and sector to regional and international agreed protocols and agreements regarding forest resources, biodiversity and climate change to which Tanzania is a party (United Republic of Tanzania 2018). Some of the interventions outlined in the 2018 policy include: effective development and sustainable management of forest and tree resources; effective conservation of forest ecosystems; enhancing investment in the development of forest and tree resources and industry.

In 2002, the Tanzania Parliament enacted the Forest Act No 14 (Cap. 323) as a legal instrument, which became operational through the Forest Regulations Government Notice 153 of 2004, to implement the forest policy. The Act inter alia provides for the development of management plans to guide effective management and utilisation of forest resources in forest reserves, provides for concessions for forest lands, prohibits unpermitted extraction of forest resources from reserves, and established the Tanzania Forest Fund to finance activities geared towards sustainable forest management practices (United Republic of Tanzania 2002). The National Forest Policy Implementation Strategy 2018–2028 outlines measures and programmes to implement the forest policy. A National Forest Programme (NFP) was developed to implement the National Forest Policy and promote sustainable utilisation of forests to meet the needs of the society while also contributing significantly to the economy through increased earnings from the trade of forest products (FAO 2020c).

Responsible forest management is a key goal in Tanzania to address the high rate of forest loss and the associated economic implications, with the cost of forest loss estimated at up to USD 3.5 billion by 2023 (FSC, nd).[17] Some of key responsible forest management strategies pursued by Tanzania include: the country's commitment to restore 5.2 million hectares of degraded land under the African Forest Landscape Restoration Initiative (AFR100); implementation of a community-based approach to forest management to secure and manage forests at community level; and approval of the National Forest Stewardship Standard (NFSS) of Tanzania Mainland by the Forest Stewardship Council in 2018. The NFSS is applicable to all forest operations seeking FSC certification for forest management in Tanzania. As of January 2021, Tanzania had 227,688 hectares of certified forest and three forest management/chain of custody certificates (FSC, nd).

7.3 Challenges and opportunities

Despite the above policy and legal framework and the role that forests and woodlands play in providing wildlife habitat, conserving biological diversity and supporting the tourism industry, deforestation remains a major challenge in Tanzania. Deforestation and forest degradation is largely driven by pressure from agricultural expansion, livestock grazing, charcoal production and fuelwood wildfires, over-exploitation and unsustainable use of wood resources and other human activities mainly in unreserved forests (FAO 2020c; Leblois et al. 2017; Romano and Reeb 2008). The high dependency on wood fuel is an especially big challenge in the country given that about 90% of the current roundwood production goes to wood energy (See Figure 13). The transition from the overreliance on wood energy for cooking and heating to modern sources will require a holistic policy intervention. As fuelwood supply is not only a forest policy issue, there is also a need to review energy and livelihood policies. Similarly, it also calls on authorities to provide alternative incomes and employment opportunities, especially for the rural population, which are highly dependent on fuel wood collection for incomes.

The success of forest policies aimed at promoting sustainable forest management in natural and planted forests and woodlots is largely dependent on the government's ability to implement the policies and the success of the agricultural sector in addressing severe development and intensification needs, which is the main cause of deforestation. However, institutional and technical capacity for sustainable forest management remains low, not only within government agencies but also among forestry industry players and tree growers. While the crucial role the private sector can play in forest management and tree-planting programmes is emphasised in the forest policy (MNRT 1998) and climate change strategies (United Republic of Tanzania 2015b), there is scarcity of resources to ensure their active engagement in driving investments, developments and desired change in the sector.

17 FSC (n.d). FSC Certification in Tanzania. https://africa.fsc.org/sites/default/files/assets/FSC_newsentry_1625752668_file.pdf

The demand for wood products is driven largely by the construction and furniture sector. Wood demand for pulp and paper production remains marginal. As already noted above, Tanzania produces only about 40,000 tons of paper and 56,000 tons of wood pulp annually. If the 56,000 of pulp is based on chemical pulp, it would require around 300,000 m^3 of wood, which is just about 1% of the total Tanzanian annual wood production. Wood, especially eucalyptus, is also used for power transmission poles, while the transport sector uses wood in the form of pallets and boxes (Held et al. 2017). The reliance on wood from plantations as opposed to those from natural forests began in the late 1990s (Wells and Wall 2005) because of the diminishing supply of natural hardwood. Plantation wood is still the main source for industrial roundwood, despite the sharp decline in the productivity of Sao Hill, which is the government's most significant plantation (Ngaga 2011). In a bid to enhance the development and utilisation of forest plantation and woodlots, the government has set ambitious targets to increase the area of state-owned forest plantations from 500,000 hectares to 550,000 hectares, and those owned by communities from 120,000 hectares to 160,000 hectares by June 2026. It also aims to increase the total area replanted, including new areas under state-owned forest plantations, from 10,000 hectares per year to 15,000 hectares per year by 2026 (MNRT 2021). The above plans to increase roundwood production are ambitious and the chances of success may not be guaranteed if roundwood production trends over the recent past are anything to go by. For example, roundwood production in 2013 was 2.6 million m^3 and 2.8 million m^3 in 2021, hence has stagnated within the eight-year period. Thus, to reach the 2035 target, radical changes should be implemented to increase roundwood production, and investment in forest plantation development at communal and industrial level would be critical.

Based on the hectares planted and an estimation for productivity and rotation age by each supply segment (assuming continuation of current practice), a forecast supply volume (for industrial roundwood) was estimated at 3.2 million m^3 in 2035. This would require a 14% increase from the 2021 figure of 2.8 million m^3. But this would still be slightly lower than the business-as-usual trend projection would imply, ie 3.4 million m^3 (Figure 15). When compared to the demand forecast, there remains a supply deficit in the market, which increases significantly between 2025 and 2035 to a supply gap of 3 million m^3. The supply-demand gap is mainly constituted by large diameter sawlogs for sawn timber and veneer production (1.4 million m^3) and wood fibre for pulp and particle/fibre board (1 million m^3). It is expected that progress in the sector will be able to reduce the deficit, as there are significant gains to be made from: a) increasing productivity; b) lengthening rotation; and c) increasing recovery rates through better processing technology. For example, lengthening small tree growers (STG) rotations from the current 12 to the standard 18 years for sawn pine timber would reduce the sawlog supply gap by 50%.

As in many African countries, agriculture plays a major role in Tanzania's economy with significant contributions from other sectors such as tourism, mining and manufacturing (ATPSNET 2021). There is a need to strengthen agricultural production through sustainable intensification to boost productivity and foster commercialisation and value-addition through agro-processing. Encouraging light manufactur-

ing, such as agro-processing, requires a productive private sector that has more capacity to export and an enabling business environment that ensures a reliable power supply, access to credit, a skilled labour force and a fewer regulatory constraints. Tourism also has the potential for job creation in both the mainland and Zanzibar. Local content development around large foreign investments in extractive industries also presents unique opportunities to create local value chains, with the right policy incentives and with more local capacity (World Bank 2017). The need for land for agricultural expansion will continue as the population continues to grow (United Republic of Tanzania 2015a). This will in turn force tree growing to be carried out in remote areas and poorer sites, hence low productivity (Call et al. 2017; Capitani et al. 2016). Allocation of degraded forestlands and grasslands owned by the government for smallholder tree growing could help alleviate the problem of land fragmentation but mechanisms allowing both smallholders and large investors access to these lands are needed. The agroforestry system presents a win-win solution for this situation where communities can integrate trees around and within their farms. The agroforestry system stands to provide varied socio-economic and environmental benefits to the farmers, including the enrichment of cultivated soils, provision of a protective canopy to the underlying crops, generation of additional income through planting of fruit trees and sale of fruits, which in turn provides additional income to the farmers.

Bioprospecting, which is a systematic and organised search for useful products derived from biological resources including plants (Oyemitan 2017), and value addition have been recommended as ways to help Tanzania develop its bioeconomy. Poor seedling quality, and poor management practices in general, impact the quality of wood produced. Most of the wood is harvested before it reaches the optimal rotation age which would maximise yield and potential returns. The challenge is not easy to navigate, even through extension services, because of the ever-available market for wood that makes quality a secondary factor (Arvola et al. 2019). The problem of early harvesting is expected to continue, and smallholders may be greatly impacted if the market demand for quality wood increases. In some cases, substitute construction materials may replace low-quality timber (Indufor 2011). Viable production technology is necessary to improve the quality of the wood together with adequate state policy and organisational support, which will enable smallholder farmers to have access to knowledge, financial and technical assistance (United Republic of Tanzania 2020).

The legal and institutional framework should be strengthened to reduce overdependence on donor-supported programmes. Out-grower arrangements whereby smallholders and industries have tree-growing contracts are a promising practice that could solve the smallholder cashflow problems that have been contributing to early harvests by farmers. Though the schemes are already being implemented and developed through collaboration by forest industry companies in the region with the support from the Ministry for Foreign Affairs of Finland, the scale and technical support services provided is not adequate to cover all tree growers. There is therefore a need to establish more of such schemes for the long-term sustainability of smallholder tree growing (Bienabe et al. 2004).

The role of plantations beyond wood production is increasing, especially for environmental services at local and regional levels, and should be further studied, particularly on national-level deforestation. Research into alternative production models, which allow for wider landscape-level resource allocation and intensified production through shorter rotation species or agroforestry systems, are necessary to solve the increasing pressures on land use (Muchiri et al. 2002). The extent to which the plantations impact the local economy and livelihoods and can contribute to poverty alleviation needs to be investigated as well as their contribution to the development of rural areas (Baral et al. 2016).

7.4 Climate change

The main sources of Tanzania's GHG emissions are from land use, land-use change and forestry (LULUCF) (Figure 15). These emissions contribute to two-thirds of overall emission levels in the country (United Republic of Tanzania 2020). The agriculture, manufacturing and energy sectors are among the key sectors that are most vulnerable to climate change. The agriculture sector is particularly vulnerable to climatic change because it relies solely on rainfall and more than 60% of the population relies on it for their livelihood. A decrease in rainfall would render most areas unsuitable for farming. The prevalence of crop pests poses more challenges to agriculture (State of Environment Report 2019). Tanzania currently ranks 67 on the 2021 Global Conflict Risk Index (GCRI) and its estimated economic costs from climate shocks is about 1% of GDP according to the latest review of the 2015 Nationally Determined Contributions (NDC) (AfDB 2022).

Tanzania aims to reduce GHG emissions by 10%–20% by 2030 through promotion of clean technologies and renewable energy sources, among other strategies, despite the challenges posed by rapid population growth and a significant renewable energy financing gap. Tanzania's NDC implementation plan depends largely on a climate finance mechanism under UNFCCC and bilateral and multilateral climate financing sources (United Republic of Tanzania 2021). About USD 60 billion is needed by 2030 for mitigation actions, which requires a scaling-up of mobilised climate finance, but the country is on track to achieve SDG 13 on climate action (AfDB 2022).

