How Could Logging Policies and Practices Influence the Future of the Congo Basin Biodiversity and Ecosystems?

Lee White, Ghislain Moussavou, David Ingueza, Le Bienfaiteur Sagang, Jean-Louis Doucet, and Kumar Mohan

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L. White (✉)
University of Stirling, School of Natural Sciences, Stirling, UK and Institut de Récherche en Ecologie Tropicale, Libreville, Gabon
e-mail: l.j.white@stir.ac.uk

G. Moussavou
Institut de Récherche en Ecologie Tropicale, Libreville, Gabon
e-mail: gmoussavou@gmail.com

D. Ingueza
Ministère des Eaux et Forêts, de l'Environnement, du Climat, Chargé du Conflit Homme-Faune, Libreville, Gabon
e-mail: inguezadavid@yahoo.fr

L. B. Sagang
C-TREES, Pasadena, CA, USA
e-mail: lbsagang@ctrees.org

J.-L. Doucet
Gembloux Agro-Bio Tech / Université de Liège, Passage des Déportés, Gembloux, Belgium
e-mail: jldoucet@uliege.be

K. Mohan
Africa Mining and Metals Group, JBC2, Cluster V, JLT, Dubai, UAE
e-mail: kumar.mohan@a2mp.com

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Abstract

The Congo Basin forests are currently undervalued. Economic and social returns from forestry and timber processing are relatively low compared to some nations outside Africa. Furthermore, the ecosystem services provided by the forests, such as the net absorption and storage of atmospheric carbon, continue to be considered by the international community as a free commodity. We propose an economic model involving maximizing the proportion of third-level timber processing and planting new forests that can increase forest economies and job creation by an order of magnitude. We argue that only by making forests valuable to the people and nations of the Congo Basin will we be able to avoid the large-scale deforestation that has occurred in West Africa and in other tropical forest regions, where the economic and social benefits of conversion were higher than those linked to preservation and sustainable harvest. We discuss knowledge gaps that need to be filled, possible technological solutions and policy reforms, and fiscal incentives needed to implement our model across the Congo Basin.

Keywords

Sustainable forestry · Timber processing · Economic model · Corruption · Fiscal incentive

Introduction

Ebony (*Diospyros crassiflora*), rubber (*Funtumia elastica*), and "redwood" (*Pterocarpus soyauxii*—whose powdered wood was used to make a red pigment) were among the earliest products traded out of the west coast of the Congo Basin, starting in the fifteenth and sixteenth centuries, along with ivory. It is testament to the rapacious nature of this commerce that very few ebony trees exist in Gabon, even today. The first export of logs from French Equatorial Africa was in 1889, when okoumé trees (*Aucoumea klaineana*) were exported from Libreville to Berlin. Due to okoumé wood's excellent suitability for making plywood (today it constitutes the world's best quality marine plywood), it was soon the subject of a thriving trade from coastal Gabon and Congo to France, Germany, and other European nations.

The economic model during the colonial period was to extract raw timber as logs, to be shipped to Europe for processing. Upwards of 90% of the economic value and jobs (see below) were thereby realized off the African continent, a model repeated in other sectors and that has seen the rest of the world develop on the back of cheap raw materials extracted from Africa. Today this model continues in all Congo Basin countries other than Gabon, which banned export of unprocessed timber in 2010, by decision of the Conseil des Ministres confirmed by order n°008/PR/2010 of the President of the Republic signed on February 25, 2010. Both Cameroon and Republic of Congo have announced similar bans, but they are yet to come into full effect.

Today Malaysia, with just over 18 million ha of forest area, has an annual forest and timber processing economy of just over $6.5 billion and wood exports of $4.8 billion. The value of timber exports in Cameroon (20 million ha of forest), Republic of Congo (22 million ha), and DRC (152 million ha) are currently about $440 million, $380 million, and $140 million, respectively, or between 10% to 0.5% of their potential value, based on the Malaysian model. In Gabon (almost 24 million ha), the value of timber exports has increased steadily from less than $200 million, since the government made in-country wood processing compulsory before export in 2010, reaching $1 billion in 2022. The huge gap in the value of forestry and timber processing between Malaysia (despite its smaller forest area) and the Congo Basin countries is a result of the following: (1) biologically Malaysian "Dipterocarp" forests have higher volumes of commercial species, resulting in larger per hectare harvest intensity and profitability (but perhaps lower sustainability); (2) its highly developed wood processing industry; (3) its development of extensive plantation forests; and (4) Malaysia supplementing its timber production through imports, including large quantities of logs from the Congo Basin. Malaysia also has tenfold more jobs in its forestry and timber sectors than the Congo Basin countries.

Looking to West Africa, industrial forestry operations in Nigeria, Ghana, and Côte d'Ivoire were a precursor to extensive deforestation by subsistence slash and burn and small-scale cocoa farmers. Many of the foresters who had been active in the forestry industry in Ivory Coast moved to Gabon and Congo in the 1980s, and for a while, it seemed likely that the same pattern would repeat itself, until these countries strengthened forestry legislation and forest conservation policies in the 1990s and 2000s, made easier by their relatively lower human population density. This has resulted in sustained low deforestation rates, although it is currently uncertain if this can be maintained in the face of growing competition for land. Deforestation rates in the more highly populated Cameroon and DRC are much higher and are currently increasing rapidly. As populations increase across the region, forestry can only hope to continue to cover large areas if it is sufficiently profitable to compete with other possible land uses and creates sufficient jobs to be socially viable.

For the Congo Basin's forests to remain standing into the next century and continue to supply the critical ecosystem services they provide to the Congo Basin and the world at large, they need to be more valuable alive than dead. For a while there was an expectation that the UNFCCC REDD+ process, agreed under Article 5 of the Paris agreement, would provide a strong mechanism to contribute to this. However, this process has largely failed; just $36.9 million of results-based

payments ($17.4 million under a bilateral agreement between Gabon and Norway and $19.5 million to DRC through the World Bank's Forest Carbon Partnership Facility for the Mai-Ndombe province) have been dispersed to the region since REDD+ was agreed in Paris in 2015. With payments averaging $5/ton of CO_2e, this will barely cover the protection and management costs to the Congo Basin governments.

