C-Quest Capital

Review of Information Note (Development of default values for fraction of non-renewable biomass) and 'Report from external experts' within CDM-MP92-A07.

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Transformation Carbon

Foreword

International Energy Agency, as per its Africa Energy Outlook Report (2022):

*"**Achieving universal access to clean cooking fuels and technologies by 2030 requires shifting 130 million people away from dirty cooking fuels each year**. Today, 970 million Africans lack access to clean cooking.*

*Liquefied petroleum gas (LPG) is the leading solution in urban areas, but recent price spikes are making it unaffordable for 30 million people across Africa, **pushing many to revert to the traditional use of biomass**. Countries are re-evaluating clean fuel subsidy schemes and exploring alternatives such as improved biomass cook stoves, electric cooking, and biodigesters.*

***The improvement rates needed for universal clean cooking access by 2030 are unprecedented. Still, the benefits are huge**: reducing premature deaths by over 500,000 a year by 2030, drastically cutting time spent gathering fuel and cooking, and allowing millions of women to pursue education, employment, and civic involvement."*

The importance of carbon finance-driven investment in clean cooking and low carbon cooking fuels to climate change in SSA.

*"**Charcoal is a dominant energy source in Africa, and its use is increasing at a rate of 7% per year because of population growth, urbanization, and low adoption rates of alternative cleaner energy sources.1 More than 80% of urban households in Africa use charcoal, predominantly for cooking**.*

Alternatives such as electricity and liquified petroleum gas (LPG) are costly, access to on-grid electricity is limited and notoriously unreliable, and charcoal is more accessible than wood in urban areas as distances to collect fuelwood increase. Charcoal has been identified as a large tropical and global source of the greenhouse gases methane and carbon dioxide (CO2) 5,6 and a contributor to forest degradation and loss from intensive and unsustainable tree harvesting. All steps in the charcoal supply chain also release short-lived trace gases and aerosols that are hazardous to health and alter the climate" (Bockaire et al. 2020 Environ. Sci. Technology).

Introduction

This report presents C-Quest Capital's review of the Information Note (Development of default values for fraction of non-renewable biomass) and of the 'Report from external experts' (hereafter referred to as the "Report") within the Information Note, presented as an attachment to the CDM Meth Panel 92nd meeting carried out in Bonn, Germany, in October 2023.

The review is organized as follows:

- Section 1: Executive summary.
- Section 2: Social and environmental context of increasing biomass fuel scarcity
- Section 3: Critical review of key supply and demand assumptions, and recommendations
- Section 4: Technical Review of MoFUSS simulated fNRB estimations
- Section 5: Preliminary comparisons of fNRB outputs between the MoFuSS model and a CDM TOOL30-based methodology

Our ability to respond comprehensively to the Report has been severely hampered by the short time limit imposed for feedback, even after the deadline for public comments to be submitted was extended. Responding adequately to a complex report that has implications for the flow of billions of dollars of private capital to climate change management across SSA deserves months not weeks.

Section 1: Executive summary

By significantly underestimating sources of demand and overestimating supply, the Report substantially underestimates fNRB levels in Sub-Saharan Africa (SSA). Declining fNRB values through 2050 are in direct contradiction with well-documented high and accelerating deforestation and land degradation rates in SSA.

Notable demand and supply data deficiencies in the Report include *inter alia*:

- Default factors for per capita firewood and charcoal consumption appear to be between one-third and one-half of values measured on the ground.
- Default factors for wood use for charcoal transformation assume much greater wood-to-charcoal conversion efficiencies than recorded in the trade (6–13 tons of wood for one ton of charcoal produced), and do not include upstream or downstream losses to the point of consumer purchase.
- Widely recognized important sources of demand for wood are acknowledged missing and are not subject to any plausible proxy of sensitivity analyses but are instead considered negligible, although they would greatly impact the estimation of fNRB.
- A 100% of standing biomass assessed by satellite imagery across the working landscapes of densely populated areas — the primary focus of efficient cookstoves and sustainable biomass fuel projects — is assumed to be legitimate sources of fuelwood, despite the critical livelihood value of an important proportion of remaining trees.

As per the evidence presented hereinafter, taking one or more of these data deficiencies into account significantly influences country-level fNRB values and would, in turn, create relevant additional incentives for carbon-financed investment in efficient cookstoves and clean and sustainable cooking fuels.

In addition to the substantive gaps pointed out above, we have sought to test the model, since the Information Note mentioned it would be an “open source and reproductible by anyone even if using different data sets and parameters". Nonetheless, when doing so we have observed that it was not possible to run the scripts nor to replicate results and values from the MoFuSS tool. Accompanying instructions and manual were also incomplete, as confirmed by the tool developers. Therefore, at the current stage, the model could not be tested as planned and, as such, it would not be appropriate to adopt it as the UNFCCC reference for fNRB factors.

Accordingly, we suggest that it is not appropriate to publish and accept the updated fNRB defaults as valid values without them first being subject to thorough independent peer-review assessments and due diligence. As in any climate change mitigation initiative, it is crucial to be conservative and use extensive peer-review processes in the determination of climate and related economic drivers. However, in this case, excessive conservatism in fixing key demand and supply drivers misinforms about the damaging power of traditional fuel consumption and production practices. Such excessive conservativism also undermines much-needed investment in climate mitigation, adaptation, and poverty alleviation in rural and peri-urban areas of developing countries.