The National Climate Change Strategy (2021–2026), the Zanzibar Climate Change Strategy (2014) and the Environmental Management Act Cap. 191 are some of the policies put in place by the government to enhance the country's climate resilience (AfDB 2022). Energy, transport, forestry and waste management are the priority sectors for reducing GHG emissions. Focusing specifically on the forest sector, promotion of forest landscape restoration programmes and initiatives will go a long way towards attaining the GHG emission targets. There is a need for safeguarding ecosystem services, which could be achieved by diversifying livelihood options for forest-dependent communities. Participatory sustainable forest and wildlife management and protection needs to be enhanced and forestry research and development strengthened to promote resilience to climate stress.

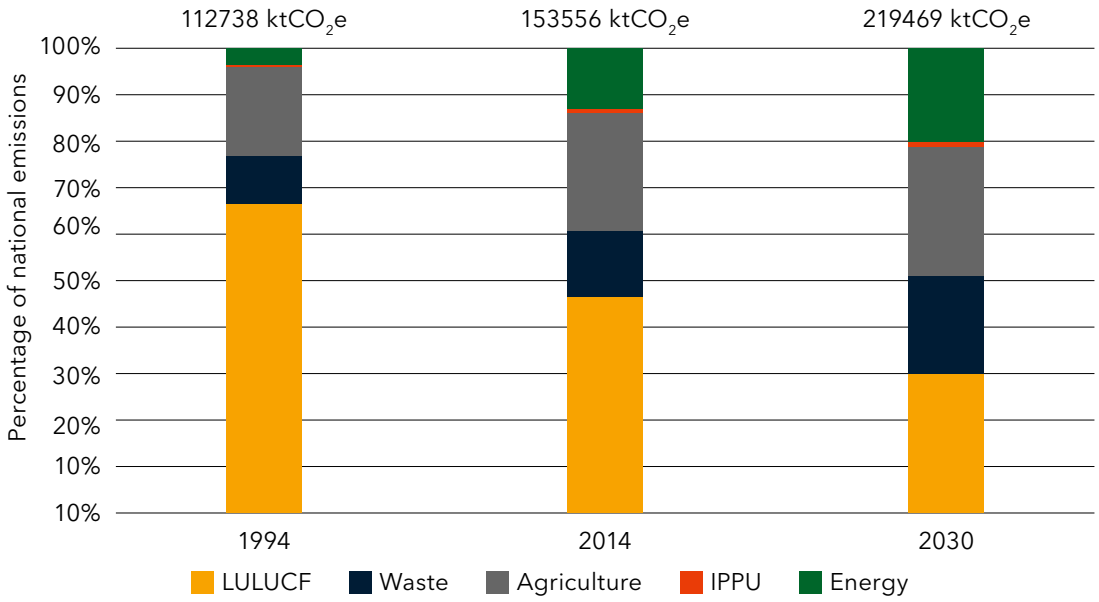


Figure 15. Relative contribution of sectors to national GHG emissions and projected (BAU 2030). Note: Transport is included in the energy sector. IPPU is Industrial Processes and Product Use. LULUCF is Land Use, Land Use Change and Forestry. Livestock is included in the agriculture sector. Data source: United Republic of Tanzania 2021.

Tanzania needs to explore the options for energy diversification and promoting climate-smart rural electrification, as stated in the country's NDC report. Increased use of natural gas and harnessing renewable energy forms have a huge potential to reduce emissions from the energy sector, which also includes wood energy. Charcoal is currently a large fuel source for most of the country's population and contributes significantly to emissions, as well as contributing to several health problems such as respiratory illnesses from indoor air pollution. There is need to expand and further utilise carbon-free options such as geothermal, solar, hydro and wind energy as well as increasing the resource and technological efficiency of wood energy (United Republic of Tanzania 2021).

In line with circular economy, waste management systems are also expected to play an important role in reducing GHG emissions in Tanzania. There is potential to increase the waste to energy management approaches that exist at the private sector and community level. Enhancing management of waste disposal sites, increasing waste recycling and reuse, identifying informal dump sites, and implementing landfill gas recovery, as well as electricity generation programmes, are worth exploring (United Republic of Tanzania 2021).

The above discussion demonstrates that Tanzania is cognisant of the potential and opportunities the forest sector presents to its economy and is equally alive to the challenges that have faced the sector over the years. Consequently, the country has developed forward-looking policies and legal frameworks to address the existing challenges and unlock the opportunities and the potential of the sector, especially through sustainable forest development, management and utilisation.

7.5 Forest bioeconomy outlook

Tanzania is yet to develop and implement a robust forest bioeconomy policy to set the framework for a transition to forest bioeconomy. However, the country has developed progressive forest-related policies and programmes on which the transition to forest bioeconomy could build. The 1998 forest policy sought to promote the rehabilitation of existing and development of new technologies for an efficient and value-added forest industry. In 2016, the government banned timber harvesting for export, a move which has been a boon for the industry. For instance, over 4,000 timber-related factories have been established in the country since 2016 when the ban was enforced (Ubwani 2023). To catalyse the export of engineered products, the government reduced the export tax for wood products to three percent from five percent, a move that increased access to engineered wood products from Tanzania to the African Continental Free Trade Area (AfCFTA) market (Ubwani 2023).

The country's National Forest Policy Implementation Strategy 2018-2028 has also outlined a forest transformation agenda relevant to forest bioeconomy. Some of these strategic interventions include the following (MNRT 2018).

1. Effective development and sustainable management of forest and tree resources through strengthening human and institutional capacity for forest resource assessment, monitoring and valuation at national and forest levels, establishment of forest and forest product certification processes to meet international standards, strengthening human and institutional capacity for germplasm production and management for indigenous and exotic species and promoting public and private sector engagement in plantation establishment for commercial purposes. These respond to low institutional and human capacity for forest plantation establishment and management, the need for better sylvicultural management of both public and private forests and better germplasm, and the need to meet emerging sustainability requirements for forest products and services.
2. Enhanced and sustained production of forest and tree products by promoting application of appropriate processing technologies and branding of forest products for domestic and international markets, strengthening the capacity of local artisans for innovative production and marketing, and establishing and equipping mobile training facilities for technology and innovation transfer to individuals and small and medium forest related enterprises. This will facilitate value addition and the creation of more jobs in the sector, the development of new value chains and increased state revenues from the forest industry.
3. Enhance investments in the development of forests, tree resources and industries by establishing mechanisms to incentivise the private sector to invest in forest and tree value chains. This will particularly enhance private investments in the forest sector.

For forest protection purposes, the government has initiated measures to enhance sustainable forest management. In 2018, the Forest Stewardship Council approved the FSC National Forest Stewardship Standard (NFSS) of Tanzania Mainland. The

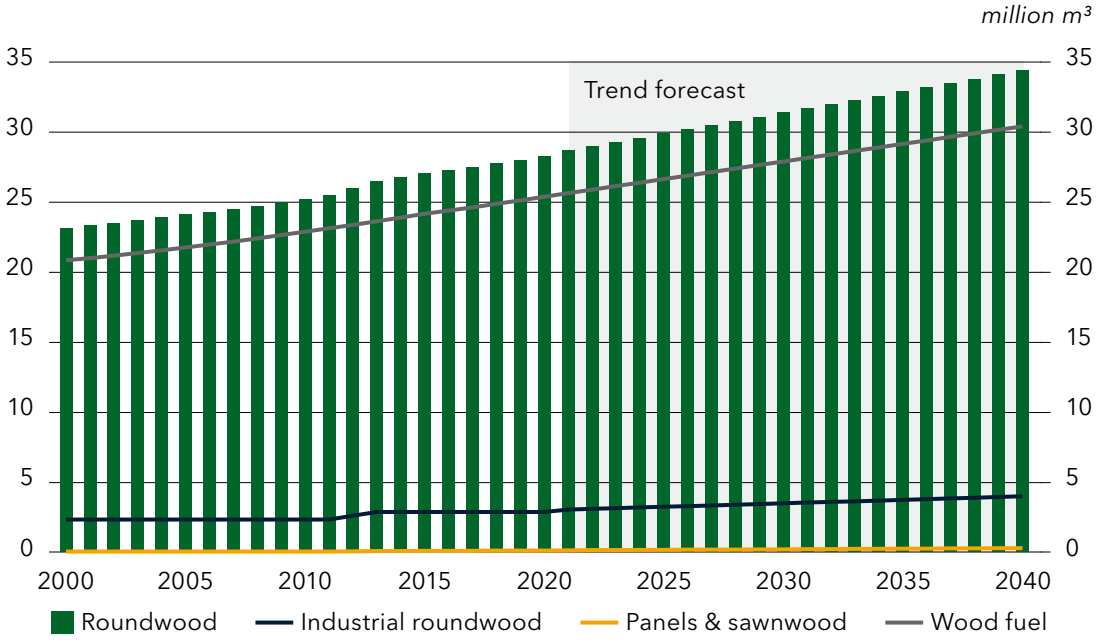
NFSS is applicable to all forest operations seeking FSC certification for forest management in Tanzania. As a result, some 227,688 hectares of Tanzania's forest have been FSC certified (FSC 2022b). There is an opportunity to enhance the sustainable management of forests in Tanzania by scaling FSC certification in the country. The country's gazettement of nature forest reserves has also played a critical role in forest protection and conservation in the country. The construction of well-equipped offices and ranger posts on the borders of the forests have also greatly improved the rangers' access to the forests to prevent illegal logging and mining as well as the spread of wildfires (UNDP 2018).

Financial investment is a key ingredient in forest bioeconomy development. Tanzania has received financial support from international entities to support forest conservation, forest plantation development and forest industry development. In 2023, a UAE-based entity – Blue Carbon – signed a Memorandum of Understanding (MOU) with Tanzanian Forest Services (TFS) for promoting sustainable forest management practices and reducing greenhouse gas emissions by supporting the government's efforts to conserve, manage and register its forest resources of eight million hectares and sell these credits under Article 6 of the Paris Agreement (Mtema 2023). The International Finance Corporation (IFC) invested a USD 10 million senior loan and an USD 8 million subordinated loan to Green Resources, a plantation and forest products company, to plant forests on grassland and deforested areas, modernise sawmill and wood harvesting equipment, and build a 15-megawatt heat and power plant fuelled by wood waste from its own and neighbouring sawmills. The investment was also meant to help Green Resources create 500 permanent jobs and 5000 seasonal positions as well as generating carbon credits from its operations and selling them directly to buyers from developed countries (IFC 2009). While these financial investments in the forest sector are noteworthy, they remain grossly insufficient. If Tanzania is to develop its forest bioeconomy, including investment in production bio-based products (eg cross laminated timber, laminated veneer lumber, modern pulping) and create 100,000 jobs, it will need billions of dollars in funding and investment by both public and private sector players. As we have noted above, establishing a modern paper mill alone requires USD 1–1.5 billion in investment.