With young, rapidly growing populations and weak economies, Congo basin nations need forests to contribute in a meaningful way to sustainable development and GDP. Unfortunately, typically representing less than 5% of GDP, forests are currently underperforming in terms of direct economic benefits, while covering at least 50% and up to 88% of land in each country, with over 100 million people directly living there and depending on forest resources at large. If this is to change, then either mechanisms to effectively integrate the ecosystem services the forests provide onto the balance sheet of the Congo basin countries need to become effective or the forest economies need to increase in order to provide an economic incentive to preserve the forests. It is difficult to envisage that the Congo Basin will avoid the large-scale deforestation that has been experienced in West Africa, the Amazon, and SE Asia through agriculture if forestry revenues and jobs are not competitive with other land uses.

In this chapter we will assess the potential of forests to sustainably contribute in a more meaningful manner to economies and job creation in the Congo Basin countries, examining the co-benefits this would provide in terms of climate change mitigation and biodiversity, as well as the threats that might derail the best laid plans. We use the economic experiment undertaken by Gabon when the decision was made to ban the export of unprocessed timber as an alternative to the business as usual scenario in which the Congo Basin countries continue to export unprocessed logs, which almost inevitably will lead to the Côte d'Ivoire or Ghanaian pattern of forest loss.

The Economic Potential of the Forestry and Timber Processing Industries in the Congo Basin

The striking difference in the forest and timber economies of the Congo Basin countries and Malaysia offers an indication of the potential economic and social gains that could be achieved through intensifying and increasing the sophistication of timber processing in the Congo Basin. Based on real costs and benefits of investment in forestry and different forms of timber processing from experience with companies owned and operated by the Gabon Special Economic Zone (GSEZ), a public-private partnership with the Government of Gabon owning 40% of the company, the authors constructed an economic model of the implications of shifting from a forest economy based on log export to third-level processing based on predicted costs and production (Table 1). This model was used by GSEZ to make investment decisions in Gabon and is therefore a real-world example tested by the private sector, although not all operators may agree the assumptions are realistic.

Table 1 Economics of a forest exploitation company

Area (ha)	100,000
Annual cut (ha)	5000
Average yield (m^3/ha)	8
Annual production (m^3)	40,00
Production cost (cost of road building, felling, extraction, etc. averaged/m^3 ($USD)	$60
Average sales price (m^3) *N.B. price will be higher in FSC certified concessions.* *This is the price at the forest park. This price can range upto $180/200 USD if the quality of logs is good and fresh.*	$90
Capital expenditure. *Management Plan, Bulls, Excavator, Trucks, Pickup, Camp* etc.	$6,000,000
Jobs created	150
Profits (before tax). *Assuming sale of 70% for peeling and 30% to sawmills near the concession.*	$1.200,000
Tax on profits (20%)	$240,000
Salaries and contributions	$1,260,000
Other costs *Of "other costs", only 30% is spent in Gabon, the rest is on equipment purchased outside Gabon and therefore only 30% contributes directly to the Gabonese economy*	$1,140,000
Return on investment	7.7 years

Table 2 Economics of a timber transport company

Average transport price (per m^3)	$50
Average transport cost (per m^3)	$41
Capital expenditure *Estimate = 7 trucks*	$1,330,000
Jobs created	28
Profits	$360,000
Taxation	$108,000
Salaries and contributions	$504,000
Other costs. *Of "other costs" only 30% in Gabon and contributing to the local economy*	$1,137,000
Return on investment	5.7 years

The model runs from an average concession covering 100.000 ha, based on a 20-year sustainable management plan, exploiting approximately 2 trees/ha/rotation above 70 cm dbh and using a conservative figure for the average timber per tree. Numbers are converted from Central African francs at a rate of 500 FCFA: 1$ for ease of calculation. Many permits in Central Africa use a rotation of up to 30 years, but would expect to harvest more cubic meters per hectare than in our model.

The forests potential, harvesting rules, stakeholders, and costs in other Congo Basin countries are sufficiently similar that it should be possible to construct similar models for each country, although the rotation period, average yield per hectare, cost

of wages, transport, and capital investment costs, would need to be adjusted for each country. Sale prices on the international timber markets are notoriously fickle and can vary significantly from 1 year to another, potentially making our model unrealistic during periods of downturn.

Table 3 Economics of a first transformation company—veneer

Plant capacity (m^3)	40,000
Capital expenditure *30% invested in country, 70% outside*	$6,000,000
Average cost of logs (per m^3)	$150
Average production efficiency	50%
Total production (m^3)	20,000
Total waste (m^3) *This is a big asset loss to the country, which could be recovered.*	20,000
Total Ex Factory cost	$470
Handling costs (per m^3)	$67.5
Av. Sales price (per m^3)	$588
Profitability (per m^3)	$50
Jobs created	400
Taxes	$287,850
Salaries and contributions	$3,840,000
Other costs *Of "other costs" only 30% in Gabon and contributing to the local economy*	$6,910,000
Benefit to owner	$1,010,000
Return on investment	6.25 years

Table 4 Economics of a first transformation company—sawn wood

Plant capacity (m^3)	40,000
Capital expenditure *30% invested in country, 70% outside*	$4 million
Average cost of logs (per m^3)	$120
Average production efficiency	45%
Total production (m^3)	18,000
Total waste (m^3) *This is a big asset loss to the country, which could be recovered.*	22,000
Total Ex Factory cost	$317
Handling costs (per m^3)	$67.5
Av. Sales price (per m^3)	$420
Profitability (per m^3)	$36
Jobs created	200
Taxes	$183,825
Salaries and contributions	$1,440,000
Other costs *Of "other costs" only 30% in Gabon and contributing to the local economy*	$5,474,000
Benefit to owner	$612,750
Return on investment	6.5 years

The economics of a forestry operation in a concession covering 100,000 ha are presented in Tables 1 and 2:

In Gabon all timber has to undergo at least first level processing, into veneer or sawn timber (Tables 3 and 4):

In these two cases, if we add all the taxes due to government, including the surface area tax and the export tax, if these products are exported at this stage, the Gabonese government receives a total of $11.3 and $9.2/ha in taxes and the economy as a whole receives a total of $135/ha and $85/ha from veneer production and sawn wood production, respectively.

Were the logs to be exported unprocessed, if we apply current taxes, the government would receive about $8.4/ha in total revenues and the economy would benefit to the tune of only $47/ha, or 30–50% of the revenues to be made from keeping first transformation in the country.