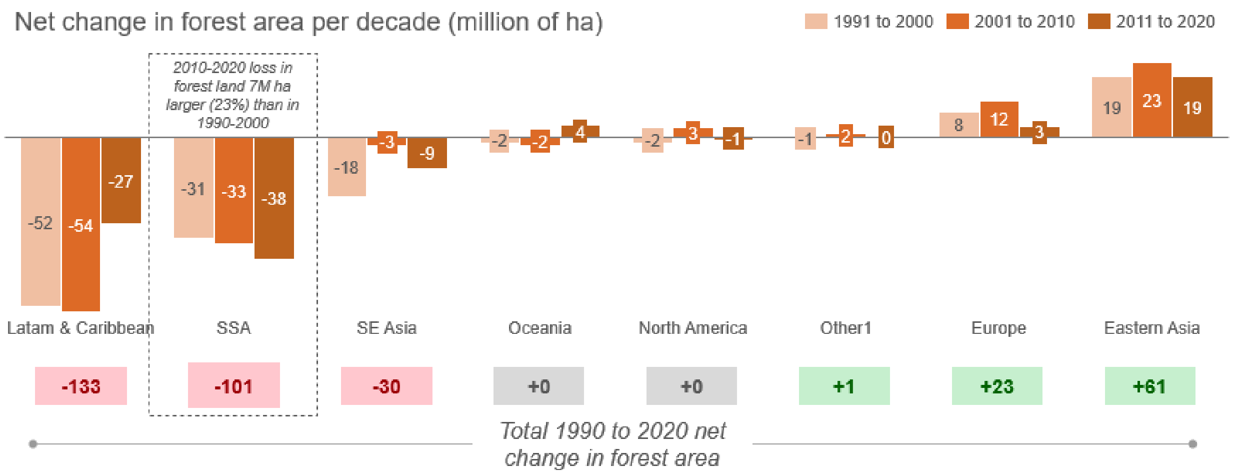
Section 2: Social and Environmental Context of Increasing Biomass Fuel Scarcity

2.1. Population growth

Population growth in Africa is the highest globally, with strong urbanization pressures. The continent is expected to be home to 1.5 billion people by 2030 and 2.2 billion by 2050, compared to 1.2 billion in 2020, with a three-fold increase of the urban population expected. According to the World Bank (2022), roughly a quarter of the global population will live in Africa by 2050. Currently, 970 million people of the African continent lack access to clean cooking, and 600 million people, mostly in sub-Saharan Africa, lack access to electricity (IEA, Africa Energy Outlook 2022).

The traditional use of biomass dominates residential energy demand in sub-Saharan Africa today, with more than 80% of the population relying on it. Three-stone open fires and other traditional stoves that burn wood, charcoal, and other forms of biomass typically have very low combustion and heat-transfer efficiencies. The large amounts of these fuels needed to meet basic cooking needs with such stoves means that they account for more than 95% of total residential energy use in sub-Saharan Africa (IEA 2022).

The demand for cooking fuel and the acceleration of wood consumption as the number of consumers using charcoal instead of burning wood is an increasingly important driver of deforestation and land degradation. The rate of deforestation is increasing in SSA, whereas in the rest of the World it is decreasing. SSA is the only region in the World where deforestation rates have increased over the last 20–30 years (FAO-FRA 2020) and this trend is likely to continue in the absence of intervention.

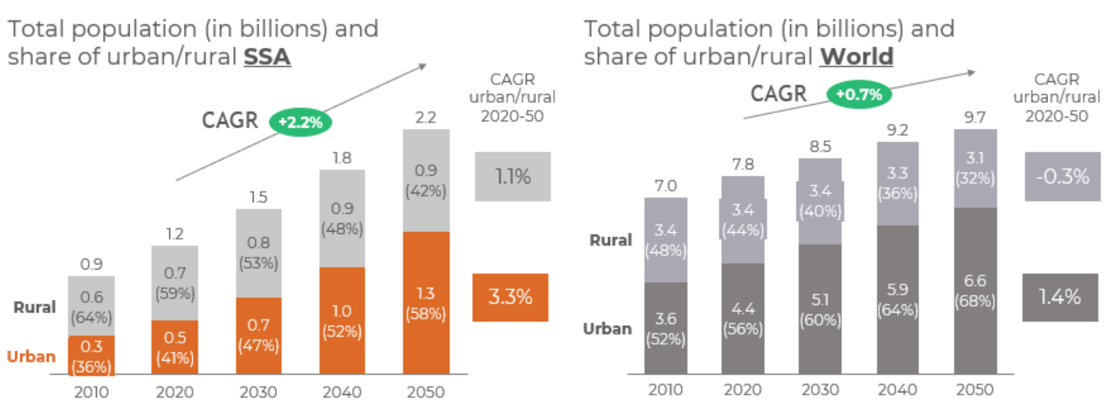


1. Others include: North Africa, Middle East, Melanesia, Micronesia and Polynesia
Source: FAO – Global Forest Resources Assessment 2020

The key drivers of deforestation and forest degradation are local/subsistence agriculture, the exploitation of forests and woodlands for fuel and building materials, and other commercial deforestation drivers, all compounded by rapid urbanization (Pacheco et al. 2021; Noriko Hosonuma et al., 2012; Kissinger et al., 2012).