Given the above efforts, which have yielded some results in terms of forest certification and the development of engineered forest product value chains and mobilisation of resources for private and public investment in forestry (though largely marginal), questions can be asked about what the future holds for the Tanzanian forest bioeconomy, and whether there are opportunities yet to be unlocked to catalyse this transition in the country. We reflect on these in the section that follows.

Figure 16 shows the roundwood, industrial roundwood, panels, sawnwood and wood fuel production for 2000 to 2020 and the trend projections to 2040. The projections to 2040 are based on 2010 to 2020 trends and, even though they are simplistic, they help to provide a useful business-as-usual scenario for reflections. The figure shows that if the current trends were to hold, roundwood production would increase by about 6 million m^3 from 2020 level. What should mostly be of concern for forest bioeconomy development in this projection is the high share of the low

value-added wood fuel (88%) in 2040, with the industrial roundwood share being only 12%. Industrial roundwood production would increase by 40% from 2020 to 2040, but would still be only at the level of 4 million m^3, which would not enable a large increase in the forest bioeconomy. Also, although the production of more value-added panels and sawnwood production would increase, they would stay at a very low level and would not play significant role in the forest bioeconomy development. Clearly, this business-as-usual scenario is not desirable from the forest bioeconomy development perspective. Consequently, there is a need to design strategy and policies that help to reduce roundwood going to energy purposes and increase industrial roundwood production going to more valued-added engineered wood products and biorefineries.



Data: FAOSTAT

Figure 16. Tanzania's roundwood, wood fuel, industrial roundwood and panels and sawnwood production 2000–2020 and trend forecast to 2040. Figure: Lauri Hetemäki.

A positive factor is that Tanzania has made some important initial progress in its transition to the forest bioeconomy and could build on this to scale up. In particular, it would need a dedicated forest bioeconomy strategy that would address the sector from a more holistic perspective, including RDI, industrial and funding perspectives, and not only from the forestry perspective.

Tanzania's social conditions are characterised by a stable society in an African context, which provides a good basis from which to develop the forest bioeconomy. Moreover, the economic environment is characterised by moderate inflation and unemployment rates, favourable food prices and declining fuel prices. On the other hand, there is a major setback for bioeconomy- and biotechnology-related pro-

jects because the country's financial institutions are not well versed in such projects. The loan by the IFC to a private forest company is a necessary start to change the landscape and bolster private investment in forest value chains in Tanzania. However, much bigger funding and investment is needed, which also requires engagement from the private sector, if forest bioeconomy development is to be scaled up. Significant investment should also be dedicated to RDI to advance bioeconomy development, which is a precursor for innovation, new technologies and bio-products. Further, there is need to ensure political goodwill, improvement in infrastructure, and creating favourable interest rates to enable the forest bioeconomy to thrive in the country. Establishment of a central coordination and regulatory body for bioeconomy activities would be an added advantage (ATPSNET 2021).

According to the World Bank (2018, p. 3), for structural transformation to happen in Tanzania, the business environment should be improved and market competition with limited state intervention should be promoted to allow the private sector to successfully drive the transformation. Power and transport infrastructure also need to be improved to ensure the efficient transport of products to markets, access to forests and plantations and a reliable supply of electricity to the timber processing industry. Reinforcement of institutional capacity to ensure the sustainability of renewable and non-renewable natural resources, manage competing demands and improve sectoral transparency is also needed. Improving rural infrastructure is key to connecting farmers to markets in urban areas. Rural areas can also be linked with secondary cities and can be fostered through the development of regional value chains and key infrastructure in secondary cities (Ngaga et al. 2001).

For those reasons, Tanzania is yet to fully develop its forest bioeconomy. However, the country's forest bioeconomy potential can be realised with the right policies, actions and cooperation between forest authorities, private forest businesses, local communities and civil society organisations. Tanzania must work towards increasing its forest cover to meet its ambitious roundwood production targets. Here, the country could draw lessons from Gabon's radical and effective policies, which included a ban on exports of raw roundwood, a move which resulted in an increase in high value-added forest industries and more value-added sawnwood exports.

The country must also address its low level of investment within the forest sector by developing and facilitating investment in high value-added forest industries. Incentives for industrial investment, such as the introduction of tax laws aimed at encouraging further wood processing for export and incentivising local value addition should be considered and strengthened. Investment should also be extended to research, development and innovation (RDI) as well as in capacity building to develop the human resources necessary for the development of the forest bioeconomy in the country.

Given that the country has a high population, which is projected to rise even further, Tanzania should invest heavily in the design of innovative and low-emission buildings and construction solutions, such as through the use of CLT and other engineered wood products. Further, the country should explore opportunities for investment in wood-based biorefinery and other non-fossil-based products, espe-

cially for the transport sector. This transition will, without a doubt, require intensive capital investment. Thus, incentives to catalyse investment in non-fossil fuels will need to be prioritised. Finally, wood fuel is still the main source of energy for cooking and heating for most of Tanzania's population. The country should promote investment in the development and commercialisation of other modern cooking and heating technologies to reduce pressure on forest resources, as well as to provide alternative forms of livelihood for those reliant on fuelwood.

8. The future of fuelwood: A critical question

8.1 Advantages and disadvantages of fuelwood

One of the key factors that will determine forest bioeconomy development in each of the AF5 countries will be what happens to fuelwood development in the future. In these countries, the total roundwood production in 2020 was 180 million cubic meters, of which 147 million m^3 or 81% was used for wood fuels (bioenergy) and only 19% for industrial roundwood (Table A1). It has been estimated that in sub-Saharan Africa, 72% of urban and 98% of rural households use fuelwood for energy (Njenga et al. 2013). Among the AF5, fuelwood is most important for Kenya, Nigeria and Tanzania, which uses between 87% and 96% of the total roundwood production for this purpose. Even in South Africa, use of roundwood for fuelwood remains high at 63%. The exception is Gabon where it stands at 27%. This is according to the FAO statistics. However, there are reasons to assume that fuelwood figures could in fact be higher than these, due to fuelwood use being heavily dependent on the informal sector and not captured by the official statistics.

It must be acknowledged that wood used for firewood or charcoal may not be suitable for many value-added forest bioeconomy products, such as for sawnwood or engineered wood products, due to quality reasons (shape of the wood trunk, wood material properties). However, the wood cellulose, hemicellulose and lignin contained in the roundwood used today for energy purposes could potentially be used for various biochemicals, packaging products and textile raw materials. Therefore, to some extent, the wood material flows going for energy purposes today could be used for the more value-added industrial processing of new forest bioeconomy products.

There are many reasons and incentives to explain why fuelwood production and consumption are so extensive in AF5 countries (see Table 4). For the rural population, in particular, it is often the only option for generating energy for cooking and heating, as well as an important employment and income generator. Fuelwood also has cultural meaning, especially related to culinary preferences. However, fuelwood production and consumption is also associated with a number of unwanted features. First, it may cause deforestation and soil erosion if not sustainably sourced and managed. Due to fuelwood demand, natural forests are being depleted, leading to the loss of biodiversity and degradation of ecosystem services. The clearing of forests for fuelwood production can lead to soil erosion and desertification, making it difficult for the land to support other forms of vegetation. Furthermore, the use of fuelwood for cooking is contributing to air pollution and health issues in the communities that rely on it. According to African Development Bank Group (2018a, p. 3) "they produce smoke and gases by incomplete combustion, causing long-term respiratory health problems and deaths, projected at about 4,000 peo-

ple per day by 2030." (IRENA and AfDB 2022). Estimates show that the number of people who do not have access to clean cooking solutions is high – for example, 175 million in Nigeria and 56 million in Tanzania. Fuelwood is also a source of GHG emissions.

Moreover, fuelwood is also likely to hinder the more value-added development of forest-based bioeconomy by reducing the raw material basis for it. Although the quality of roundwood used for fuelwood is often not suitable for, for example, the sawnwood industry, it could provide the raw material basis for bioproducts that utilise the wood's cellulose, hemicellulose and lignin. Thus, the value of wood that is currently used for fuelwood could be increased by channelling the same to these high value-added products, with attendant increases in incomes, jobs and revenues.

In summary, there are strong arguments for measures that help to reduce fuelwood consumption. However, this should be carried out in a way that takes the needs of the people who are dependent on fuelwood into consideration, and provides alternative affordable energy, employment and income opportunities for them.

Table 4. Advantages and disadvantages of fuelwood production and consumption in AF5 countries, compiled by Lauri Hetemäki.

Advantages	Disadvantages
Accessibility: Fuelwood is often readily available in rural areas where other forms of energy may be scarce or expensive.	*Environmental:* Overuse of fuelwood can lead to deforestation and forest degradation and have negative impacts on local ecosystems.
Affordability: Fuelwood is often a low-cost alternative to other forms of energy, such as electricity or gas.	*Climate change:* Deforestation and the burning of fuelwood contributes to greenhouse gas emissions.
Sustainability: Fuelwood is a renewable resource and **can be** sustainably harvested **if managed properly**.	*Health impacts:* Indoor air pollution from burning fuelwood can lead to respiratory illness and other health problems.
Local employment and income: Harvesting and distributing fuelwood can provide jobs and income for local communities.	*Food security:* Overuse of fuelwood can lead to land degradation and loss of productivity, which can affect food security.
Cultural-culinary significance: Fuelwood is often used in traditional cooking and cultural practices.	*Social impacts:* Women and children are often responsible for collecting fuelwood, which can take up a significant amount of time and prevent them from engaging in other activities such as education or income-generating activities
	Economic impacts: Fuelwood is low value-added and may reduce resources for more value-added bioproducts.

8.2 How could AF5 reduce the dependence on fuelwood?

There are several ways that AF5 countries could reduce their dependence on fuelwood (World Bank 2011; Copenhagen Centre on Energy Efficiency 2015; Ouedraogo 2017).

- Promote the use of alternative energy sources such as solar, wind, hydro and gas. This would help to reduce the demand for fuelwood and decrease pressure on forests. This should be accompanied by campaigns raising awareness of the importance of fuelwood conservation and the benefits of using alternative energy sources.
- Encourage the use of efficient cooking stoves. These stoves use less fuelwood and can reduce indoor air pollution.
- Invest in new technologies such as gasification and pyrolysis to convert biomass into clean energy that can replace wood and charcoal. Also, increase the use of brickettes and pellets instead of charcoal (more resource-efficient).
- Encourage the development of local industry for production of clean and sustainable energy.
- Encourage the use of urban waste for energy production, which helps to reduce the demand for wood and improves waste management.
- Develop and promote agroforestry practices, including establishing fuelwood and biogas facilities at household and commercial levels. This can help to increase the availability of fuelwood while also improving soil fertility and crop yields and incomes.
- Invest in modern, sustainable forest management practices, including forest certification to promote responsible/sustainable forest management. This can help to ensure that forests are managed in a sustainable way and that fuelwood is harvested in a responsible manner.
- Support research into and development of bioenergy crops that can be used as a biofuel and feedstock for bioplastics, fertilizers and other bio-based products.