Moving to a second transformation and at the same time investing in recovering some of the waste wood from the first transformation (focusing on plywood for simplicity—results from sawn wood show the same tendency but are slightly lower), the numbers look like this (Table 5):

This results in an additional revenue of $3.3/ha for the government and a further $102/ha injected into the economy. Finally, if there is investment in third transformation factories to transform the plywood/sawn timber into furniture, the numbers are as follows (Table 6):

In this case the Gabonese government receives a further $8.1/ha and an additional $206.3/ha is added to the economy.

Table 5 Economics of a second transformation company

Plant capacity (m^3)	20,000
Recovery of waste	8000
Total output:	28,000
Capital expenditure *30% invested in country, 70% outside*	$6 million
Average cost of veneer (per m^3)	$240
Average production efficiency	80%
Total production (m^3)	22,400
Total Ex Factory cost (m^3)	$470
Handling costs (m^3)	$67.5
Av. Sales price (m^3)	$588
Profitability (per m^3)	$50.5
Jobs created	600
Taxes	$441,000
Salaries and contributions	$5,760,000
Other costs *Of "other costs" only 30% in Gabon and contributing to the local economy*	$6,280,000 (only 30% in Gabon)
Benefit to owner	$1,075,000
Return on investment	5.6 years

Table 6 Economics of a third transformation company, furniture

Plant capacity (m^3)	22,400
Capital expenditure *30% invested in country, 70% outside*	$12 million
Average production efficiency	90%
Total export (m^3)	20,160
Average cost of veneer (per m^3)	$520
Total production (m^3)	22,400
Total Ex Factory cost	$920
Handling costs (m^3)	$67.5
Average Sales price (m^3)	$1600
Profitability (per m^3)	$610
Jobs created	1000
Av taxes	$3,690,960
Salaries and contributions	$9,600,000
Other costs *Of "other costs" only 30% in Gabon and contributing to the local economy*	$12,303,200
Benefit to owner	$11,688,040
Return on investment	1.03 years

Table 7 Projected government revenues, GDP contributions, and direct job creation if all of Gabon's timber concessions are harvested sustainably and timber undergoes first-, second-, or third-level transformation

	Gvt. revenues	GDP contribution	Direct Jobs[a]
Log exports	$126 million	$705 million	26,700
1st Transformation	$165.5 million	$2025 million	86,700
2nd Transformation	$215 million	$3555 million	176,700
3rd Transformation	$336.5 million	$6650million[b]	326,700

[a]There will be at least as many indirect jobs created

[b]In 2023 Gabon's oil sector contributed $7.7 billion, representing 40% of GDP. The exact number of jobs in the oil sector is not clearly defined in the available official sources but it is thought to be well below 10,000

In summary, taking the plywood model, assuming 15 million hectares of active concessions in Gabon (there are just over 16 million ha allocated but not all are currently active), theoretical government revenues, GDP contribution, and jobs created are presented in Table 7.

These figures can be further improved by investing in industries that use waste from first level transformation, such as the production of activated charcoal, biochar or particle board, or at the very least the use of waste biomass in wood dryers and for electricity generation or to make charcoal. Wood waste should also be used to support and develop a more efficient local cottage industry led by smallholders and communities to generate more added value in terms of yield, employment, and income through mentoring mechanisms involving large companies and the government.

Table 8 Plantation establishment and production costs and profitability

Planted area (ha)	100,000
Annual rotation	6 years
Annual area harvested (ha)	16,667
Average Yield / ha/rotation (m^3) *= 50 times natural forest—this is an ambitious but conservative figure, based on yields achieved in Brazil and India, that can reach 500m^3 using new clones* (de Assis et al. 2004; Dhiman and Gandhi 2022) *and similar yields obtained in Kenya* (e.g., Oeba et al. 2009). *The decision by GSEZ to invest in plantations in Gabon was taken based on a projected yield of 330m^3/rotation, confirmed by experimental plantings*	300
Average production (m^3) *(from year 7 onwards)*	5000,000
Average Production cost:	$30
Average Sale price:	$44
Profitability/m^3:	$14
Annual profits from year 7:	$70,000,000
Investment in forest:	$360,000,000
Jobs created:	12,000
Average Taxation from year 7:	$14,000,000
Salaries and contributions	$100,800,000
Other costs *Of "other costs" only 30% in Gabon and contributing to the local economy*	$99,200,000
Benefit to owner *(from year 7 onwards)*	$56,000,000
Return on investment (interest rates on loans will influence the return time)	c.15 years

Learning from Malaysia, if Gabon was to also plant 100,000 ha of plantations of fast growing trees (e.g., *Eucalyptus* spp, *Acacia* spp), production figures, investment, and revenues would look something like this (Table 8):

One investment (or a series of smaller investments) in 100,000 ha of plantations would almost double the sustainable wood harvest in Gabon from 6 million to 11 million m^3/yr. While the plantation wood would be made into lower-quality (value) products, it would still result in comparable profits and job numbers and would potentially allow more stringent sustainability rules and lower harvest intensity to be implemented in natural forests. Plantations of native species would be up to five times less productive and take longer to mature, making them a lot less profitable (De Wasseige et al. 2014; Chapter ▶ "Agriculture, Ecosystem Functions and Services in the Congo Basin") although Doucet et al. (2016) suggest that Ayous may be an exception. They would however be more ecologically valuable and climatically resilient. Before taking the decision to invest massively in plantations of exotic species, a clear understanding of the value of lost ecosystem services and the potential costs is necessary. Typically non-native fast-growing plantation trees can be very ecologically damaging and use large quantities of water. Some species also become invasive, which may entail control costs in future years, but

A. auriculiformis, for example, is not invasive in Africa, indicating that species choice is critical. Given the comparatively low productivity of plantations of native species, their economic viability is considered low given the cost of borrowing in the region (e.g., ONFI 2005). Such investments may only be viable if the negative costs of exotics are factored in through taxes, or the carbon and biodiversity benefits of natural plantations are realized through carbon and biodiversity credits, which is not currently the case.

The figures emerging from this model are consistent with the statement in ANRC (2021) that "adding value to primary processed products before export could generate additional margins of between 350% and 1000% and a multiple of 4-12 times more jobs." However, comparing the modelled economic impacts of forestry with those currently achieved by the Congo Basin countries (see above and Chapter ▶ "Pastoralism: Access to Land and Ecosystem Functions and Services in the Congo Basin"), it is apparent that with the possible exception of Cameroon, Congo Basin countries are not currently seeing even the minimum projected revenues appearing on their balance sheets. For example, in 2023 the contribution of the forestry sector in Gabon to government revenues and GDP were estimated at $ 70 million and $ 642 million, respectively, a factor of 2–3 times less than predicted just for first-level transformation at optimal forest productivity.