2.2. Growing urbanization and cooking fuel demand

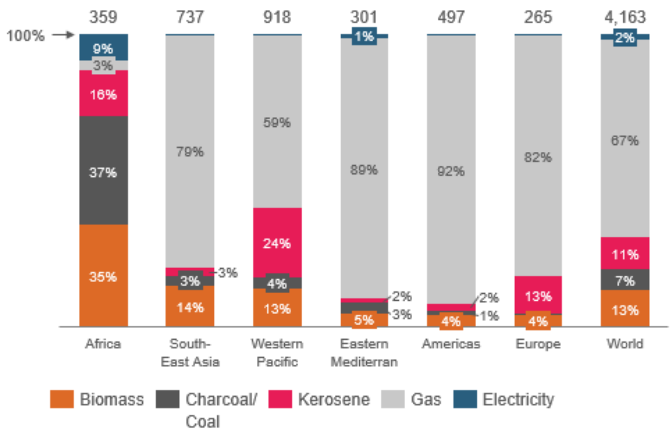
Urbanization in SSA accelerates demand for charcoal as a more convenient fuel in crowded settlements compared with firewood burned on crude stoves and in open TSFs. In this region, urban population is increasing at three times the rate of the rural population, leading to an increase in charcoal consumption of 7% per annum (Bockaire et al. 2020).



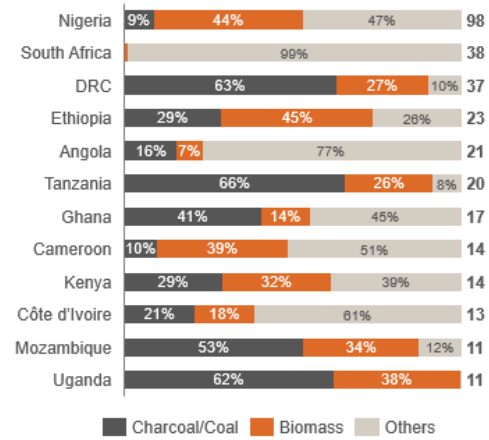
Source: World Bank - Population estimates and projections. Last update 23/Dec/2022

Across the whole urban SSA, about 40% of urban households use charcoal for cooking although in some countries the percentage of urban households using charcoal is much higher, going as high as 70% in countries such as the Democratic Republic of Congo, Tanzania, Mozambique, Malawi, Zambia, and Uganda.

Cooking fuels and technologies (by fuel category)
Urban pop. (million) and % of population per fuel type
WHO regions - 2019



Cooking fuels and technologies (by fuel category)
Urban pop. (million) and % of population per fuel type
Top 12 countries in urban population

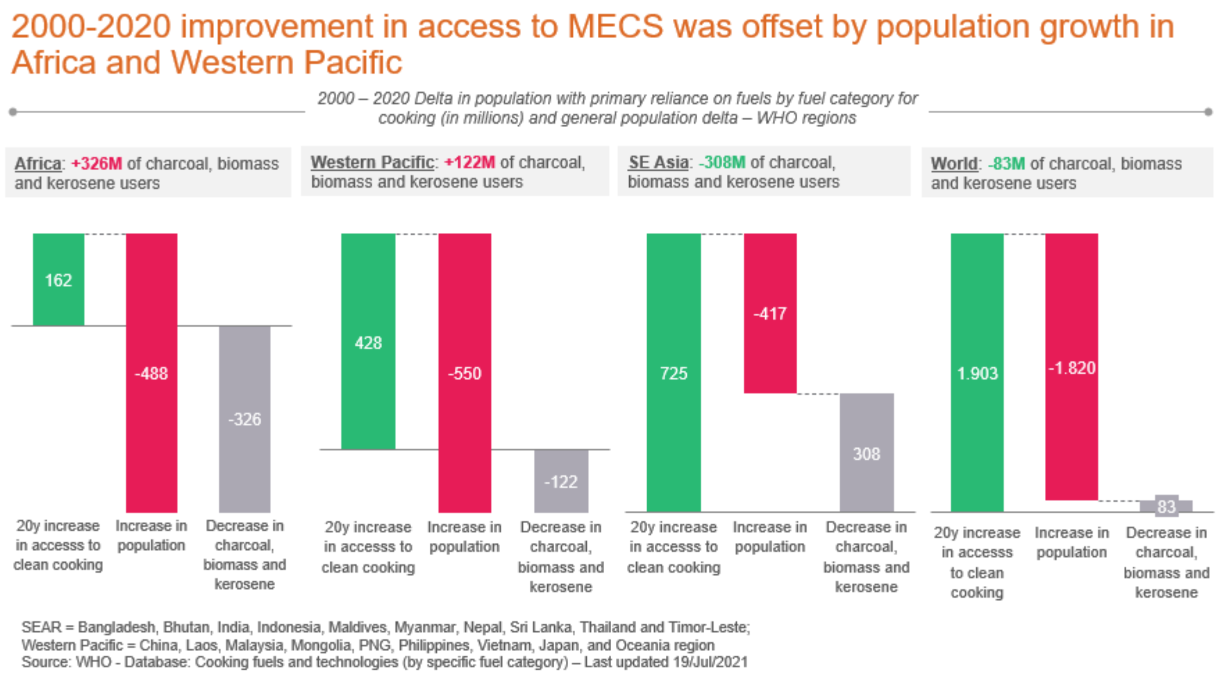


Note: SEAR = Bangladesh, Bhutan, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand and Timor-Leste; Western Pacific = China, Laos, Malaysia, Mongolia, PNG, Philippines, Vietnam, Japan, and Oceania region.
Source: WHO - Database: Cooking fuels and technologies (by specific fuel category) – Last updated 19/Jul/2021

Traditional earth-mound charcoal production uses between 6–13 tons of wood for one ton of charcoal produced in the carbonization phase. These figures do not include upstream losses from whole tree harvesting, when tree parts that are unsuitable for charcoal production are discarded as waste. Further, downstream losses of usable charcoal in the form of fines generated by long-distance transport of lump charcoal are also not included in the above ratio range.