Hetemäki et al. (2020) considered a hypothetical "what-if" example for decreasing African fuelwood production. Assume that technological efficiency and fuel wood consumption in Africa could be improved eg by 30%, and/or 30% of the wood energy could be produced using other energy sources (eg solar, wind and gas). Thus, the same amount of energy as in 2018 could be produced by about 208 million cubic meters less wood. In comparison, this is clearly more than total of Canada's roundwood production (152 million m^3) or equal to the total roundwood production of the three biggest producers in the EU combined in 2018 (Finland, Germany, Sweden produced 213 million m^3). In short, there is a huge potential to produce energy more efficiently than is done today from roundwood, and use other energy sources for this purpose, and by that, decrease fuelwood consumption.

AF5 countries are rich and diverse in their potential energy resources, with substantial gas, geothermal, hydro, solar and wind resource opportunities (IRENA and AfDB 2022). Table 4 shows how heterogenous the power generation in AF5 is in terms of the source of electricity. It also shows that, in terms of electricity genera-

tion, bioenergy does not play a large role in AF5 – it is dominant only in cooking and heating. Currently, among the renewable energy sources for electricity, only hydropower has been extensively developed in all AF5 countries, except for solar power in South Africa (IRENA 2022). But solar power is the fastest-growing renewable energy source in Africa and it will be a key driver of new capacity additions in the decades to come (IRENA and AfDB 2022).

Table 5. Installed electricity-generating capacity by source, 2020 (MW). Original data source: IRENA (2022), for this report, the table was modified and compiled by Lauri Hetemäki.

	Bioenergy	Coal and peat	Oil	Natural gas	Geothermal	Hydropower	Solar	Wind	Total
Gabon	1	0	87	192	0	**330**	1	0	**612**
Kenya	88	0	**750**	57	824	837	106	336	**2998**
Nigeria	10	0	43	**10959**	0	2111	28	3	**13154**
South Africa	265	**40686**	2440	0	0	3479	5990	2636	**55496**
Tanzania	70	0	344	**974**	0	589	24	0	**2000**
TOTAL	***434***	***40686***	***3664***	***12182***	***824***	***7346***	***6149***	***2975***	***74260***

Nigeria and Tanzania have large natural gas resources. Gas has a lower carbon footprint than other fossil raw materials. Natural gas also helps to support the baseload, provide reserves and balance the electricity grid. Thus, it could act as temporary energy form in a longer run process of moving to totally fossil-free energy forms. In terms of other fossil resources, in future South Africa will have a major challenge in reducing its significant use of coal in electricity generation. Apart from these cases, the AF5 countries are not heavily dependent on fossil fuel infrastructure and, therefore, they are in a better position to leapfrog to an economy centred on renewable energy than, for example, Europe and North America.

The energy transition in AF5 would, to a significant extent, depend on imported energy technologies. Consequently, AF5 will need new energy technologies, management systems and finance to develop and integrate its energy resources to drive its energy transformation. Gradually and increasingly, solar and wind energy may soon provide the most cost-efficient sources for the energy transformation. With fossil energy becoming more costly due to CO_2 costs, renewables will be even more competitive.

Renewable energy allows potentially significant economic and employment impacts downstream. Unlike fossil fuels, which are at the basis of resource-orientated economies (such as Russia), renewables provide opportunities for manufacturing, such as bio-gasifiers, electrical equipment, windmills and solar cells. For example,

Kenya is a growing manufacturing country of solar PV components (Asian Development Bank 2022).

Given the importance of fuelwood consumption for forests in AF5, how fuelwood use will develop in the future is a key question. It seems that at least two critical trends should take place to improve the situation. First, an increase in the resource and emissions efficiency of generating energy from wood. This requires the application of new wood energy technologies. Second, gradually reduce or replace wood-based energy by increasing other forms of energy generation, such as solar, wind, natural gas and, in the longer-run, also hydrogen and possibly small-scale nuclear energy. The health and environmental sustainability benefits could be great. The new energy forms would also generate new investment, employment and income opportunities in energy sectors, as well as in the forest bioeconomy sector by replacing energy wood use with more value-added use in materials sectors, such as in wood construction and the textile industry.

To reduce fuelwood dependency, there is a need to mobilise public and private investment in more resource efficient, healthy and affordable wood bioenergy, especially in rural areas, and new or upgraded energy infrastructure in urban areas (power grids, district heating and cooling networks, electric charging stations) and foster innovation. In addition, efforts to raise public awareness of more modern renewable energy solutions and their benefits will be central to ensuring popular acceptance and support for the energy transition.

Policies that include regulatory measures and financial incentives (and disincentives for fossils) should be used to create a market for more resource-efficient bioenergy and other renewable energy. For example, taxes for coal and oil, financial incentives for renewables (technology and investment subsidies, feed-in tariffs, public procurement), support measures for small- and medium-scale enterprises and decentralised energy infrastructure in rural areas.

A major challenge is that a large part of fuelwood employment and incomes are in the informal sector. Moreover, the gainers and losers of energy transformation could be different. Therefore, it would be essential to plan the transformation in such a way that the people dependent today on wood energy – both as energy generation and income and employment – would not be excluded from new opportunities. Therefore, a transition to more resource efficient and healthy bioenergy and other renewables should be carried out in such a way that alternative employment and income opportunities for people depending on the informal sector for their livelihoods have an opportunity to move to the formal economic sector. Policies will have to address the misalignments that may emerge in *time* (if new jobs are not created as quickly as old ones disappear); in *space* (new jobs may be created in locations different from old ones); in *education* (the energy transition may require different skill sets); and in *economic structures* (the transition may feature different sectors and supply chains than those prominent under the old informal fuelwood economy).

To facilitate the energy transition, AF5 countries will also need bilateral and multilateral funding, such as the International Just Energy Transition Partnership between South Africa and France, Germany, the United Kingdom, the United States and the

European Union, announced at COP26 (IRENA and AfDB 2022). These types of funding mechanisms are also needed for the other AF5 countries.

In summary, the social, economic and environmental costs of the fuelwood-dominated cooking and heating energy system are immense in AF5. In addition, it is difficult to see a viable forest-based bioeconomy development in these countries if the more efficient, sustainable and value-added use of forest resources do not take place. Providing opportunities and platforms for reducing fuelwood use is a necessary step for forest-based bioeconomy development, especially in Kenya, Nigeria and Tanzania.

8.2 "What-if" scenario for the future

To conclude the discussion on energy wood, we computed for illustrative purposes a hypothetical *what-if type of scenario* for forest bioeconomy development in AF5 countries up to 2050. Assume that fuelwood production in AF5 countries would decline from 2021 by the following percentages: 30% by 2030, 50% by 2040 and 70% by 2050. On the other hand, industrial roundwood for existing and new forest bioproducts would increase as follows: 30% by 2030, 60% by 2040 and 150% by 2050. Probably, the bulk of these products would be sawnwood, wood panels and the emerging engineered wood products, such as CLT and LVL elements and modules.

This scenario is illustrated in Figure 17. In 2050, the AF5 countries would produce 55 million m^3 or 34% less roundwood than in 2021. Yet, it would be very likely that the value added of the roundwood production would be many times higher than in 2021. This would be due to the 150% increase in industrial roundwood production and the forest bioeconomy products value chain. In this scenario, the AF5 countries would also have more forests saved for non-wood forest products, recreation, forest carbon sinks and biodiversity conservation. Now the key question is, how could the AF5 countries move to this type of forest bioeconomy development? In the next chapter, we address this question.

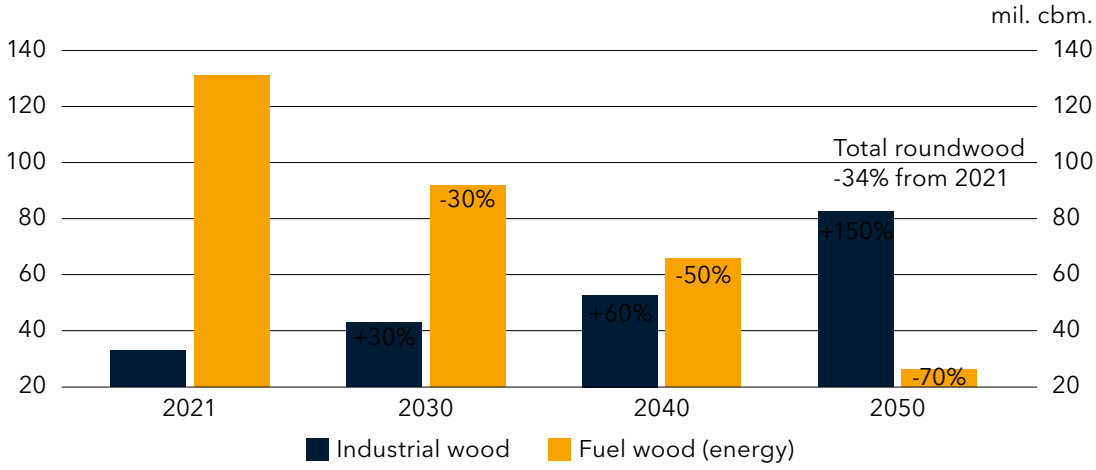


Figure source: Lauri Hetemäki; Data for 2021: FAOSTAT

Figure 17. "What-if" scenario for AF5 roundwood production to 2050. Figure: Lauri Hetemäki.

9. The way forward: Management and policy implications

9.1 Africa at a crossroads

Africa is at a crossroads in many ways, and that is also true for the AF5 countries. First, it seems necessary that there will be a systemic transformation from the current economic structures that are very much based on the agriculture sector, fuelwood, fossil resources and low value-added manufacturing. Moreover, there is an urgent need to develop better adaptation to the risks related to the changing climate. This is at a time when, in many countries, populations and urbanisation are projected to grow rapidly, the educational level is low, there is high unemployment, high levels of bureaucracy and corruption, and significant shortage of capital for new investment and advanced technologies. It would seem easy to conclude that there is a clear gap between the current needs and future challenges, and the potential of existing resources and institutional settings to meet them. Therefore, there is a need to change the current way of managing things – just continuing with ongoing trends is insufficient to bridge this gap. In this report, we argue that *forest-based circular bioeconomy* offers a necessary – although insufficient itself – approach to move forward and answer many of the future challenges.

