Cookstoves and REDD+
Understanding woodfuel's impact on tropical forests

Key Points

- Woodfuel use is responsible for around 800 $MtCO_2$ per year, or 2% of global GHG emissions. This is equivalent to entire annual GHG emissions from the aviation sector.
- Combined, China, India, Indonesia, Ethiopia and Pakistan account for 50% of GHG emissions from household woodfuel use.
- For many countries in Sub-Saharan Africa, woodfuel GHG emissions are roughly half the size of nationally reported GHG emissions.
- Annual GHG emissions from woodfuel consumption are equivalent to roughly a quarter of gross GHG emissions from deforestation in the tropics.
- GHG emissions from woodfuel use in some countries are up to nine times greater than reported GHG emissions from deforestation.
- Adoption of clean cooking technologies could reduce GHG emissions by as much as 214 $MtCO_2$ per year, and dedicated woodfuel plantations would reduce GHG emissions by a further 734 $MtCO_2$ per year.
- Considerably larger areas of land would need to be set aside for sustainable plantations in countries with high woodfuel demand.
- The international mechanisms known as REDD+ represent a promising source of finance for clean cookstoves and offer synergies in addressing forest degradation as well as delivering social benefits.

Introduction

The use of woodfuel for cooking and heating is a vital source of energy for an estimated two and a half billion people in developing countries.[1] It has also become an increasingly discussed topic in climate change mitigation, both within the international climate change negotiations on reducing greenhouse gas (GHG) emissions from deforestation and forest degradation (REDD+), and within the private sector where there has been an increase in clean cooking solutions offered in developing countries under the Clean Development Mechanism (CDM) and voluntary carbon markets.[2]

While there has been considerable research within the international community on the contribution of deforestation and forest degradation to global GHG emissions[3] and the role of cooking in causing forest loss[4], very little empirical data exists on GHG emissions from woodfuel use for cooking and the corresponding contribution to forest loss.

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Using recent data from Yale/UNAM, the UN Energy Statistics Database, WHO, UN FAO, and recent scientific literature, this study draws together research on woodfuel consumption and deforestation to understand the impact of woodfuel use on forest loss, and the potential for clean cooking technologies to address the resulting GHG emissions.

Where is woodfuel used?

Most woodfuel is consumed in a small number of countries. China, India, Indonesia, Brazil and Ethiopia account for more than 50% of woodfuel consumption.

> "Countries with the highest household reliance on woodfuel are generally located in Sub-Saharan Africa"

Perhaps unsurprisingly, countries with a high percentage of households using woodfuel as a main source of energy for cooking are likely to be Least Developed Countries (LDCs). In comparison, the number of households reliant on woodfuel in India (54%) and China (20%) is relatively low.

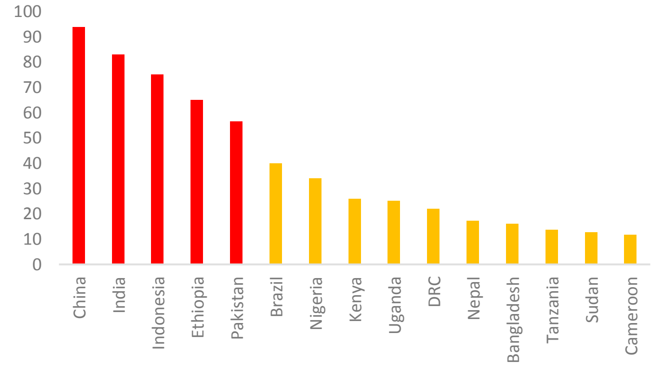
Of those households consuming woodfuel, the average amount consumed per household per year varies greatly between countries, with households in Latin America tending to use larger quantities of woodfuel than households in Sub-Saharan Africa.

Emissions from woodfuel use

Forests and trees naturally regenerate and not all woodfuel combustion is a source of GHG emissions. In order to determine the quantity of wood that is non-renewable (i.e. harvested at a rate that is beyond the ability of the forest to regenerate), the total quantity of woodfuel consumed can be multiplied by a 'fraction of non-renewable biomass' (fNRB). Our study uses Yale/UNAM values for fNRB that are based on existing geo-referenced global data and national/sub-national statistics.

Using the Yale/UNAM 'expected' fNRB figures, households in the sample countries emit roughly 800 Mt CO_2/yr through woodfuel use[5]. In terms of absolute GHG emissions, China emerges as the largest overall emitter (12%), followed by India (11%) Indonesia (10%), Ethiopia (8%) and Pakistan (7%). Combined, these countries account for 50% of total GHG emissions from household woodfuel use, and just 15 countries account for 75% of total GHG emissions (see Figure 1).

Figure 1 Total GHG emissions from woodfuel use in non-Annex I countries using mid-fNRB values, chart (Mt CO2/yr). Red = 50% of total GHG emissions, red+ orange = 75% of total GHG emissions



The most significant woodfuel using countries in comparison to national GHG emissions, however, are those of the global south and in particular LDCs. Woodfuel GHG emissions in many Sub-Saharan African countries are roughly half of total GHG emissions, and the fraction is even higher in Bhutan, Rwanda, Liberia, and Uganda, where woodfuel GHG emissions are equal to or greater than nationally reported annual GHG emissions.