Unfortunately, there is no evidence of the penetration of modern fuels in urban markets at rates that would suggest an abatement in charcoal demand. The use of alternative sustainable biomass fuels or modern energy cooking services (MECS), such as LPG and electricity, is negligible. MECS adoption is less than 15% in African urban areas — constrained by foreign exchange and infrastructure — with few countries in SSA having reliable, low-cost electricity supply to urban areas. Consequently, projections showing lower fNRB trends for the 2030–2050 period contradict the observed increasing demand for wood biomass fuels and expanding demand for wood for rural industry and household construction.

Without the economic driver of carbon finance, one massive source of new and additional funding for clean cooking and sustainable or low-carbon fuels will be lost. The updated fNRB default factors seriously delay such capital flows, particularly if the methods/analyses have not been subject to any thorough independent peer-review and validation process.



Section 3: Critical review of key supply and demand assumptions, and recommendations

3.1. Overestimating biomass supply

The Report assumes that all standing biomass assessed from satellite imagery is part of the fuel supply and can be harvested as firewood or made into charcoal. This assumption belies the reality of land use in Africa under increasing population pressures.

An expanding rural population leads to larger percentages of arable land being under continuous cultivation, with marginal land also being brought into cultivation at the expense of natural woodlands. In addition, the growing demand for wood fuel and building materials has become a significant driver of deforestation across SSA and contributes to the increased scarcity of suitable sources of firewood and timber accessible to communities.

Slow-growing trees that are sources of food and revenue, such as mango and baobab trees, shea butter, mongongo nut, gum Arabic trees and even culturally important trees such as *Faidherbia albida* (prized for improving soil fertility), or trees traditionally preserved for medicinal uses, such as *Erythrina abyssinica*, are being felled given the high levels of scarcity of firewood. This strongly indicates there is no natural regeneration occurring at a time scale that could be enough to decrease deforestation pressures and hence the use of nonrenewable biomass. Such observations can substantiate a more rational assumption of constrained supply with concurrent observations of increased demand for wood. Nonetheless, the updated fNRB default factors inadequately assume that all standing biomass is a source of wood fuel and overestimate firewood supply to the extent that lower-value sources of firewood are no longer available within the working landscape of densely populated rural areas.

Recommendation: fNRB models should include a proxy value for the proportion of standing biomass outside forest reserves that should be deducted from fuelwood supply. Conventional transect analyses in the more populous areas can be used to fix that value for specific countries or regions within countries targeted for investment.

3.2. Missing sources of wood demand

In addition to the demand for fuelwood, many other common, sustained, and growing demands for wood are not considered in the fNRB Report. That these common sources of demand are excluded is expressly acknowledged, and the reason given is that the quality of data on such sources of demand is poor. While it is true that data is hard to gather, there is a reasonable amount of data that is enough to shed light on the impacts of other deforestation drivers in the estimation of fNRB, as below. There is no doubt about the nature and importance of these common sources of wood demand across SSA.

These include:

- **Brick-making** across much of sub-Saharan Africa, especially in the South and East, houses are made of bricks fired in crude brick kilns. Houses need constant maintenance and repairs, and new houses and other shelters are built to meet the demands of a growing rural and urban population. Geist (1999) reported that traditional kilns use 1m^3 stacked wood (equivalent to 425 kg) to make 3,000 bricks. Other sources suggest even higher figures pointing to the need for 3m^3 of firewood for just 1,000 bricks (Beamish & Donovan, 1989) (Sampe & Pakiding, 2015). A typical rural house needs 9,000 bricks, and a typical urban house needs 15,000 bricks.

  For example, in Malawi, several reports estimate that firing bricks consumes roughly 850,000 tonnes of fuelwood annually (Bossard, 2022; Ngwira & Watanabe, 2019; Wiyo et al., 2015). The Malawian government has even attempted to ban brick burning to decrease deforestation, although the legislation is rarely enforced.

  Likewise, most urban housing and official building construction in Sudan uses clay bricks produced by numerous traditional kilns fired with fuelwood. The estimated amount of wood lost from the total growing stock of wood in forests and trees is 1,466,000 m^3 encompassing 505,000 m^3 round wood and 961,000 m^3 branches annually (Alam & Starr, 2009).

  The same trends apply to multiple African countries. A survey conducted by the Southern African Development Community, consisting of 15 member countries, has indicated that the informal brick-making industry within such countries produces approximately 400 million bricks per year (CBASA, 2017).

  We acknowledge that gathering data on an activity like brick-making is difficult, but it is not impossible to make conservative estimates of demand relative to firewood consumption from the available literature.

- **Tobacco curing**: tobacco is grown across Southern and Eastern Africa. Tobacco is typically air-cured under sheds made of wood and hung on wooden sticks, subject to different replacement levels over time. The amount of wood required to cure 1 ton of tobacco depends on the variety and is reported by Geist (1999) as 14.2 tons for flue-cured, 16.1 tons for fire-cured and 2.2 tons for air-cured or burley tobacco, although the figure for burley excludes roofing material and sticks for hanging the tobacco. If we take the example from Malawi to provide orders of magnitude, the amount of wood to cure Malawi's tobacco crop, which averaged 157,365 tons per annum from 1995 to 2014, was 619,985 tons based on Geist's figures above. From the example, a conservative underestimate of 475,837 tons was assessed as unsustainable wood from forests and woodlands, equivalent to a loss of 5,533 ha of tree cover based on an average standing wood biomass of 86 tons/ha. Therefore, tobacco curing reduced the available wood supply for cooking and other household and farm needs.