Before moving on to the general principles for enhancing circular forest bioeconomy development in AF5, a few major disclaimers are necessary. First, although the bioeconomy concept – as we understand it – also includes non-wood products (such as fruits, berries, mushrooms) and ecosystem services (for example, nature tourism and recreation), the focus in this report has been restricted to wood products. This is not because the other forest-related goods and services would not be important. Indeed, in many regions they could be more important than wood products. However, simply due to the scope of the study and the expertise of its authors, it has focused on wood products. Secondly, forests and agriculture are interlinked in many ways in AF5 countries, and analysing these separately loses some important aspects. For example, the study has not analysed in detail the possibilities offered to forest bioeconomy by agroforestry. In future studies it would be important to address this topic as well. Thirdly, the report is based on literature study and data analysis, and primary data sources such as expert interviews or field studies have not been carried out. These would have generated new insights and perhaps corrected some errors and misinterpretations that may still be present in this report. Finally, we do not think that the following recommendations on how to advance forest bioeconomy in the AF5 in the future are exhaustive, rather we see these as a necessary part of a larger set of actions.

9.2 Measures for advancing sustainable forest bioeconomy

While all the AF5 countries have seen important progress in this century, there is no guarantee that socio-economic growth and poverty reduction will automatically continue given the current volatile global economic environment, changing climate and the countries' high population growth. Thus, it seems likely that the business-as-usual model will not bring the countries to the next level of development and help address the sustainability challenges ahead. Given this, one important element of a new strategy should be *circular forest bioeconomy*. The circular economy and forest bioeconomy share several synergies that can support sustainable development. They can both provide economic benefits by reducing the cost of raw materials and energy, improving resource efficiency and creating new market opportunities. They can also contribute to a more sustainable environment by reducing greenhouse gas emissions, conserving natural resources and reducing waste. For example, in a circular economy, waste is reduced by designing products and processes to minimise waste and converting any generated waste to new products and value chains. Similarly, a well-managed forest bioeconomy can help to reduce waste by using all parts of the trees and the side-streams of the forest products production processes, and designing products in a way that they are easily recyclable or reusable for other products.

Leveraging their rich forest resources in a sustainable and circular way, the AF5 countries can transform into a more value-adding, diversified and sustainable economies and societies. However, this will not be easy and will not take place without systemic changes. They include factors outside the conventional forest sector. For example, economic transformation, developing a public sector that is more capable of delivering quality services, higher human capital and gender equity, technological change, better infrastructure (such as transportation and electricity grids) and establishing a social safety network (such as social security) that builds foundations for people to be willing to take new risks and opportunities they would not normally take. Moreover, especially in Kenya, Nigeria and Tanzania where large parts of the population still live in rural areas, better rural-urban connectivity and infrastructure – in rural areas as well as the urban ones – is essential.

To lay out measures for advancing forest bioeconomy in AF5 context, we start first with two very general *national-level objectives,* namely *governance* and *sustainability*. After addressing these, we move to discuss what *sectoral level actions* are needed to enhance and develop the circular forest bioeconomy. These we also categorise in sequence: *short-term*, *medium-term* and *long-term* actions.

The suggested actions consist of general and broad requirements for enhancing the circular forest bioeconomy. Each of these needs to be detailed and tailored to the regional circumstances. As this report has shown, the AF5 countries have a wide range of different forest resources and forest sectors, development experiences, socio-demographic patterns and institutional capacities. Therefore, each country embarks on the forest bioeconomy transition from its own starting point, implying

different sets of strengths and weaknesses. Policymaking and actions must be tailored to these characteristics.

9.2.1 Good governance is a precondition

Forest bioeconomy is not an entity separate from the society. It is very much part of the environmental, economic, social and institutional setting of the society. Successful forest bioeconomy requires the sustainable use of forests, well-functioning institutions and societal cohesion and governance. If a country is facing governance challenges, such as widespread political turbulence, civil conflicts, military rule, over exploitation of natural resources, lack of educational opportunities, etc, it is difficult to see how a flourishing circular forest-bioeconomy could arise.

Among the AF5 countries, the biggest governance challenges are observed in Nigeria (see Figure 16). The country confronts multiple societal and economic challenges to its governance. First, Nigeria is suffering from ethno-religious conflicts, attributed to cultural, ethnic and religious communities and identities, as well as herder–farmer conflicts, typically involving disputes over land and/or cattle between herders. For example, the Islamist militant organisation Boko Haram based in north-eastern Nigeria and the Biafra separatist rebellion in the south are causing threats to societal cohesion. According to the 2022 Global Terrorism Index (GTI) ranking, Nigeria scores sixth highest among the 163 countries (Institute for Economics and Peace 2022). Things do not seem to have improved, indicated by the fact that the ranking has increased recent years. Moreover, according to the 2022 Afrobarometer, 89% of the population said that the overall direction of the country has gone the wrong way. This is the most negative Afrobarometer assessment in more than a decade.[18] However, the elections of 2023 and peaceful transfer of power offers some optimism for future development.

Secondly, in the past decades, Nigeria has also suffered from poor economic conditions. According to the World Bank (2022c), macroeconomic instability has worsened to historically high levels and caused Nigeria's potential output growth to decline dramatically from an average of a strong 8.2% in 2000–2010 to 4.4% in 2011–2014, and further to 2.1% in 2015–2021. Moreover, high petrol subsidies continue to consume a large portion of gross oil and gas revenues, taking resources away from other needs, such as health, education, research and social security. The subsidies have increased in recent years and are forecasted to have been N4.8 trillion, or 2.3% of projected GDP (World Bank 2022c).

Thirdly, one of the many challenges is the heavy dependence on the oil sector, and the lack of efforts to reduce this by diversifying the economy. Previously, Nigeria exported a broad range of primary commodities, but over the past decades oil has consistently represented more than 90% of Nigeria's total exports. In terms

18 www.afrobarometer.org/publication/ad600-nigerians-grim-outlook-points-to-high-stakes-in-competitive-elections/

of a measure of the relative knowledge intensity of an economy – the Economic Complexity Index (ECI) – Nigeria ranked 125, one of the lowest in world in 2020 (The Observatory of Economic Complexity 2022). Low-complexity index countries have failed to diversify their knowhow and therefore face low growth prospects. In contrast, high complexity index countries have successfully added productive capabilities to enter new sectors that can drive growth over the coming years. Besides helping to predict and explain future economic growth, the ECI index is also used to predict, for example, future income inequality and greenhouse gas emissions.

To facilitate good governance, Cloutier et al. (2021) stress the importance of a vibrant *social contract*. This is a contract "in which citizens share a strong sense of collective solidarity and purpose and broadly trust that private resources they relinquish to the state will be spent on public goods and services benefiting society as a whole." For this purpose, the key building blocks are taxation and redistribution policies that help to reduce inequality and broadly enhance the welfare of citizens, as well as education possibilities for all. Strengthening the social contract has been identified as a necessary condition for Nigeria to achieve greater and shared prosperity (Cloutier et al. 2021).

As the World Bank (2022c) states, "Nigeria could choose reforms that would put it on the path to finally rise to its potential." In the next decades, the forest-based bioeconomy could provide one of the opportunities for diversification and, gradually and in the long-run, helping to phase out the fossil sector. Hopefully, the better governance and the structural changes Nigeria needs will get a boost from the new administration of President Tinubu (since May 2023).

Gabon, Kenya, South Africa and Tanzania are not suffering from as serious governance and economic challenges as Nigeria (see Figure 18). For example, terrorism is not as bad in these countries, although still problematic in Kenya. In terms of the 2022 Global Terrorism Index (GTI), Kenya ranks 20, Tanzania 36, South Africa 73 and Gabon 86. For comparison, USA ranks 28 and United Kingdom 31, ie both perform worse than Tanzania, South Africa and Gabon. Indeed, Gabon even ranks better than any of the "peaceful" Scandinavian countries.

On the other hand, in terms of the Economic Complexity Index (ECI), Gabon's ranking is 122 and it has similar challenges to those of Nigeria. Gabon's economy has been too oil dependent. Moreover, the military coup that took place in Gabon in August 2023 casts uncertainty on the political development of the country. However, under the President Ali Bongo's governance, Gabon at least clearly understood the need for change and has already taken serious efforts to diversify its economy. One of these efforts is to boost the forest bioeconomy, as discussed in Chapter 3. The ECI index for the three other AF5 countries are: Tanzania 86, Kenya 80 and South Africa 54. That is, South Africa has the most diversified economy and growth and innovation potential based on this index. As discussed in Chapters 2 and 6, South Africa's economy already has a strong forest products industry, which also forms a good basis from which to develop innovative forest products.

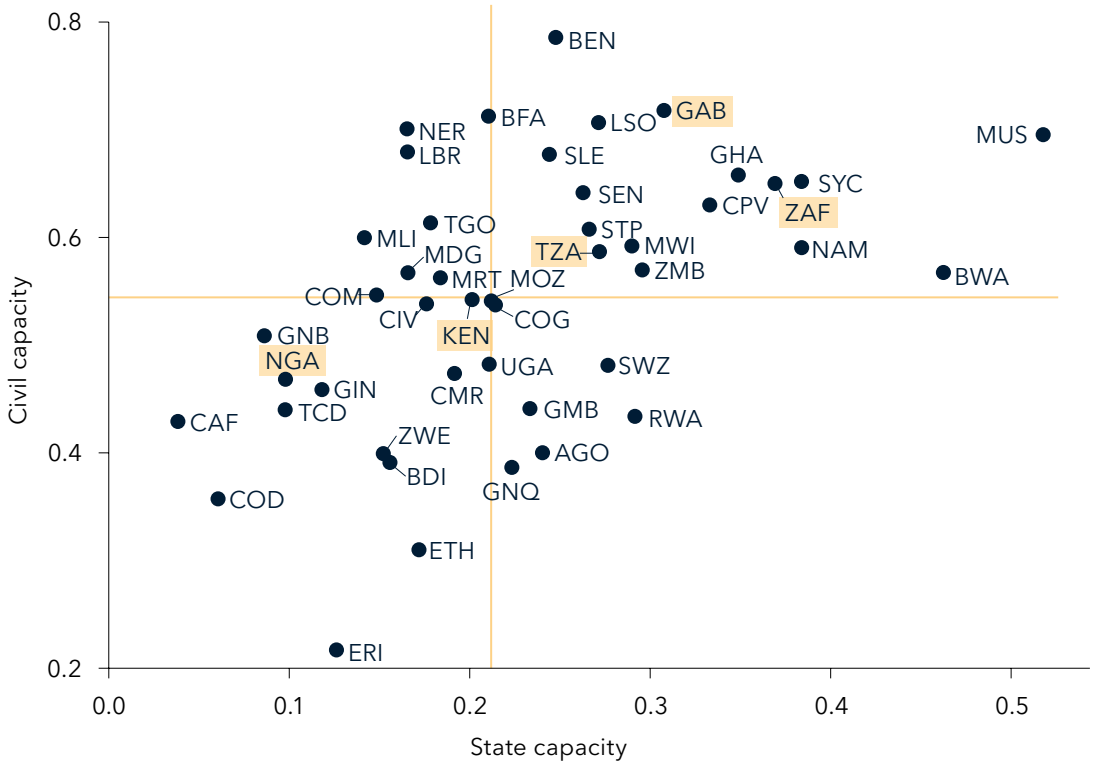


Figure 18. Civil and State Capacities across Africa. Adapted from Cloutier et al. (2021). GAB = Gabon; KEN = Kenya; NGA = Nigeria; ZAF = South Africa; TZA = Tanzania.