In 2023, with production of round logs estimated at 3.58 million m^3, Gabon's projected forest economy with first-level transformation would have been c. $1.2 billion, yet the declared revenues were only around half that amount. Is the model overestimating the potential of forestry and timber processing to contribute to the economy, or are there factors that result in leakage? The 2019 report, Toxic Trade: Forest Crime in Gabon and the Republic of Congo and Contamination of the US Market (EIA 2019) documented many cases of serious fraud and illegal forestry activities, including almost systematic tax evasion through false declarations of profitability and corruption. For example, many companies investigated admitted to keeping two sets of accounting, one for government authorities demonstrating +/− 0% profits while in reality they were achieving profits of 30–40%, up to twofold higher than predicted by our model, through a combination of illegal activities, including overharvesting, stealing wood either from outside authorized areas inside their concession or outside their concessions, or underreporting harvest volumes and mis-reporting species harvested, including unauthorized species, in favor of less valuable timber both in harvest logs, transportation, processing, and export paperwork. In addition, there are inefficiencies in revenue billing by Ministry of Economy staff and in labeling of certain in-country spending as being related to the forestry sector.

This under-declaration is confirmed by the doubling of the annual timber production figures between 2019 and 2022, when the forestry ministry tightened up reporting significantly, going from less than 2000,000 m^3 in 2019 to more than 4,000,000 m^3 in 2022. Considering this period corresponds to the decrease in economic activities during the COVID-19 pandemic, the recorded doubling of annual harvested logs was due to improved law enforcement and statistics, rather than a growth of logging activities.

All told, it seems highly likely that our numbers, based on commercial activity by GSEZ companies in Gabon, are relatively close to reality and that a mix of government inefficiency and corruption, as well as active tax evasion by some companies, is the cause in the gap between our model and reality on the ground.

This model, based on today's costs and prices, demonstrates clearly (1) that the forestry and timber processing sectors have the potential both to make a significant (>30%) contribution to GDP across the Congo Basin and to grow to be the major employer, a critical consideration for nations where over 50% of the population are less than 18 years old and unemployment is already in double digits and where significant of populations live in forest and directly depend on forest resources (Chapter ▶ "Central African Rainforest Archaeology"). Indeed, Gabon's national vision for the development of the sector, adopted in Cabinet in 2022, aimed to achieve full third-level transformation by 2030 based on this model (MINEF 2021).

The next question is to ask whether there is sufficient affordable capital and interested investors to lead the transition to third-level processing and whether the Congo Basin governments see this as a priority. When Gabon announced its ban on the export of unprocessed timber it was not met with applause in the halls of power in Europe and Asia and all Congo basin countries kept doubting and hesitating, waiting to see the results in Gabon before considering following suit. The biggest challenge for the Gabonese government trying to attract investment was not a lack of interested parties (60 companies invested in timber mills in the Special Economic Zone after the log export ban): but rather the lack of affordable financing from commercial banks and multi-lateral institutions.

If we consider retrofitting our model to investigate how Congo Basin countries' economies might have benefitted from retaining the transformation of their resources from the moment of their Independence in 1960 (rather than continuing to export logs for transformation in Europe and elsewhere in the world), assuming compound interest at 10% for the period 1960–2009, Gabon's economy could have been $439 billion richer today. Currently its GDP is about $21 billion and its debt burden is about $14 billion. If a more conservative interest rate is applied, using 7% as the average cost of Gabon's sovereign debt, the figure reduces to $182 billion, but if we use the average cost of private sector debt across the region, estimated at 18% compound interest rate, it rises to $6.10 trillion.

The strategy for management and development of the forestry and timber sectors in Congo basin is based on current understanding of maximum sustainable harvests. It is founded on the principal of implementing a sustainable harvest of a renewable resource, a very different approach to that of the oil and mining sectors that currently dominate the economies of most Congo Basin nations. Our model suggests that by transitioning to second- and third-level transformation, forestry provides an attractive combination of economic returns and jobs for Congo Basin countries. Having answered the question about the economic and social potential of forestry and timber processing, before recommending the "in-country transformation model" as a silver bullet for forest management across the Congo Basin, we must consider possible weaknesses or knowledge gaps that might undermine the strategy.

Key Questions Still To Be Answered?

Sustainability?

The long-term sustainability of extracting timber selectively from natural forests will depend on the ability of target species to grow and regenerate after logging or on the possibility that species not exploited today can become commercially viable in the future. For long-lived species, some of which grow to be 1000 years old or more, and do not necessarily regenerate in the conditions that exist today, this may prove problematic. Important commercial species such as Okoumé (*Aucoumea klaineana*), Sipo and Kosipo (both Mahoganies: *Entrandophragma utile* and *E. candollei*), Ayous (*Triplochiton scleroxylon*), Azobe (*Lophira alata*), and Moabi (Baillonella toxisperma) all regenerate in large open areas following slash and burn farming or are otherwise dependent on human activities (Biwol et al. 2015; Fay 1997; Morin-Rivat et al. 2017; White and Oates 1999). In the case of Okoumé, which only live up to about 150–200 years, their presence is an indication of relatively recent human farming activity, while the mahoganies can live for almost 1000 years and are the result of farming up to a millenium ago. Moabi (*Baillonella toxisperma*) regenerates almost exclusively in old hill-top village sites, subsequently living for up to 1000 years (Oslisly et al. 2000). Village sites were located systematically on hill tops and ridges, which is exactly where the majority of Moabi trees are found and were the only places where the seeds would have been protected from seed predators such as red river hogs and porcupines and avoid the predatory browsing by elephants, who consume saplings whole and push over young trees.