The case of Tanzania also provides a good example. Flue cured tobacco accounts for over 95% of the tobacco crop grown in the country, which averaged 88,281 tons per annum from 2010/11 to 2018/19 (Ministry of Agriculture, 2020). Based on an average of 14.23 tons to cure 1 ton of flue tobacco (Geist 1999), the wood to cure the crop averaged 1,256,240 tons per annum, 85% of which is considered unsustainable, extracted from miombo woodlands. This translates into an annual loss of 12,416 ha of miombo woodland for a total of 111,747 ha over this 8 year period based on the standing wood biomass of miombo woodlands (Ministry of Forestry and Natural Resources 1993)

- **Beer brewing** is standard across SSA. A household brewing beer as a cottage industry consumes 10 to 20 times as much wood as a regular household in rural areas. It is likely that even a small proportion of household brewing would increase the demand for wood, adding further pressure to deforestation. Geist (1999) reports that $1m^3$ stacked wood is needed to brew 400 liters of beer.

- **Smoking and drying of fish** are common practices in Malawi, Tanzania, and Zambia to extend the shelf life of fish and reduce post-harvest losses. However, securing the large quantities of wood needed to smoke and dry fish is becoming increasingly laborious and costly because of the rising scarcity of wood from forest loss. In Malawi, an estimated 69,623 tons of wood were used in smoking and drying fish in 2016 (Drigo 2019).

- **Wood for cooking meals in boarding schools:** it is estimated that 132,942 tons of wood were used for preparing meals for approximately 1 million boarding students in Malawi in 2016 (Drigo, 2019).

- **Construction of animal enclosures and farm structures**: Other uses of wood by rural households in SSA include the construction of cattle corrals, pig pens, raised goat enclosures, chicken coops, outhouses, granaries, and bathrooms. All require regular maintenance due to damage to wood by termites, which shortens the life of these structures. It is essential to seek and analyze more data on these potential deforestation drivers to properly consider them in the report.

The above are just some of the traditional or common and growing wood demands. Collectively, they illustrate that such uses are non-negligible and should not be ignored in an fNRB analysis.

Recommendation: introduce a conservative proxy for unaccounted traditional sources of wood demand in the range of 10–20% of fuel wood demand and permit governments and advisors to develop or use nationally available data, enabling designated national authorities (DNAs) to publish the best estimates of such wood demand in their countries.

3.3. Consumption statistics

3.3.1. Firewood

The Report applies a UNFCCC default factor of 400kg/capita/per year to estimate overall firewood demand. By contrast, careful measurement of firewood consumption in the baseline of households targeted by CQC projects reveals much higher per capita consumption values. These data are obtained from robust 3-day Kitchen Performance Tests (KPTs) done in households in each of CQC target countries. During these KPTs, weight and moisture content of fuel wood are measured and recorded every day across a 3-day period for each household, which allows for the determination of baseline fuel consumption, as well as for the use of consumption statistics across countries and within sampled households. The same 3-day KPTs are performed on the intervention stoves to establish fuel savings.

CQC is conducting these KPTs across 20 countries in Africa and South and Southeast Asia. At the time of submission to the CDM feedback on the Report, only the following country data had been completed: Cambodia, India (Eastern States), Lao PDR, Philippines, Thailand, Vietnam, and Zambia. By the end of December, all country data will be available.

The process is rigorous, and the data are robust. Results so far uniformly show per capita consumption levels above 800kg/capita and range up to 1.2 tons/capita per year, 2–3 times the default factor applied in estimating fNRB factors published in the report. Moreover, these results are in line with the woodfuel consumption of 1.14 tons/capita per year reported by the FAO (2019) in Ghana.

3.3.2. Charcoal

The method used in the Report to estimate charcoal demand works backward from wood demand, using assumptions about the relative calorific value of wood and charcoal, as well as the relative efficiency of wood and charcoal stoves. This method yields 140kg of charcoal per capita.

First, the calculus used to estimate charcoal consumption uses default efficiencies for open-fire cooking and traditional charcoal stoves. These default levels are much higher than actual efficiencies from cooking fires and cookstoves in developing countries. In real life, fires are not stopped, and coals are snuffed out, collected, cooled, and weighed. Fires burn out or smolder on until the next cooking event. Oregon State University has developed a rigorous protocol to measure the efficiency of traditional cookfire/stove management called the Uncontrolled Cooking Efficiency Test (Moses, et al., 2019). Using this test across Africa, three-stone fires for cooking so far average 9.5% and traditional charcoal stoves 20%. Data gathering is still ongoing.

Second, in the time available, the only recent comprehensive dataset on charcoal consumption CQC could access is from Malawi and arose from USAID Modern Cooking and Healthy Forests program. It shows a country-wide average charcoal consumption of ~260kg/capita. The Government of Malawi has been enforcing a ban on charcoal consumption with increasing effort over the past 5 years; hence, these data may not be representative of countries where charcoal trade is legal.

Recommendation: per capita charcoal consumption was found to be approximately double the derived default values used in the Report, based on the Uncontrolled Cooking Efficiency Test and data available for Malawi. Currently, our preferred approach is to use data from rigorous on-the-ground protocols and surveys done across households using charcoal in urban areas in SSA, rather than making use of back-calculated statistics based on disputable cookstove efficiency assumptions. We however recommend commissioning independent experts and institutions to conduct surveys, research, and analyses to determine country-specific charcoal consumption trends and statistics, subject for review and approval of DNAs.

3.3.3. Wood use in traditional charcoal production in Africa

Another important aspect of charcoal consumption is the amount of wood required to produce charcoal. The UNFCCC has recently changed the default conversion rate for wood to charcoal to 4 tons of dry wood to one ton of charcoal.