Woodfuel use and forest loss

In the 1970s, it was widely feared that a growing gap between woodfuel consumption and the rate of supply from forest land would lead to mass deforestation in developing countries within a few decades (the "fuelwood gap" theory).[6] This theory proved unfounded due to a number of factors including higher regenerative capacity of forest land than initially thought, the harvesting of woodfuel by communities from non-forest areas, the availability of other fuels and the fact that woodfuel demand decreases with scarcity.[7]

> "The global population has doubled since 1970, while forest cover has depleted, altering the dynamics of supply and demand for woodfuel"

Notwithstanding these concerns, the global population has doubled since 1970, increasing four-fold in Africa,[8] whilst at the same time forest cover has depleted in many countries with high woodfuel use, altering the dynamics of supply and demand for woodfuel. Furthermore, a comparison in terms of scale and orders of magnitude is important in order to understand to what extent GHG emissions from woodfuel use compare with GHG emissions from deforestation (rather than as a subset of those GHG emissions). Complicating the issue are several important factors:

- Woodfuel can be harvested from both forest and non-forest land, whereas many existing deforestation studies tend only to focus on biomass loss occurring on forestland
- Woodfuel collection is largely a process of degradation rather than deforestation, yet existing global studies that use satellite monitoring have thus far been unable to capture these GHG emissions
- The quality of data for woodfuel use and the proportion of woodfuel that is unsustainable (i.e. that leads to forest loss) have, historically, been rudimentary

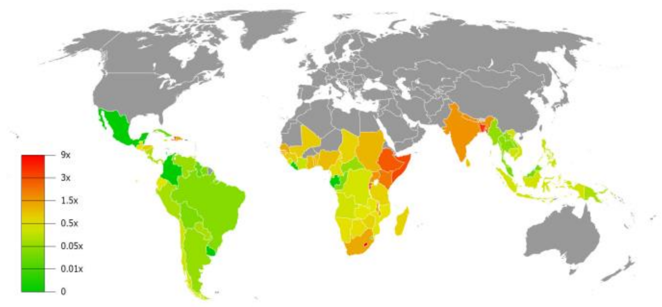
Nonetheless, there is a strong argument that woodfuel harvesting, where it leads to biomass loss from forest or non-forest land (excluding plantations for woodfuel production), should be accounted for as a GHG emissions source in the same manner as GHG emissions from deforestation and degradation. REDD+ accounting systems in countries with high woodfuel use should adopt forest definitions, and consider forest-degrading activities that go beyond traditional national inventories if they are to capture the majority of GHG emissions from biomass conversion.

Our study compares GHG emissions from woodfuel use with GHG emissions from deforestation in the tropics from Harris et al.[9], which finds that gross emissions from deforestation between 2000 and 2005 were approximately 3.0 $GtCO_2$ per year. As a crude estimate therefore GHG emissions from woodfuel use are roughly a quarter of deforestation GHG emissions in the tropics.

> "GHG emissions from woodfuel use in some countries are up to nine times greater than reported GHG emissions from deforestation"

Bangladesh and Ethiopia have particularly high GHG emissions from woodfuel relative to deforestation and in most East African countries, woodfuel GHG emissions are at least the same and often greater than GHG emissions reported from deforestation (see Figure 2). By way of contrast, woodfuel GHG emissions are dwarfed by deforestation GHG emissions in most countries in Latin America.

Figure 2 Size of household woodfuel GHG emissions relative to GHG emissions from deforestation/degradation according to Harris et al. (2012). Figures for China are not included in the Harris study



A second, important indicator of scarcity of woodfuel is the ratio of annual non-renewable biomass (NRB) consumption to known forest carbon stocks. Using data from Baccini et al.[10], ten countries in Africa stand out as having very high rates of NRB consumption as a percentage of forest carbon stock (see Table 1). All of these countries have higher GHG emissions from woodfuel use alone than average global deforestation rates in developing countries.[11]

Table 1: **Top 10 countries household non-renewable biomass GHG emissions as a percentage of remaining above ground biomass (figures from Baccini et al.)**

Country	Woodfuel GHG emissions ($ktCO_2/yr$)	Forest carbon stocks ($ktCO_2$)	Rate of loss of forest carbon stock
Rwanda	4,879	20,455	1.77%
Kenya	25,833	148,909	1.29%
Burkina Faso	6,402	38,182	1.25%
Eritrea	2,150	13,364	1.20%
Haiti	5,013	31,636	1.18%
Burundi	3,296	21,000	1.17%
Uganda	25,179	166,909	1.12%
Ethiopia	65,081	519,000	0.93%
Nigeria	34,100	446,182	0.57%
Senegal	3,551	48,000	0.55%