Sustainable harvest of species with this type of life history is almost impossible, certainly on the "short" 20–25-year rotations practiced today, and inevitably they will be treated as being analogous to mineral resources, even if active promotion of regeneration through replanting can ensure the species will be available for near-future generations. In forests where these are the dominant species, such as for the mahoganies in Northern Congo, sustainable harvests will have to be measured in terms of timber volumes rather than volumes of specific species, at least for this life-history group. Even with the relatively short-lived Okoumé, there are important questions about regeneration that need to be answered, given that most of the trees being logged today were established during the 1930–1960 period, when the colonial authorities forcibly moved all Gabonese villages out to the forest and relocated them along roads, leaving Okoumé trees to regenerate in their abandoned fields (CNC 2021; Hymas 2015). As the species that makes the best quality marine plywood, there is a strong economic argument for promoting the regeneration of Okoumé and as a relatively fast-growing species, able to reach up to 70 cm dbh in just 40 years (Nestor Laurier Engone Obiang et al. 2013), but this species highlights the problems that exist when planning for long-term sustainability rather than just one or two rotations. There is an extreme lack of data on the life histories, ecology, and regeneration of even the most important commercial species.

The question of how to deal with species that regenerated massively in the past open conditions but do not regenerate under a closed forest canopy, such as Okoumé,

Ayous, Azobé, and the Mahoganies is an important one. Recently, the EU proposed adding Okoumé to Annex 2 of CITES on the basis that forestry represents a threat to its commercial sustainability. Okoumé is a wind-dispersed species that specializes in colonizing open ground but cannot regenerate under the forest canopy. It is an early succession species that naturally dies out over a period of about 150 years as the forest develops (e.g., White et al. 2000). As such, it can occur at huge densities in early successional stages of forest establishment in old farms or savannas, often exceeding 10,000 stems per hectare (1 million stems per km^2!—see Guidosse et al. 2022) but is absent from the lower size-classes in closed-canopy forests. It is illogical to apply sustainability criteria to the exploitation of such r-selected species and highlights the overly simplistic view that non-specialists have of tropical rain forests, as stable habitats that have always had the same species composition as we see today. We simply cannot judge a species with a 1000-year life strategy that includes periods of rapid expansion and periods of relative stasis in this way.

This begs the question, because there is no in situ regeneration, should we ban the exploitation of these types of species because it is not locally sustainable? If we do not log, the species is likely to disappear naturally even if forests persist, but for the forest to be economically viable and thereby resist deforestation, we need to log these species. There is a need for a much more sophisticated approach to these questions, based on better understanding of the life strategies and ecology of the Congo Basin trees. In the case of Okoumé, it is relatively easy to promote regeneration through active interventions (Doucet 2003).

The issue of regeneration and sustainability across rotations has been the subject of much applied, but unpublished research and regeneration models for all commercial species are included in forestry management plans. However, we are just seeing the first companies coming to the end of their first logging cycles (e.g., Precious Woods in Gabon in 2026) and beginning to undertake the inventory work to update their management plans, and this will provide the data to assess the reliability of the models used. This is a critical field for future applied research in the Congo Basin if the Congo Basin countries and their private sector partners are to have the confidence they need to make the long-term investments in timber processing that we are proposing. There is research to suggest that improving regeneration through assisted or artificial methods is relatively easy (e.g., Doucet et al. 2016), but for this to become a widespread management strategy reform in the politics of allocation of forestry, concessions will be needed. Companies are unlikely to make significant investment in silvicultural techniques to promote regeneration of even the fastest-growing species that will not reach harvestable dimensions before 30–40 years, in areas where their concession is only valid for half that period. For slower-growing hardwood species even longer forest stewardship will be required.

Impacts of International Policies on Deforestation

The EU's Regulation on Deforestation-Free Products (EUDR—formally known as Regulation (EU) 2023/115) aims to prevent certain products, including wood,

entering the EU common market that have contributed to deforestation globally. To define imported deforestation, one first needs to define what a forest is. Generally, international agreements and regulations refer to the FAO definition that states that a forest is an area of at least 0.5 ha with a canopy cover of 10–30% (countries decide which is most appropriate to their forests) of trees with the potential to exceed 5 m in height. This UN definition adopted by consensus was crafted to allow all countries to be able to say that they possess forests, but it is not adapted to the Congo Basin ecosystem where a "forest," in the sense of most traditional communities in the region, is a "mature forest," with close to 100% canopy cover and trees above 40 m. By the FAO definition, many Congo Basin savannas qualify as "forests" and it would be impossible for a forestry company to establish a camp or log-loading area of more than 0.5 ha in their concession without being accused of deforestation, even though their economic activity is the reason the forest will survive in the medium term.

If this regulation is applied appropriately, it might result in a price increment for sustainably harvested tropical timber in the same way as FSC certification and be positive, but if applied "*bêtement*," without economic incentive mechanisms, there is significant risk of perverse effects. Indeed, in its UNFCCC NDC, the Gabonese Government went as far as to make its emission reduction and forest preservation commitments conditional on continued access of its certified sustainable wood products to international markets (CNC 2022), on the basis that its economic model involves using sustainable forestry as a mechanism to maintain forests, which in Gabon's case net absorb about 100 million tons of CO_2 annually.

Furthermore, decisions by CITES to place species of African timber that scientists do not consider threatened (such as *Afzelia* and *Pterocarpus*)—e.g., Nkenne Tikeng (2025) under CITES Appendix II on the basis of proposals submitted by the EU, imposes enormous constraints on producer countries and forestry companies. This results in export blockages, particularly due to the slowness of permit issuance within the EU. Even FSC- or PEFC-certified timber ends up being held for months and deteriorating in EU ports. The attitude of several EU Member States amounts to a kind of unacknowledged boycott of tropical timber, stemming from a lack of understanding of the reality of African forests.

Human Population Increase and Competing Land Uses?

As described in chapter ▶ "Climate Change and Ecosystem Functions and Services in the Congo Basin", human populations are increasing rapidly in all of the Congo Basin countries and are predicted to reach 261.7 million by 2050 (e.g., de Wasseige et al. 2012). In both DRC and Cameroun, this is resulting in increased deforestation rates, as people turn to forested areas as the only land available for subsistence agriculture (eg. Shapiro et al. 2023). There is a risk that the scenario that played out in West Africa and resulted in the loss of almost all the forest in, for example, Ghana and Ivory Coast, is beginning to occur in the Congo Basin. Loss of humid primary forest in DRC has increased over the last 25 years from 169,000 ha in 2000 (0.16%)

to 590,000 ha (0.56%) in 2024, while tree cover loss increased from 456,000 ha (0.23%) to 1,380,000 ha (0.69%) in the same period (data on Global Forest Watch; see chapter ▶ "Effects of Diseases on Wildlife Species in the Congo Basin").