The charcoal supply chain is comprised of three phases from the perspective of assessing the overall demand for standing biomass. These are:

1) Wood harvested to provide the charge suitable to make charcoal. In whole tree harvest, portions of the harvested tree wood are not suitable for making charcoal, and in remote areas where there is no prospect of this residue being used for firewood, they are discarded as waste.
2) Wood effectively loaded into the kilns for carbonization, and the resulting charcoal bagged and ready to be sent to market. Wood harvested but not utilized in the carbonation process is upstream wood loss.
3) The usable charcoal that consumers buy. The weight difference between the charcoal bagged at the production site and that reaching the consumer stoves is the weight of unusable fines produced in transporting charcoal to retail markets.

Research commissioned by CQC and conducted by independent third parties shows wood-into-charcoal ratios ranging between 6:1–13:1 out of commonly used earthen kilns. The overall range of wood used-to-charcoal delivered to the consumers' kitchen ranges between 7:1 to 17:1.

Data are still being gathered and processed for Ghana and Malawi, and similar research has been commissioned for Kenya and Uganda. While these types of research are time-consuming, logistically complex, and expensive, they are critical in demonstrating that the damage function of traditional fuel production is much higher than what is assumed from the relatively few, date-measure assessments of charcoal production.

Recommendation: Revert back to applying the IPCC default factor of 6:1 wood-to-charcoal ratio and make provision to insert measured entire supply chain ratios to account for wood and charcoal loss during harvesting, processing, and transporting. DNAs in relevant countries should assess and publish the acceptable ratio to be used in fNRB calculations in their countries.

Section 4: Technical Review of MoFuSS simulated fNRB estimations

4.1. Comparison of methods

Estimating the fNRB requires an understanding of the available wood resources for harvesting (total woody biomass), the actual quantity being harvested (consumption), and the amount regenerating (renewable biomass).

A comparative assessment of the MoFuSS model and CDM TOOL30 v4.0 methodological guidelines regarding the estimation of fNRB is presented below.

Comparing estimations derived from two distinct modeling techniques inherently presents challenges. Nevertheless, it is essential to recognize the significant influence of numerous factors, such as differences in methodology, input data, underlying assumptions and nuances, as well as the associated uncertainties.

4.2. CDM TOOL30 v4.0

CDM TOOL30 relies on forest cover extent within areas considered accessible for harvesting (excluding protected and geographically remote areas) to calculate the available wood resources. Mean Annual Increments (MAI)[1], specific to various ecological zones and age categories of stands, are then applied to forest cover considered accessible to determine the quantity of wood that regenerates (renewable biomass). Additionally, per capita consumption rates, derived from official statistics and country-specific data, are used to estimate the amount being harvested (consumption).

Non-renewable biomass (NRB) is then estimated by calculating the difference between consumption and renewable biomass. The ratio of NRB to total woody biomass is subsequently calculated to estimate the fNRB value. This methodology can be applied at regional scales, including specific project areas or administrative levels, districts, and provinces, or national scales. TOOL30 provides a snapshot fNRB estimate for the harvest, growth and consumption occurring in a one-year period. It is essential to underscore that CDM TOOL30 operates as a **methodological guideline** for fNRB estimation, allowing for flexibility in its application and the incorporation of diverse assumptions and nuances, provided they are justifiable and contribute to more accurate estimations.

4.3. MoFuSS

The MoFuSS model extracts above-ground biomass (AGB) data from historical AGB maps dated 2010. A biomass growth function is then applied to these data, with a wood harvest parameter that includes a pressure index, to determine the current availability of wood resources. This evaluation is conducted at a pixel scale with a specified resolution. The regional and global models use a 1 x 1 km pixel resolution, whereas sub-national or project-scale models use higher resolutions (e.g., 100 m or 30 m). For each pixel, consumption values are determined using a combination of population densities, urban/rural population density thresholds, estimated percentages of wood resource usage by rural and urban populations, as well as a default per capita consumption rate.

Non-renewable biomass (NRB) for a period of interest is then obtained by calculating the difference of estimated AGB values of two boundary time points of aforementioned period. A negative AGB value is classified as NRB, while a positive AGB value is categorized as renewable biomass (RB) and is assigned a value of zero. The fNRB for each pixel is calculated as the quotient of NRB divided by consumption.

MoFuSS is a complex model, demanding specialized expertise to correctly interpret the input data, as well as the results and outputs. Moreover, MoFuSS is used to produce predicted estimates of the fNRB for future time periods up to 2050.

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[1] The Mean Annual Increments (MAI) serve as a proxy for growth rates.

4.4 Inputs and assumptions

Regarding input data, the MoFuSS model depends on various spatial input datasets, each characterized by differing resolutions, and thereby introducing uncertainties which are further compounded by any necessary resolution adjustment and manipulation required. In contrast, CDM TOOL30, and our application[2] of its guidelines thereof, rely on a more streamlined set of input data, of which only one is a spatial dataset, simplifying the model and resulting in a lower overall level of uncertainty related to input data.

4.5. Comments from the MoFuSS model developers on CDM TOOL30 v4.0 and corresponding responses

Point 1:

“TOOL30 provides guidelines for calculating fNRB without using explicit spatial analyses. The calculation requires project developers to have access to estimates of forest areas and forest productivity defined by the mean annual increment or MAI. For forest areas, the tool suggests using data from a 2000 FAO publication. However, this is both outdated and inadequate because it ignores trees outside forests, which are important sources of wood fuel. If some version of TOOL30 is to be included in future methodologies, we suggest using more recent sources of land cover data that also account for trees outside forests. For example, the European Union’s EU’s flagship Copernicus programme provides free and open global land cover maps through 2019 which include 12 categories of forested land as well as shrubland, grassland, croplands, and other areas that are likely to include trees outside forests.”