In summary, the better the country's governance and the more cohesive the society, the better are the prospects for developing the circular forest bioeconomy. Moreover, developing the forest bioeconomy needs to be a priority at the country's highest decision-making power (the president, the government) in order to move to concrete actions. Of the AF5 countries, this is the case in Gabon (at least before the August 2023 military coup) and South Africa. The other three countries need to work on this – and not only on agriculture-based bioeconomy, which is more often already acknowledged, but also on the forest-based circular bioeconomy.

9.2.2 Sustainability needs to be imposed and monitored

One should not assume forest bioeconomy is sustainable per se, but address and design policies to support all dimensions of sustainability and monitor its development. The first-generation biofuel production from agribiomass in the beginning of this century is a lesson in how bioeconomy development could be derailed and cause sustainability problems, such as food crises and deployment of inefficient production technologies (Mohr and Raman 2013). Forest bioeconomy can create synergies and trade-offs with other forest ecosystems services depending how it is implemented. Therefore, forest bioeconomy also requires careful consideration of the potential trade-off effects that manifest in producing and consuming more biomass. These effects can include the use of, and competition for, water resources

and land, which can result in unintended spill-over effects, such as loss of natural vegetation and biodiversity, reduced food security, labour competition, and other adverse socio-environmental outcomes. For example, a review of plantation forest literature concluded that plantations can have negative social impacts such as to livelihoods and employment (Malkamäki et al. 2018). There has also been discussion of the potentially negative impacts that exotic tree plantations could have on biodiversity, as well as for fires and water supply in regions suffering from droughts, such as in South Africa (Carnie 2020; Wang et al. 2021; Zerga et al. 2021).

History shows that markets do not automatically lead to or produce sustainability. Policies are needed to avoid resource depletion and other unwanted externalities that markets can create, and for placing value on ecosystem services that are not traded in markets. Therefore, policies are also needed to monitor, assess and ensure the sustainability of the bioeconomy.

According to Hetemäki et al. (2017), when launching a circular forest bioeconomy it is essential that environmental sustainability issues are addressed at an early stage, for example in the design phase of production chains and consumption patterns. This means that companies and governments address potential sustainability issues using the best available knowledge and information on environmental aspects, in addition to market and technological issues. Sustainable R&D of new products/materials includes screening for potentially high environmental risks or unacceptable burdens. Such screening may use predictive tools and can lead to significant environmental efficiency and business gains, as the lessons learnt from history indicate. In the past there were examples of promising new technologies that later proved detrimental for humans or the environment, such as dichlorodiphenyltrichloroethane (DDT), chlorofluorocarbons (CFCs) or asbestos cement. In this context, the regulatory role of public authorities is to apply the precautionary principle to foster sustainable progress but without inducing immobilisation – 'nothing ventured, nothing gained'.

Potential environmental impacts should be avoided along the whole lifecycle of products and services, from the resource extraction and production process to the use phase, and eventually the multiple reuse of recycled resources in new products. Consider the example of using woody biomass to produce raw material for textiles (Kallio 2020). Traditional production technologies, such as dissolving pulp for the textile industry, have suffered from environmental issues, but new technologies, now at the pilot scale, do not have these problems. Therefore, for environmental sustainability reasons, it is essential to build on new technologies rather than the old ones. On the other hand, in the global textile industry, recycling (circularity) is almost non-existent. When forest bioeconomy companies move to invest in producing raw material for the textile industry, it is essential that they also take responsibility for helping to build the recycling institutions for textiles after the end use, and do not only take responsibility for the production element. Here, the history of developing paper recycling acts as an example.

For the forest bioeconomy, it is essential to regulate harvesting so that the standing biomass stock in the forest is kept at a high enough level to ensure its continued

growth. This principle of sustainable use is less simple than it looks, but forest science has a long history of developing tools to survey, monitor and predict the annual allowable cut of forests in complex and highly variable landscapes (Hetemäki et al. 2017). It is also crucial to make sure that natural regeneration of forests continues without being hampered.

When enhancing the forest bioeconomy, it is important to take into account potential land use impacts. Replacing fossil-based resources with bio-based ones can lead to increasing land scarcity, which would boost land prices, and may increase potential conflicts between land use options. For example, these types of problems may emerge when establishing new forest plantations, but may be solved through proper policies and management supporting land use optimisation and taking environmental and social issues into account. With plantation forests, it is also important to pay attention to biodiversity impacts. Depending on how, where and what type of plantations are established, they are likely to have different biodiversity impacts.

Yet, it is also important to consider the synergies that the forest bioeconomy can generate and seek to maximise these. Forest bioproducts can have clear advantages over fossil-based ones. They are often less toxic and biodegradable, which facilitates their reuse, recycling and disposal. Wood products can also substitute for fossil products and store carbon just like forests do, with increasing benefits usually coming along with higher product longevity (Hetemäki et al. 2022). In short, the circular forest bioeconomy needs to focus on its strengths, ie in the diversity of biomaterials and their applications, biorefinery-based resource-efficient systems and non-material ecosystem services (eg tourism, environmental regulation), and avoid overemphasising just one subsector, such as the bioenergy subsector.

In summary, forest bioeconomy development should not only be oriented towards technology and economics. There are multiple pathways to develop the forest bioeconomy and not all have the same sustainability potential. Therefore, it is important to design policies, tools, indicators and monitoring systems to support the development of a truly circular and sustainable bioeconomy and avoid or minimise the trade-offs with other forest ecosystem services.

Box 9.1. Forest certification as a tool to increase sustainably managed forests

In all AF5 countries, deforestation has continued to take place during the last decade (Table A1). It is still particularly high in Nigeria, South Africa and Tanzania. Forest resources have faced a range of problems, which have prevented these countries from realising their forests' potential contribution to economic and social development as well as environmental conservation. These problems include not only deforestation, but also reductions in forest quality, the environmental degradation of forest areas, the loss of biodiversity, the loss of cultural assets and knowledge, the loss of livelihoods of forest-dependent people and climate change (Teketay et al. 2016).

Besides central or local government policies and regulations to enhance sustainable forest management and reduce the above problems, it is clear that other approaches are also needed. In this respect, an important contribution could be achieved via more extensive ***forest certification*** **(FC)** in AF5 countries. Forest certification is a market-driven approach, and it attempts to provide an indicator of how well a product is environmentally appropriate, socially beneficial and economically viable.

There are several different FC schemes promoted by various organisations in Africa (Teketay et al. 2016). The two most prominent FC systems globally are the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). FSC is the most prominent certification scheme in Africa, but some countries, such as Gabon, have PEFC-certified forests. In addition to FSC and PEFC, African countries have developed their own national or regional certification schemes to promote sustainable forest management.

FC involves assessing the quality of forest management in relation to a set of predetermined principles, criteria and indicators and their means of verification (FAO 2022a). Forest certifications seek to provide consumers and wood products importers with a credible guarantee that the product comes from forests that are managed in environmentally responsible, socially beneficial and economically viable ways. Thus, the users of wood and forest products can use their purchasing power to promote environmentally friendly and socially beneficial products.

Among the AF5, and Africa in general, Gabon and South Africa have been the pioneers in FC, and they currently have the relatively largest forest areas under FSC-certification in Africa. Relatively bigger certification challenges remain in Kenya, Nigeria and Tanzania.

Successful forest bioeconomy requires sustainably manged forests. For this purpose, one important tool that should gain a more extensive role in the AF5 countries (especially Kenya, Nigeria and Tanzania) is FC. It is also a precondition for these countries to increase their forest products exports in the future. There is a large number of measures they could use to FC. Teketay et al. (2016) provide a list of recommendations to enhance forest certification in Africa. They argue for "stronger commitment from governments on effective law enforcement to control illegal forest resources use" through:

(i) strengthening close collaboration among stakeholders for Forest Law Enforcement, Governance and Trade (FLEGT)
(ii) enhancing the individual and institutional capacities of officers responsible for forest resources
(iii) reviewing and instituting legal reforms that recognise the role of forest certification in enhancing FLEGT effectiveness
(iv) using certification bodies, civil society organisations and environmental NGOs to lobby government policymakers and decision-makers to support forest certification initiatives.

9.2.3 Sequencing the actions

Not all the necessary actions to boost forest bioeconomy can be implemented simultaneously, or it is not wise to seek to do so. Some can be implemented in the short term, some in the medium term and some structural reforms are possible only in the long term. Moreover, some short- and medium-term actions can be preconditions to implement some long-term actions successfully.

In Table 6 we have illustrated several actions for boosting the forest bioeconomy and their sequence. The "sprints" are measures that can be implementable within 1–12 months at no or small fiscal costs, given political will. The "medium-distance run" actions are typically implementable in one to three years. They require more planning, time to reach political agreement and funding. The "marathons" are long-term structural measures that can be initiated and put on a firm footing only in three to ten years' time, or they require preparatory actions in the short-and medium-term to be implemented successfully.

It is not enough to launch actions, they also need effective implementation. Too many actions could devalue each other, if not enough resources and efforts can be allocated to all. Therefore, a select number of actions probably need to be categorised as high priority. Moreover, the authorities should develop institutional arrangements that promote accountability, coordination and focus on improving results in a limited number of priority areas.

Table 6. Examples of key actions to foster forest bioeconomy. Table compiled by Lauri Hetemäki.

Time horizon	Actions
Sprint **0–12 months**	• Start to work on a dedicated forest bioeconomy strategy. • Establish a government taskforce and value chain networks for forest bioeconomy. • Formulate a science-based narrative on how the forest bioeconomy can help society to achieve SDGs. • Start a communication campaign and regional dissemination about forest bioeconomy opportunities, including as an alternative to wood energy.
Medium-distance run **1–3 years**	• Implement measures to reduce fuelwood (energy) use and emissions by providing more efficient technologies. • Eliminate petrol subsidies and introduce new GHG regulations, in a way that helps to protect the poor who could suffer from these. • Establish new forest plantations that also take into account biodiversity needs and potential land-use trade-offs. • Build regulation and institutions to boost circularity in the forest bioeconomy. • Make roundwood exports more costly (eg tariffs). • Invest in forest bioeconomy RD&I and education. • Attract capital to forest bioeconomy value chains. • Enable an increase in small- and medium-scale forest bioeconomy companies. • Start pilot-scale forest biorefineries. • Provide up-to-date sustainable forest management and harvesting education and extension.
Marathon **3–10 years**	• Implement measures to reduce fuelwood (energy) use by providing more opportunities to use other energy forms (solar, wind, natural gas, building electricity grid, etc). • Start or increase the value-added wood products production (eg prefabricated CLT and LVL elements and modules). • Introduce green city planning and building regulations that help to increase wood use in cities. • Start building larger scale forest biorefinery plants.