Agriculture is critical to the well-being, nutrition, and food security of the people of the Congo Basin (cf. Chapter ▶ "Global, Regional, and National Economic Drivers of Deforestation and Forest Degradation in the Congo Basin") but so too are the ecological services provided by the forests. Indeed, the rainfall generated through evapotranspiration over the forest is critical to sustaining agriculture (cf. Chapter ▶ "History, Development, and Politics of Protected Areas in the Congo Basin Countries"), particularly in light of the generalized climate change-induced drying of the region seen in ground observations (cf. Chapter ▶ "Geology and Geodynamics Evolution of the Congo Basin"). Transitioning from relatively unproductive agricultural techniques that date from the beginning of the Iron Age (see ▶ "Central African Rainforest Archaeology" chapter) to modern tropical agriculture and agroforestry is a critical component to preservation of the forests, although some argue that improved productivity and stabilizing farmers on the same piece of land through soil improvement techniques is no guarantee of forest preservation, given the enormous agricultural potential of the region and the growing global human population (e.g., Hourticq and Megevand 2013). Moreover, as long as small farmers or local communities don't receive better financial benefits from their commitment and efforts to conserve a piece of forest land rather than shifting it to crops, no policy will be able to guarantee forest preservation.

For the forest to survive, it needs to be seen to be playing an equally important role in the economies of the Congo Basin Nations and the lives of its peoples in order to be able to resist the pressures of competing land uses. Table 1, which summarizes the potential of the forest to contribute to the economic and social development of Gabon, and by analogy the other Congo Basin countries, by making a similar contribution to GDP as oil, while employing over 700,000 (direct and indirect employment). This economic benefit will probably be enough to protect areas that are producing less direct economic gains and jobs (e.g., protected areas) but which provide enormous ecosystem benefits to the basin and the world at large. Given the failure of processes such as REDD+ and the carbon market to reward ecosystem services that are easily quantifiable, it seems unlikely that payment for these services will be an alternative to forestry and timber transformation in the short to medium term.

Impacts of Climate Change?

In Gabon's revised NDC, the second qualifier of its commitment to remain carbon neutral forever was that it would be powerless to act and could not be held responsible if climate change caused by global emissions of CO_2 and other greenhouse gases, to which the Congo Basin has made no net contribution (the entire region continues to be a net sink of CO_2), becomes so severe that the forest begins to die faster than it is growing. Currently the Congo Basin forests are proving to be

more resilient to the effects of climate change than the Amazon (Hubau et al. 2020; Sullivan et al. 2020), but the evidence of massive forest fires and replacement of forests by savannas and degraded forests during a dry climatic phase between 2500 and 2000 years ago (Maley 1992; Peyrot et al. 2003; White 2001) suggests that as temperature increases toward the +3 °C increase that seems currently to be the trend, (perhaps large) parts of the Congo Basin will no longer be able to support humid tropical rain forests. Rainfall models tend to predict slight increases in overall but more seasonal rainfall and more extreme storm events, but ground measurements seem to show the opposite, with progressive drying recorded in both Yangambe (DRC) and Lopé (Gabon) (Bush et al. 2020a; Kasongo Yakusu et al. 2023). Bush et al. (2020b) demonstrated a catastrophic reduction in fruit availability in Lopé, Central Gabon over a 30-year study with corresponding loss of body condition of forest elephants. This is the first sign of dramatic impacts of climate change on Congo Basin forests and suggests possible direct (reduced seed availability for regeneration) and indirect (reduced seed disperser availability) impacts on forest regeneration, including after logging. In the Republic of Congo, similar observations have been noted by some foresters (Ifo, S. A., pers. comm.).

The possible implications of climate change for humans and biodiversity are severe (e.g., Beekmann et al. 2024) and the biggest contribution the Congo Basin countries can make to mitigating the worst impacts is to preserve the forest ecosystems, including the vast peatland wetlands in Congo and DRC.

Concession Allocation and Forest Management Policies and Laws in Congo Basin Countries

A key feature of Central African forests is that they belong to the state, which retain management rights but grant harvesting rights to private companies for periods covering one rotation, generally around 25 years. As noted above, this is considered by forestry companies too short a time period to justify investment in silvicultural methods that will produce harvestable trees a further two rotations later. Renewal of forestry concessions is not guaranteed in current legislation and until operators have a longer-term vision, or there is stricter, more hands-on management by forestry authorities to ensure forestry practices promote regeneration of commercial species, sustainability of timber yields across multiple rotations is unlikely. Currently, all too often, concession holders are expected to assume all responsibilities, including those that are the responsibility of the state, to make up for shortcomings, such as the lack of transport and unfair competition from illegal timber, among others.

Another key management issue is the control of hunting in forestry permits, which is key to maintaining healthy populations of animal seed dispersers, which are vital for healthy regeneration of logged forests (e.g., Daïnou et al. 2021). This nature-based solution to replanting in disturbed areas is easily interrupted in forestry permits, where poaching is prevalent and government wildlife managers are not present. The debate about whether the private sector permit holder or the government

should foot the bill for wildlife management is ongoing, but some companies do share the costs of government wildlife brigades in their concessions.

Co-benefits of Implementing Sustainable Forestry at a Large Scale Across the Congo Basin: Carbon and Biodiversity

In Central Africa, tall forests with the highest densities of large trees have historically been targeted for commercial forest concessions. Well-managed forestry as practiced in the Congo Basin involves the sustainable selective harvest of 1–3 trees per hectare on a 20–30-year rotation (e.g., Medjibe et al. 2013; Umunay et al. 2019; White 1994) typically results in the loss of about 10% of standing biomass, most of which is released as carbon emissions. However, the resulting opening up of the canopy causes increased growth of surviving trees, resulting in accelerated carbon uptake, which makes logging neutral or even positive in carbon across the rotation (CNC 2021; Gourlet-Fleury et al. 2013). As such, sustainably managed forestry concessions in the Congo Basin are an effective way of maintaining or even enhancing forest carbon stocks (CNC 2021; Poulsen et al. 2020; Sagang et al. 2024; in prep).

However, when timber harvesting occurs in uncertified logging concessions, with no effective oversight by government, illegal practices often result in higher harvesting intensity and damage rates. Figure 1 maps aboveground carbon measurements across the Congo Basin and presents measurements of average carbon stocks in old growth forests, in certified and uncertified timber concessions, and in areas with active slash and burn farming. Areas where forestry is underway, particularly when it is certified, consistently have higher carbon stocks than unlogged old growth forests.