The statement above presents a measure of accuracy in its reference to the utilization of outdated data concerning forest cover and mean annual increment within TOOL30. Notably, TOOL30 offers flexibility by accommodating various land classes, which allows for the inclusion of trees beyond traditional forested areas. However, it is worth noting that this data may not be readily available at a national level. The above criticism of inaccuracy relies on the omission of the explicit requirement, outlined in the latest version of TOOL30, that up-to-date data must be utilized, with a cutoff not exceeding the year 2000. A 2020 version is readily accessible, rendering it a viable alternative.

For instance, in our application of CDM TOOL30 v4.0’s methodological guidelines, we estimate tree cover using Hansen spatial data spanning the years 2000 to 2022, providing recent information on tree cover, primary tree cover, and tree cover gain. This approach aligns with option three (UNFCCC, 2022) for determining tree cover within the CDM TOOL30 v4.0, which accommodates remote sensing surveys as a valid method. It is important to note that TOOL30 offers two additional methods for determining forest cover: data from national official statistics or data from the Global Forest Resources Assessment by the Food and Agriculture Organization of the United Nations (FAO).

Point 2:

“For biomass growth rates, TOOL30 recommends using Table 4.9 from the IPCC’s 2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories. This is a more recent source of data, which makes it more appropriate for current estimates. However, the data

[2] CDM TOOL30-based methodology and fNRB developed by third-party experts contracted by C-Quest Capital.

presented for each land-use and land-cover category includes up to three values that vary with the age of the forest area in question. These growth rates can differ by up to a factor of 10. Project developers can obtain wildly different fNRB values depending on which growth rates are used. As with forest and non-forest areas, clearer guidance about the use of age-based MAI values is required if a version of TOOL30 is going to be used in future methodologies. For example, the Copernicus data cited above could be integrated with tree cover data from a source like Global Forest Watch to create less ambiguous estimates of growth rates."

In our application of CDM TOOL30 v4.0 for determination for fNRB, we avoid the application of a single Mean Annual Increment (MAI) value across entire forest stands in an area of interest, regardless of ecological zone or age. Instead, the methodology we rely on disaggregates tree cover into global ecological zones. This disaggregation allows for the application of respective MAI values corresponding to different ecological zones. Additionally, the primary tree cover data, and the tree cover gain data, sourced from Hansen spatial data for 2000 to 2020 allows for the disaggregation of tree cover stands below 20 years of age and above 20 years of age. Consequently, respective MAI values, can be applied to the corresponding ecological zones and ages of the stands, resulting in a more precise estimation of biomass growth, ultimately enhancing the accuracy of this CDM TOOL30-based fNRB assessment.

The developers of MoFuSS further highlight the following differences between the MoFuSS model and the CDM model:

Point 3:

"Though both TOOL30 and the MoFuSS use biomass growth parameters such as Mean Annual Increment (MAI) and Current Annual Increment (CAI) respectively, to define long-term average wood growth, in case of TOOL30 biomass growth parameters are applied to the entire land cover categories regardless of their conditions. In contrast, the new model relies on growth functions, which are specific to land cover type and ecological zone and vary with current stock levels. The model applies these functions at the pixel level, so that every pixel has a unique woody biomass production function. Therefore, it is expected that the model simulates biomass harvest and regrowth after harvest more realistically".

While the approach employed by the MoFuSS model may theoretically lead to more realistic growth estimates, the accuracy of the growth function must undergo cross-validation and peer-review, before the recently estimated fNRB are to be confirmed as the new defaults.

Furthermore, the MoFuSS developers further state that under TOOL30, biomass growth parameters are applied to the entire land cover categories regardless of their conditions. As mentioned under Point 2 above, the TOOL30-based approach we rely on for fNRB calculations disaggregates the land into distinct regions and ecological zones, and the tree cover according to age of stand, before respective IPCC MAI values are applied to the corresponding regions, ecological zones, and tree cover stand age.

Point 4:

"TOOL30 only considers accessibility in the sense that it removes protected areas from consideration of biomass supply. MoFuSS also accounts for protected areas but goes further by considering physical accessibility based on topographical features and the effort that wood fuel users must expend to access sources of woody biomass."

The above statement is inaccurate, as CDM TOOL30 accommodates and provides guidelines for defining geographically remote areas by considering factors such as proximity to roads or rivers. This provision is explicitly articulated on page 11 of CDM TOOL30 v4.0 as follows:

“To define ‘geographically remote area’, DNAs/PPs may consider proximity to roads or rivers. For example, forests/other wooded lands that are beyond the average distance travelled to collect fuelwood can be considered non-accessible. The information of the average travel distance may be sourced from national studies or peer-reviewed literature, or surveys in the project area. All areas that are accessible to either the forest industries or to individual households are ‘accessible’. Therefore, wood extraction by the forest industries and fuelwood collection by individual households should both be considered when estimating the ‘non-accessible areas.”

The TOOL30-based methodology we rely on sources data from recent road maps that encompass both classified and unclassified roads. Further a 2.5 km distance buffer is applied, designating that tree cover within this buffer area is considered accessible. The latter buffer was derived from peer-reviewed literature. Furthermore, the IUCN classification of protected areas is used in the analysis to ensure that only protected areas where harvesting is most unlikely to occur are excluded from the accessible forest area.