Introduce a dedicated forest bioeconomy strategy

The International Advisory Council on Global Bioeconomy (IACGB) provides an overview and synthesis of global bioeconomy strategies. In 2020, almost 60 countries around the world were pursuing bioeconomy-related policies and, of these, 19 had dedicated national and macro-regional bioeconomy policies and strategies. The first, and still only, national-level dedicated bioeconomy strategy in Africa is the South African one from 2013. However, at the regional level, the East African bioeconomy strategy in 2022 was launched (East African Community 2022). Of the AF5 countries, Kenya and Tanzania are participating countries in this strategy (others are Burundi, Rwanda, South Sudan and Uganda).

The East African bioeconomy strategy aims at the sustainable use of bio-resources and is a strategic driver for the transformation of bio-based sectors for sustainable economic growth and development. The overall objective of the strategy is to "achieve economic growth and job creation, making use of the region's bio-resources to develop products and services, while contributing to an improved environment and climate change mitigation." The specific objectives are:

- regional and international collaboration sharing knowledge and building capacity
- promoting regional markets for bio-based trade
- a harmonised regional approach to create structures for innovation and deployment of technologies and knowhow for value addition to primary produce and biowaste
- development of *national* bioeconomy strategies and policy agendas in the region
- joint monitoring and information sharing of bioeconomy development.

A central feature of the strategy is that "scientific research, knowledge and innovation can be applied not only for the production of food, feed, fibre and fuel, but also to produce a wide range of agro-industrial and value-added products" based on local bioresources. The strategy seeks to enhance collaboration, for example by aligning policies promoting innovation and trade; harmonisation of regulations and standards for bio-based products; facilitating trade and economies of scale; collaborative capacity building in key areas of the bioeconomy, and increasing the attractiveness of the region for local and foreign investments to bio-based industries.

Although Kenya and Tanzania are part of the overall East African bioeconomy strategy, it would be beneficial to build on this regional strategy in the more focused national forest bioeconomy strategies in these countries. This would help to focus and tailor the needs and actions to national characteristics and capacities in Kenya and Tanzania. It would be also essential for Gabon and Nigeria to start to draft a national forest bioeconomy strategy. The drafting process for such national forest bioeconomy strategies would provide a starting point for creating the requisite narrative on bioeconomy and ensuring social inclusiveness while spelling out its main goals and objectives.

The importance of narrative and social inclusiveness

Once a forest bioeconomy strategy has been launched, it is important to disseminate and implement it. People need to absorb its objectives and understand the opportunities that the bioeconomy can generate. For this purpose, communicating the forest bioeconomy narrative is important. Narratives have been increasingly recognised as important in engaging society behind different movements and changes (Davidson 2016). There is a growing body of research in fields such as psychology, cognitive science, political science and sociology showing that people do not make decisions through a purely rational process, and that emotion and a range of cognitive biases are important. Narratives are central to the mental models and social beliefs and practices that guide individuals' decision-making and behaviour, and thus are important in bringing about change. In AF5 countries, in which the concept of forest bioeconomy and its objectives are unlikely to be widely known, the concept can provoke diverse views, and even negative ones. Therefore, for forest bioeconomy development to succeed, it is necessary to be able to tell an *evidence-based narrative* that is understandable and engages most of the people who are in one way or another part of the forest bioeconomy value chain, from the rural population working in forest management to city people building their houses and consuming various forest-based products.

According to Table A1, the urbanisation rate varies significantly in AF5 countries. In Gabon it is 90%, but in Kenya only 28%. On the other hand, Gabon and South Africa have a relatively strong forest products sector, whereas Kenya, Nigeria and Tanzania do not. Because of these and other differences, the narrative needs to be tailored to regional circumstances. However, it must appeal to both the rural and urban population and to current and future investors in bio-based forest products and industries, policymakers and non-governmental agencies. An evidence-based narrative about a forest-based bioeconomy should therefore be different things in different regions and cities, elaborating on the specific features that are important to these regions.

One necessary part of the narrative is also its *social inclusiveness*. It must generate new opportunities and incentives, not only challenges, to all those who are expected to be engaged with it. It is also important to provide guidance around how the forest bioeconomy can impact other needs for forests. For example, how to maximise synergies and minimise potential trade-offs between the forest bioeconomy and other forest ecosystem services. Finally, whatever the narrative, it is very important that it is fact (science) supported, otherwise it will most likely lose its credibility, and therefore power.

Medium-term measures

As discussed in Chapter 8, the **very high consumption of roundwood for energy purposes has several unwanted impacts**. One of these is that the wood used for energy purposes could at least partly be used for more value-added forest products. Although the quality of fuelwood may often be unsuitable for wood products (sawnwood, wood panels), it could potentially be used for biorefinery products,

such as chemicals. On the other hand, unsustainable fuelwood production also causes forest degradation and deforestation, which undermines the potential for forest bioeconomy development. Therefore, the actions to reduce fuel wood consumption discussed in Chapter 8 should also be part of the forest bioeconomy strategy and development.

For value-added development, it is also important that countries seek to **process the wood for more value-added products**, rather than exporting low value roundwood. In this respect, the example of Gabon has been promising (Chapter 3). In 2000, it exported 2.6 million m^3 roundwood and today almost none. However, exactly the reverse trend has taken place in South Africa. In 2021 it exported around 1 million m^3 roundwood, more than three times that of year 2000. For the value-added forest bioeconomy it would be important to reverse this trend. Looking at the similar roundwood export reducing measures launched by Gabon could help. In Kenya, Nigeria and Tanzania, roundwood exports were either marginal or relatively small in 2021. However, a forest bioeconomy offers the opportunity to increase the value of wood in these countries.

Given that biotechnology and innovation, especially from advanced life sciences, lies at the heart of bioeconomy, synergies with general **research and innovation policy** have a crucial role. This requires enhancing the following aspects: skilled workforce, R&D investment, stable business environment, strong system of knowledge creation and diffusion, policy encouraging entrepreneurial activities and focus on governance and implementation. Education, public support for research and development, and creating bioeconomy technology clusters to support bioeconomy development.

Sustainable forest management can be regarded as the basis of forest economy. Given that deforestation has continued in all the AF5 countries in the past decade, especially in Nigeria, South Africa and Tanzania, improving forest management is a key objective. In all AF5 countries forest bioeconomy is likely to be based heavily on existing and new forest plantations. Therefore, paying attention to the sustainability of these plantations is essential, as discussed above. Improving forest management requires capacity building, especially in education and extension services. New investment in these should already be taking place in the medium term to provide a sustainable resource base for forest bioeconomy investments in the long run.

A circular economy, as defined by the Ellen MacArthur Foundation, is "one that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles".[19] A circular forest bioeconomy aims to design forest products for a cycle of disassembly and reuse and, through that, increase resource efficiency. On the other hand, a forest bioeconomy offers the possibility of substituting fossil-based, non-renewable and non-biodegradable materials for renewable and biodegradable solutions. It can also offer new functions for bio-based materials, such as longer lifespan, higher endurance, less or no toxicity, etc, that circularity

19 https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

cannot alone offer. In summary, it makes sense and creates synergies to combine the two concepts: circular economy and forest bioeconomy (Hetemäki et al. 2017).

Bioeconomy and circular economy do not imply sustainability per se, they must be made sustainable. An integral part of creating synergies is to assess how biomass and biodegradable materials behave in the circular economy. For instance, how easy the reuse in production is and when recycling possibilities are exhausted. This implies that when new forest bioproducts are being planned, they should already be taking reusability and recycling needs into account at the design stage.

Bio-based materials can mitigate climate change and assure resource security compared to fossil-based options. They are often more regenerative and restorative and therefore better adapted to circular designs. In AF5 countries there is significant potential to increase the reuse of post-consumer wood and wood packing waste. Thus, the circular economy can help to make the forest bioeconomy more resource efficient and restorative in nature. In summary, circular economy and forest bioeconomy should be developed in parallel and combined.

Long-term measures

Implementing structural changes to advance forest bioeconomy may typically take three to ten years. These could include measures such as changing energy infrastructure to help to reduce fuel wood consumption; investing and building new engineered wood products mills or forest biorefineries; and introducing new city planning regulations to boost wood construction.

To reduce fuel wood consumption, both upgrading technologies for producing and using wood energy (such as new stoves, small- to medium-scale heat plants) and moving to alternative energy forms (for example, solar panels, windmills) are needed. The latter will also require building electricity grids and off-grid systems, especially in rural and underserved urban areas. All these require investment, human and equipment capacity building, policy regulations, etc, which take many years to implement. Similarly, **the new engineered wood mills (CLT, LVL) and forest biorefineries** most likely require importing knowhow, capital, multi-actor cooperation and supporting policies that are likely to take three to ten years to be implemented. Forest bioeconomy strategy should help to boost all these.

Given the very high urbanisation expectations in many of the AF5 countries, there will inevitably be large construction needs in the cities. **Cities are also key infrastructures where there is a need to advance climate mitigation measures and SDGs**. Globally, the construction and building sector was responsible for around 37% of energy and process-related CO2 emissions in 2021 (UN Environment Programme 2022). Thus, replacing fossils in the sector is critical for reducing overall emissions. For this to happen, the sector must improve building energy performance, decrease building materials' carbon footprint, and introduce policy and investment commitments for more resource-efficient low-carbon buildings. Wood construction will play a key part in helping to achieve these goals. In Europe, for

this purpose, initiatives such as the New Bauhaus Europe[20] and Charter for the City and the Earth has been launched.[21] They seek to engage scientists, architects, spatial planners and policymakers to build more sustainable urban areas, for which wood and forests are seen as a key pillar. In Africa, one example of similar type of approach is evidenced by the Green City Kigali project in Rwanda.[22] One key objective of this project is "to serve as a model for sustainable urban development linking affordable housing with climate change adaptation and mitigation measures". It is important that the AF5 countries launch similar initiatives as part of forest bioeconomy or other strategies.

9.3 Conclusions and policy implications

The role we see for the circular forest bioeconomy in the AF5 context is to help in achieving several economic, environmental and societal goals. These include reducing CO_2 emissions, adapting to climate change, minimising the use of fossil resources, developing urban and rural areas, creating new products, markets and job opportunities, as well as developing a more sustainable economy across all possible dimensions. This report has argued that the circular forest bioeconomy will be a key strategy and tool to help achieve these objectives. In this report we have drawn attention to a limited number of key issues, mainly at the strategic level only. Other, more detailed, studies and work are necessary to supplement and support the current report.