The map also clearly demonstrates that slash and burn agriculture, which is increasing in extent outside logging concessions, is a significant threat to carbon stocks and environmental services generally.

The physical damage caused by felling and extraction (skidder trails, roads, log loading areas) of trees results in more light penetrating into the forest understory, increasing temperature and reducing humidity, resulting in the loss of more sensitive components of the biodiversity. However, wildlife management in these concessions is undertaken more and more systematically, with active participation in prevention of poaching and in promoting sustainable subsistence hunting (e.g., Zwerts et al. 2024). As a result, they act as a sanctuary for healthy populations of medium- and large-sized mammals, which are susceptible to hunting, including elephants and apes (Laguardia et al. 2021; Morgan et al. 2018; White 1994b; Zwerts et al. 2024), although certified concessions tend to perform better than non-certified (Zwerts et al. 2024).

As such, sustainable forestry concessions are an effective means of managing Congo Basin forests both for economic plus social returns and ecological services such as carbon and biodiversity. Indeed, given that they exist on government-owned

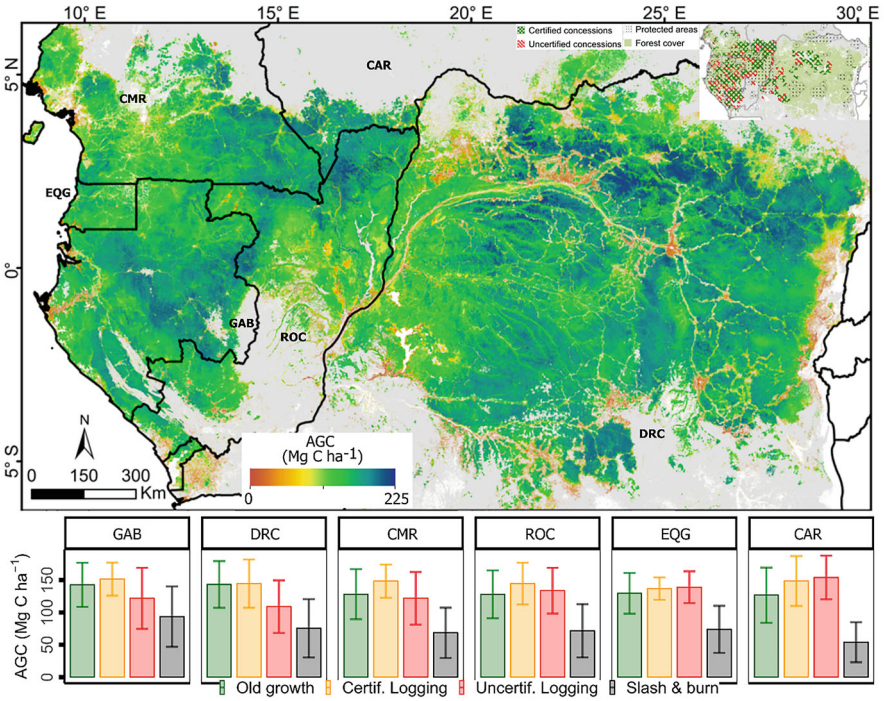

Fig. 1 Aboveground carbon (AGC, Mg C ha-1) density in the Congo Basin rainforest for the year circa 2020 (a) with the distribution across land-use disturbances including certified and uncertified logging as well as slash-and-burn (Sagang et al., in prep. GAB—Gabon, DRC—Democratic Republic of Congo, CMR—Cameroon, ROC—Republic of Congo, EQG—Equatorial Guinea, CAR—Central African Republic)

land and are subject to legally binding management plans, they are almost equivalent to the "National Forests" in the USA, which are considered IUCN Category VI protected areas. As in the US system, some parts of the concessions, e.g., protected, river protection and community zones, would qualify as higher category protected areas. Applying these criteria to Gabon's forests, for example, would raise the % of terrestrial areas under protection to about 80–85% of the territory.

What Investments in Skills Will It Take to Get the Basin onto a Sustainably Logged Future?

In order for the vision for sustainable harvest and in-country/regional processing of timber to become a reality, a number of investments in capacity and law enforcement and certification are required:

Law Enforcement and Certification

Law enforcement and certification go hand in hand. Perhaps the greatest threat to the creation of a sustainable timber economy is the pervasive presence of illegality in the industry and corruption in the administration. The EIA Toxic Trade report (EIA 2019) resulted in the US wood market being closed for Gabonese timber products for several years. More and more the international market expects the legality of natural resource extraction to be guaranteed. This will require a significant, ongoing investment in legal framework improvement, law enforcement, and forest concession auditing to be undertaken throughout the Congo Basin and will require training of staff, enhancing of operations capacities, and implementation of anticorruption measures in forestry, customs, and the judiciary. Achieving this also includes investing in digitization of systems of authorizations and controls to facilitate real-time verification by international markets and improve confident in legality and traceability.

Certification of legality and environmental sustainability is gradually becoming a requirement rather than a premium. Indeed, in 2018, in response to the preliminary findings of the EIA investigation, Gabon announced the requirement for all forestry concessions and factories to be FSC certified by the end of 2022 (informally extended to 2025 post-COVID). This is complex because, in some systems, e.g., FSC, governments have no formal influence or ability to make input on the adoption of norms and rules, creating a parallel governance structure that forestry companies need to conform with. In July 2021 the French government announced that no tropical timber would be used in the construction of venues for the 2024 Olympic Games. This restriction was lifted in in June 2022 for FSC certified "tali," used to make outdoor decking and barriers. In the context of the implementation of Regulation (EU) 2023/115 and China's new forestry law that lays the foundation for prosecution of Chinese companies and individuals found guilty of illegal forestry practices anywhere in the world, certification is likely to become more and more widespread.

Capacity Building

Implementation of government sustainability legislation and norms of certification, both in forestry operations and timber processing factories, require a high level of qualified personnel. Today we often still lack even the basic knowledge of the ecology of target species, their life history characteristics, phenology, growth rates, seed dispersers, and pollinators. As such, there is a need for increased investment in applied forestry research. There is also a lack on management capacity within government departments, whose ability to intervene on the ground is limited because of lack of budgets and equipment and absence of modern traceability software. As such, inventories generally do not exist before concessions are allocated and monitoring and auditing of commercial forestry operations is often inadequate. There is also a distinct lack of capacity in wood processing, especially third-level

transformation (e.g., manufacture of furniture and housing). There is an urgent need for the development of targeted professional training programs as well as fiscal incentives designed to help private sector companies undertake extensive on-the-job training.