4.6. Conclusion

Considering the points raised, it would not be prudent to presume that the fNRB estimates derived from the MoFuSS model hold accuracy across all countries and administrative boundaries. The intricate nature of the model necessitates numerous assumptions and manipulations applied to the input data and analytical methods which may lead to inaccuracies and incorrect fNRB estimations. The variance between these values and the prior WISDOM model further supports this notion, considering that similar approaches were undertaken. While the methodology may be theoretically justifiable, it should still undergo validation, verification, and peer-review.

In this regard, the following is stated in the CDM Information Note: *“MoFuSS is a spatial analysis and modeling tool. After setting the input parameters, it can be run from cradle to grave with very little intervention.”* This is the referring to the user-friendly WeBMoFuSS tool that can be freely accessed by anyone via an internet browser. As it stands, to the best of our knowledge, this tool is not yet fully functional, and can only be run for Haiti. It is further stated in the Information Note that [the MoFuSS tool] *“It is also entirely free and open source, for the sake of reproducibility of results by anyone interested in doing so, or even going farther and using different datasets and parameters.”* While it is possible to download the backend source code/scripts/datasets, the accompanying instructions manual for the latter are currently incomplete (confirmed by the tool developers). Therefore, attempting to run the scripts to replicate and generate fNRB results and values from the MoFuSS tool at this stage is a very complex, technical, time-consuming, and detective-like task. Given the development stage in which the MoFuSS is currently at, exact reproducibility of fNRB default results published in the CDM Information Note is very cumbersome. Consequently, the UNFCCC/CDM and other Standards should delay ratifying the fNRB results published in the Information Note as the new defaults, until project developers and external consultants or experts have had an opportunity to fully run and test the MoFuSS tool.

For instance, the validation and verification of the estimated Above Ground Biomass (AGB) maps for accuracy is strongly recommended before officially adopting the fNRB estimates derived from them as defaults. Inaccuracies in the AGB inputs can have a cascading effect, introducing inaccuracies in the fNRB estimations, particularly given its sensitivity to changes in AGB. Likewise, the precision of the estimations related to population, consumption, tree growth, pressure index, and harvest should undergo validation and verification to ensure reliability.

Furthermore, it is essential to consider the UNFCCC Board's directive that these default estimates should align with the methods outlined in "TOOL30 Calculation of the fraction of non-renewable biomass." There may be discrepancies in this alignment, particularly since the determination of accessibility and harvest relies on a notably different approach.

Section 5: Preliminary comparisons of fNRB outputs between the MoFuSS model and a CDM TOOL30-based methodology

The below tables present a comparison of resulting fNRB values when respectively computed by the MoFuSS model and by a methodology following CDM TOOL30 — noting that the CDM TOOL30 is not a methodology in itself, but rather a set guidelines.

Table 1. Simple comparison of input parameters and resulting fNRB value for Malawi between the MoFuSS model and a CDM TOOL30-based methodology.

fNRB estimation for Malawi by MoFuSS model	fNRB estimation for Malawi based on methodology following CDM TOOL30 guidelines
Wood-to-charcoal conversion ratio, UNFCCC default factor applied **4**	Wood-to-charcoal conversion ratio, country-specific factor for Malawi, determined from research commissioned by CQC, applied **7**
Global average per capita consumption statistic for fuelwood applied = **0.40 t/capita/year**	Per capita fuelwood consumption in rural areas of Malawi determine from 3-day Kitchen Performance Tests conducted by CQC applied = **0.80 t/year/capita** Per capita charcoal consumption for Malawi from USAID Modern Cooking and Healthy Forests program (2019) applied = **0.26 t/year/capita** Urban fuelwood and rural charcoal consumption were conservatively excluded to reflect geographical usage patterns of the different fuels.
Estimated fNRB for 2020–2030 period **0.47**	Estimated fNRB for equivalent period **0.96**
Not applicable.	VMR0006 uncertainty deduction (26%) applied **0.70**

Table 2. Simple comparison of input parameters and resulting fNRB value for Ghana between the MoFuSS model and a CDM TOOL30-based methodology.

fNRB estimation for Ghana by MoFuSS model	fNRB estimation for Ghana based on methodology following CDM TOOL30

	guidelines
Wood-to-charcoal conversion ratio, UNFCCC default factor applied **4:1**	Wood-to-charcoal conversion ratio, country-specific factor for Ghana, determined from research commissioned by CQC, applied **10:1**
Global average per capita consumption statistic for fuelwood applied = **0.40 t/capita/year**	Per capita fuelwood consumption in rural areas of Ghana determine from 3-day Kitchen Performance Tests conducted by CQC applied = **0.80 t/year/capita** Per capita charcoal consumption for Ghana from CQC-commissioned research applied = **0.28 t/year/capita** Urban fuelwood and rural charcoal consumption were conservatively excluded to reflect geographical usage patterns of the different fuels.
Estimated fNRB for 2020–2030 period **0.20**	Estimated fNRB for equivalent period **0.93**
Not applicable	VMR0006 uncertainty deduction (26%) applied **0.67**

We further intend to perform sensitivity analyses of the MoFuSS model. This will first involve running the model to replicate the updated fNRB defaults presented in Information Note (CDM-MP92-A07), and secondly, the model will be run with different input data and parameters, including *inter alia* tree cover data, forest gains and losses data, per capita woodfuel and charcoal consumption statistics, wood-to-charcoal conversion ratios.

This will allow the assessment of the sensitivity of the MoFuSS model to one or more of the above input data and parameters and would at the same time constitute a comprehensive and appropriate peer-review and validation of the model, and fNRB default values generated for SSA thereof. Unfortunately, we have not been able to complete this peer-review and validation process within the short timeframe allocated for public comment, even after the extension was granted.

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