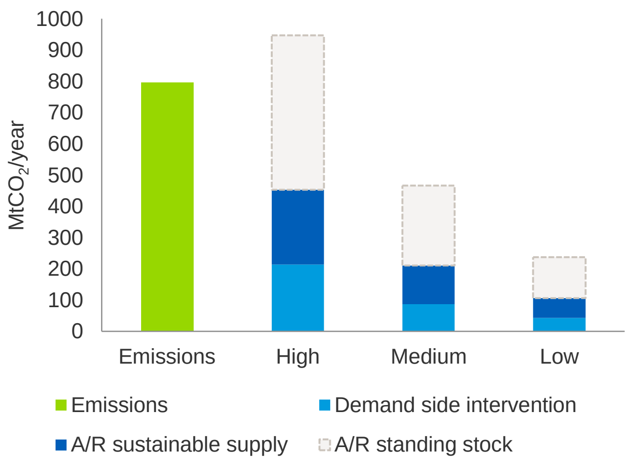
Mitigating potential

Although woodfuel is a major source of GHG emissions from deforestation and forest degradation, these can, to a large extent, be avoided. Activities to address the impact of woodfuel can be divided into two broad groups:

- **Demand-side options**: these technologies address the demand for non-renewable biomass by burning biomass more efficiently or by replacing the use of biomass with different fuels, such as biogas, solar cookstoves or briquettes made from waste or renewable feedstock.
- **Supply-side options**: these approaches address the sustainability of biomass at production to ensure that biomass consumption does not lead to deforestation. This includes afforestation and reforestation and improved forest management.

Under a high adoption scenario (more than 130 million clean cookstoves adopted by 2020), demand-side technologies could mitigate up to 214MtCO_2/yr, equivalent to approximately 27% of woodfuel GHG emissions. Assuming a high scenario of supply-side activities (more than 130 million hectares of new woodfuel plantations) a further 734 MtCO_2 could be mitigated per year: 240 MtCO_2 through increases in sustainable supply, and 494 MtCO_2 from sequestration in new standing stock (see Figure 3). Combined, these reductions would reduce emissions by 948 MtCO_2, more than offsetting total GHG emissions from woodfuel use. There are, however, considerable barriers to reaching this potential scale of GHG emissions reductions, as well as lessons from experiences in REDD+ countries.

Figure 3: **Emission reduction potential from replacement cookstoves and afforestation/reforestation according to high adoption scenarios and expected-fNRB values (MtCO2/yr)**



Conclusions

REDD+ represents a promising source of finance to support the implementation of clean cooking solutions and related supply-side mitigation options. A large proportion of current REDD+ finance is being targeted to address woodfuel consumption. Of the eight countries supported by the Forest Investment Programme, four specifically integrate reduced woodfuel use into the proposed investment plans; and six of the eleven countries in the funding pipeline of the FCPF Carbon Fund make reference to improved woodfuel use in the program idea notes. There are, however, some key barriers to overcome in aligning REDD+ finance with clean cookstoves and fuels:

- Methodologies to quantify GHG emissions reductions from clean cookstoves are currently not consistent with REDD+ accounting approaches. Effort is needed to ensure that GHG emissions are accounted for accurately from cookstove use.
- Clear land tenure and effective law enforcement is a precondition for countries that aim to improve the sustainability of woodfuel production.
- Domestic energy policies, where they are not aligned with environmental objectives, can create perverse incentives for woodfuel producers and consumers

Notwithstanding these challenges, REDD+ objectives are closely aligned with those of the clean cooking sector, and closer alignment between these two processes offers synergies in addressing forest degradation as well as delivering other social and environmental benefits.

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[1] FAO (2010), Forestry Paper, Criteria And Indicators For Sustainable Woodfuels

[2] Clean cookstove projects had a 24% share of the voluntary carbon market in 2013. *See* Forest Trends (2014), State of the Voluntary Carbon Markets 2014

[3] See e.g. Harris, Nancy L., et al. (2012) "Baseline map of carbon emissions from deforestation in tropical regions."

[4] See e.g. Skutsch, M. Ghilardi, A (2008) Energy Access in REDD+:

[5] Using CDM fNRB values the figure is much higher at 1.36 Gt CO_2/yr and Yale 'minimum' figures for sustainable woodfuel use produce a value of 400 Mt CO_2/yr .

[6] See Erik P. Eckholm (1975), The Other Energy Crisis: Firewood, Worldwatch Institute.

[7] See John C. Woodwell (2002), Fuelwood and Land Use in West Africa: Understanding the Past to Prepare for the Future, International Resources Group,

[8] Figures calculated from UN (2013), World Population Prospects, The 2012 Revision, Volume I: Comprehensive Tables.

[9] Harris, Nancy L., et al (2012) Baseline map of carbon emissions from deforestation in tropical regions. *Science* 336.6088: 1573-1576

[10] Baccini, A., et al. (2012) Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps, Nature Climate Change 2.3.

[11] According to FAO (2010), Forest Resource Assessment, deforestation rates are on average around 0.5% of remaining forest area per year in developing countries