It is important to bear in mind that forest bioeconomy is not an entity outside society. Therefore, its advancement depends on how well the country is governed in general. In this respect, especially in Nigeria, there is a need to improve governance to pave the way for a flourishing forest bioeconomy, and President Bola Tinubu, who assumed office in May 2023, will be a key player. However, good governance needs to reach the whole society and requires actions at many levels of society, which is also the case in the other four AF5 countries.

One of the first steps to advance forest bioeconomy in AF5 countries is to draft a strategy for it. The strategy should set beacons that let each country navigate to more sustainable forest sectors and societies in general. It would advance the general knowledge about the forest bioeconomy, its potential and its advancement in AF5. The forest bioeconomy strategy needs to focus on the most important issues and find tools to advance these. It should not provide an endless list of suggestions. If it is a commitment to everything and everybody, it is not a strategy. Thus, it needs to have a set of a limited number of priority targets – and tools to achieve these. The action plans and other supporting documents can go into more detail. It is also important to build on sequences of actions, which take place in the short-, medium- and long-run.

20 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2141
21 https://efi.int/sites/default/files/files/news/2022/Charte_ENG.pdf
22 https://greencitykigali.org/

To implement the forest bioeconomy strategy, one also needs an action plan. The government or key ministers need to commit themselves to the strategy for it to gain priority. A system to monitor the progress made towards meeting the strategy targets is also necessary.

Circular bioeconomy strategies should not take sustainability as given but address it explicitly. The impacts depend very much on how the bioeconomy development will be advanced and monitored (Hetemäki et al. 2017). The objective should be to maximise the synergies and minimise the trade-offs between bioeconomy, biodiversity and climate mitigation. *Circular bioeconomy can help to support biodiversity and climate mitigation, and biodiversity and climate mitigation are necessary for successful circular bioeconomy.*

More generally, there can be synergies between economic growth and improvement in the state of natural capital. As Helm (2016) argues, "de-growth or zero growth has two major defects: it is not necessarily desirable; and it is never going to happen." Consequently, the *pace* of growth is not the problem, but rather the *quality* of growth. It requires the advancement of truly sustainable economic growth, and not the type of unsustainable growth often seen in the past. In this, one essential requirement is that renewable resources are not used to the extent that they can no longer reproduce themselves, ie they become non-renewable. There are, of course, many other requirements for environmentally sustainable growth, and a forest bioeconomy strategy should address the policies needed to advance these.

In the Gabon and Nigerian context, linked to this is the need to *stop subsidising fossil fuel production*. In this respect, it is promising that Nigeria's new President Bola Tinubu decided to abolish fuel subsidies.[23] IMF economists have estimated the true costs of fossil fuel subsidies (Coady et al. 2017), which are understood to include not only the direct subsidy costs but also the indirect environmental costs such as global warming and deaths from air pollution, amount to 6.5% of global GDP in 2013. The key point is that policymakers and the public need to be aware of the true costs of fossil fuel subsidies that arise from pricing fossil fuels below their true social costs.

Research, development and innovation (RD&I) need to increase to strengthen the foundations of the circular forest bioeconomy. For this, there are also international funding arrangements available, which the AF5 countries should target. Funding needs to increase across the innovation network, for example, basic research, applied research, education (a curriculum better suited for circular forest bioeconomy studies), and for piloting new products and services. In addition, there needs to be platforms bridging science knowledge to policymaking and actions. In a research context, funding is not only required for biotechnology, engineering and chemistry sciences, but also, increasingly, for social and environmental sciences, and social sustainability research.

23 https://edition.cnn.com/2023/06/01/energy/nigeria-ends-fuel-subsidy-intl-lgs/index.html

It is evident that circular forest bioeconomy, and therefore the strategy for it, has links to many policies in different areas. For example, to all natural resource related policies, innovation policies, R&D policies, growth policies, etc. It is not fruitful to list all these policies in more detail, rather the key point is that circular bioeconomy needs to be mainstreamed and coordinated to a large number, if not all, of these policies, one way or another. Therefore, the actions needed involve innovating at a systems level, not just improving the performance of the components of that system or a sector.

Bioeconomy also needs to be seen as a key strategy for cities and urban areas, not only for rural areas, as has traditionally tended to be the case. This is also related to the societal acceptance and inclusiveness of bioeconomy. The circular bioeconomy will not succeed if the urban population do not see the relevance of it. To support societal engagement, a fact-based *circular bioeconomy narrative* and its efficient communication is needed.

Key messages

- Circular forest bioeconomy strategy will be a key tool to help achieve the Agenda 2030 SDGs and Paris Climate Agreement in AF5 countries.
- Forest bioeconomy is not a separate entity in AF5 societies. Thus, general good governance is also a precondition for a flourishing forest bioeconomy.
- Launching a dedicated national bioeconomy strategy is an essential tool for forest bioeconomy development, and AF5 countries should start to draft such a strategy.
- Circular bioeconomy can help to support biodiversity and climate mitigation, and biodiversity and climate mitigation considerations are necessary for successful forest bioeconomy.
- There is an immediate need to stop subsidising fossil fuel production in those AF5 countries in which such subsidies are in place. This not only provides funding opportunities for forest bioeconomy (and other societal needs), but drives the demand for non-fossil solutions, such as forest bioeconomy.
- Investment in research, development and innovation need to increase to strengthen the foundations for a circular bioeconomy.
- Bioeconomy needs to be seen as a key strategy for cities and urban areas as well, rather than only for rural areas, as traditionally has tended to be the case. To support societal engagement, an evidence-based *circular forest bioeconomy narrative* and its efficient communication is needed.

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Appendices

Table A1. Societal, economic and forest sector indicators for AF5. Data sources: FAOSTAT, IMF, The Observatory of Economic Complexity; UN Pop, WIPO; World Bank. Table compiled by Lauri Hetemäki.

	Gabon	Kenya	Nigeria	South Africa	Tanzania
1. Population, millions	2.2	53.8	206.1	59.3	59.7
2. Population projection for 2040, millions *(UN, medium variant)*	3.3	79.5	329.1	71.4	102.6
3. Rural population, % of total	9.9	72	48	32.6	64.8
4. Human Development Index, 2019 *(0.957 highest, 0.394 lowest)*	0.703	0.601	0.539	0.709	0.529
5. GDP per capita, constant prices, PPP; 2017 international $	15 950	5 054	5 185	13 289	2 925
6. Gini index, World Bank[1] *(0 perfect equality, 100 perfect inequality)*	38	40.8	35.1	63	40.5
7. Economic Complexity Index (ECI) (Japan is best with rank 1 in 2020)	122	80	125	54	86
8. Global Innovation Index (GII) WIPO for 2022 (max 100, best Switzerland 64.6)		22.7	16.9	29.8	19.4
9. Ease of doing business rank, 1 = most business-friendly regulations*	169	56	131	84	141
10. Dedicated bioeconomy strategy	No	Regional, 2022[n]	No	Yes 2013	Regional, 2022[n]
11. Agrisector value added, % of GDP	6.7	23	24.1	2.5	26.7
12. Renewable energy consumption, % of total final energy consumption**	89.9	72.3	79.7	10.3	83.7
13. CO_2 emissions, tons per capita**	2.2	0.3	0.7	7.5	0.2
14. Global Climate Risk Index. CRI score for 2019, rank***	118	33	70	32.5	66.5
15. Forest area, 1000 ha *(change from 2010, %)*	23531 *(-0.5)*	3611 *(-0.1)*	21627 (-7.0)	17050 *(-2.1)*	45745 *(-8.4)*
16. Forest area, % of total land area	91.4	6.3	23.9	14.1	52.2

	Gabon	Kenya	Nigeria	South Africa	Tanzania
17. Planted forests, 1000 hectares	30.0	152.8	217.9	3143.6	553.0
18. Forest area under certification scheme, 1000 hectares	2061.2	0	0	1427.2	227.7
19. Proportion of forest area under a long-term management plan, %	50.9	4.3	10.9	-	4.4
20. Proportion forest area within legally established protected areas, %	14.4	33.4	12.9	1.3	59.3
21. Roundwood production, mil. m^3	4.0	25.9	76.9	28.5	28.1
22. Fuel wood production, mil. m^3 *(% of total roundwood)*	1.1 *(27.5)*	24.9 *(96.1)*	66.9 *(87.0)*	12.2 *(42.8)*	25.3 *(90.0)*
23. Industrial roundwood production, mil.m^3	2.9	1.0	10.0	16.2	2.8
24. Sawnwood production, mil. m^3	0.8	0.3	2.0	2.2	0.07
25. Sawnwood consumption, mil. m^3	0.1	0.3	1.96	2.1	0.04
26. Wood panels production, mil. m^3	0.0.5	0.08	0.1	1.5	0.03
27. Wood panels consumption, mil. m^3	0.01	0.2	0.7	1.5	0.05
28. Paper and paperboard production, 1000 tonnes	0	0	19.0	1801.0	40.0
29. Paper and paperboard consumption, 1000 tonnes	1.9	302.7	298.8	1907.7	80.5
30. Forest products export. value, mil. US$	578.0	23.2	104.2	1427.6	54.0
31. Forest products net-exports, value in mil. USD	572.0	-307.1	-375.0	596.0	-18.7

[1] The Gini Index is reported from different countries in different years between 2010-2018.

* 2019;

** 2018;

*** source Eckstein et al. (2021). Note that many studies (used also by this report) provide forest sector statistics that differ from that of FAO, for example for plantations and roundwood production. However, for consistency, we use only FAO statistics in this table.

[n] Kenya and Tanzania are part of the seven country East Africa Bioeconomy Strategy.

Table A2. Forest products exports from AF5 countries in 2020. Data source: FAOSTAT, table compiled by Lauri Hetemäki.

Product	Value (1000 USD) Shares from all forest products (%) in parenthesis				
	Gabon	**Kenya**	**Nigeria**	**South Africa**	**Tanzania**
Industrial roundwood	994 (2.5)	2 190 (8.3)	40 912 (66.4)	42 145 (6.7)	3 782 (7.2)
Wood chips and particles	6 (0.00)	15 (0.04)	1 893 (3.1)	128 954 (20.6)	80 (1.5)
Sawnwood	360 306 (91.9)	1 965 (7.5)	17 471 (28.4)	25 766 (4.1)	18 193 (34.6)
Wood panels	28 560 (7.3)	3 469 (13.2)	16 (0.03)	59 953 (9.6)	3 880 (7.4)
Fibreboard	89 (0.02)	3374 (12.8)	2 (0.0)	11 677 (1.9)	344 (6.5)
Paper and paperboard	2 134 (0.5)	15 299 (58.1)	1 291 (2.1)	356 567 (57.0)	26 366 (50.1)
TOTAL	392 089	26 312	61 585	625 062	52 645

The Circular Bioeconomy Alliance initiative was established in 2020 by His Majesty King Charles III, when Prince of Wales. The CBA provides funding, expertise, and know how to facilitate projects designed to accelerate the transition to a circular bioeconomy that is climate neutral, inclusive and prospers in harmony with nature.

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