Remote sensing (RS) could be a game changer in the future both for inventory, management planning, and monitoring felling and illegal exploitation. Laser technology mounted on aerial and satellite systems generates a three-dimentional view of the forest, measuring precise details about the tree density, height, shape and even the forest floor, all of which are essential for sound management. Coupled with multispectral optical imagery and artificial intelligence to identify tree species, RS will help to optimize forest inventories, including biomass mapping and monitoring of canopy disturbances at relevant frequency and scale, allowing forest administrations to effectively channel management and law enforcement measures. Unless governments invest in managing their forests and controlling illegal activities, the optimal model we present here will not be achieved.

What Economic, Fiscal, and Policy Levers Are Needed to Help the Rollout of Such a Program?

While our model demonstrates that return on investment is relatively rapid, averaging about 6 years in much of the sector in an ideal situation, even this is considered a blockage for many investors, nervous about the business climate, including corruption, political stability, and risk in the Congo basin countries, in addition to unpredictable changes in demand from the international markets. There is a need for the provision of relatively long-term capital at affordable cost if the private sector is to make the investments needed to realize the potential of the sector. Bilateral and multilateral banks and partners need to prioritize making debt affordable and putting in place political risk insurance and sovereign guarantees for investors willing to make the large investments needed. Obviously, the Congo Basin governments have a critical role to play in this, putting in place favorable fiscal regimes and good governance in order to promote strategic investments and investing in the infrastructure (road, rail, and ports) needed to support this logistic-heavy industry. That also includes a strategy for optimizing forest permits allocation in favour to long-term investments that require large concessions to guarantee sustainable projects with healthy economic, social, environmental, biodiversity, carbon, and other ecosystem services returns.

Fiscal incentives are a good way to reward early movers during the transition to increased transformation within the region. For example, Karsenty and Salau (2023) describe the Gabonese Governments use of a differential surface area tax involving lower annual per hectare surface area taxes for companies with forest management ($0.5/ha) or legality ($1/ha) certification compared to uncertified companies ($1.35/ha). A similar scheme is applied to export taxes, which are progressively higher from third- to second- to first-level transformation products.

There will always be a friction between private sector investors seeking to maximize returns on investment and governments, seeking to maximize fiscal revenues and local development. The extremes, characteristic of the colonial model of exporting 100% of raw materials to maximize offshore value-added, which was replicated by many companies operating illegally in Gabon and Congo, who maximize short-term profitability to the detriment of sustainability, using corruption to bypass laws and fiscal frameworks (EIA 2019) result in minimal revenues, jobs, and development for the Congo Basin nations while also undermining the long-term viability of the forest.

The other extreme, with full third-level transformation and investment in regeneration and plantations, requires higher levels of capital expenditure and longer-term economic models. This seems to have been most successful in the public-private partnership (PPP) model developed in the Gabon Special Economic Zone and since replicated in DRC and Congo, where government is a shareholder, has full visibility on investment and financial returns, and actively supports the commercial success of the investment through policy reforms. In an industry that has long thrived in the shadows of the forest, transparency is perhaps key to creating a healthy dynamic between governments and private sector partners (EIA 2019). Use of modern traceability systems to track production, transport, and processing of timber can greatly help ensure this transparency while improving efficiency, reducing corruption, and guaranteeing payment of appropriate taxes.

Principals of Sound Forestry

The DYNAFAC consortium brings together institutions from both the Global South and North and published a series of sound recommendations to improve sustainability (DYNAFAC 2023).

- Tailor management to the region's ten major forest types rather than using one-size-fits-all.
- Set a standard 30-year rotations as a best compromise to balance stock recovery and sustainability.
- Aim to restore harvested stocks to 100% for the commercial species group and at least 50% for each individual species by the end of each rotation.
- Revise and harmonize minimum harvest diameters (DME) region-wide based on biology, so enough seed trees remain.
- Install forest monitoring plots/transects in every large concession (≥50,000 ha) and partner with national research bodies to improve knowledge on the natural history and regeneration of commercial species, so these parameters can be fed directly into management plans.
- Actively encourage natural regeneration (including enrichment planting with native timber species) and protection/restoration of wildlife, considering that many tree species ~70–90% depending on forest type—rely on animals for seed dispersal.

How Does the Vision Presented in This Chapter Differ from the Business-as-Usual Scenario?

The business-as-usual scenario for the forestry and timber industries is one in which almost all round logs or mostly only first level transformed wood is exported from the Congo Basin to other countries. In this scenario, <10% of the forest economy and jobs are generated locally, to the detriment of the Congo basin countries. It is also one scenario in which all added value is generated from natural forests, without investment in planted trees to increase the volume of harvested wood while reducing pressure on natural forests. In this scenario the sector will remain insignificant in terms of economic impact and social returns and other more favorable land uses will be sought by governments desperate to grow their economies and provide jobs for their people. This will result in a scenario similar to that observed in Ivory Coast and Ghana, where forests have dwindled to <5% of their previous extent and agriculture has replaced forestry as the primary land use.

In this scenario, the Congo Basin will become a net contributor to global carbon emissions and both the region and the world at large will lose the priceless ecosystem services currently provided free by the basin's forests. For example, the rains in the Sahel and the Ethiopian Highlands are likely to dwindle as the forests are cut, weakening agricultural productivity in these regions and further exacerbating the already consequential effects of climate change.

We believe our model provides a viable solution to this disastrous scenario and would result in the survival of the majority of the Congo basin forests. It should be noted that our model does not rely on payments for carbon or other ecosystem services in order to be viable and of great interest to the Congo basin nations. If carbon credits, biodiversity certificates, and other mechanisms for recognition and payment for ecosystem services become effective, our economic model will be enhanced.

While the numbers we present are specific to the forestry and wood processing sectors, similar benefits would accrue from the transformation of non-timber forest products and mineral resources, although preconditions, such as the need for cheap, reliable sources of energy, are likely to be more acute for some sectors. In a continent and a subregion blessed with exceptional natural resources and a growing young population, we consider in situ transformation not only to be the only development pathway that guarantees sustainable exploitation of renewable resources and optimized use of non-renewables, but that it is critical to the future stability and economic prosperity of all who live in the Congo Basin and more widely in Africa.

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