Food and Agriculture Organization
of the United Nations

THE CHARCOAL TRANSITION

Greening the charcoal value chain to mitigate climate change and improve local livelihoods

Executive summary

KEY POINTS

- About half the wood extracted worldwide from forests is used to produce energy, mostly for cooking and heating. Of all the wood used as fuel worldwide, about 17 percent is converted to charcoal.
- Global charcoal production is expected to continue increasing in coming decades. The charcoal sector, which is largely informal, generates income for more than 40 million people, but a lack of regulation means that it promotes inefficiency and governments forgo billions of dollars in revenue.
- An estimated 1–2.4 Gt CO_2e of greenhouse gases are emitted annually in the production and use of fuelwood and charcoal, which is 2–7 percent of global anthropogenic emissions. These emissions are due largely to unsustainable forest management and inefficient charcoal manufacture and woodfuel combustion.
- The greening of the charcoal value chain has considerable potential for reducing greenhouse gas emissions on a global scale. It can be done at all stages of the value chain, especially in wood sourcing and carbonization but also in transport, distribution and end-use efficiency.
- Five actions needed for the greening of the charcoal value chain are:
  1. Simultaneously initiating multiple interventions for reducing greenhouse gas emissions, targeting the entire charcoal value chain.
  2. Increasing the financial viability of a green charcoal value chain by reforming tenure, increasing legal access to land and resources, providing evidence-based evaluations of the benefits of the charcoal sector for national economies, putting a fair price on wood resources, incentivizing sustainable practices, and attracting investment for a transition to a green charcoal chain.
  3. Developing comprehensive national policy frameworks for the sustainable management of the charcoal value chain and integrating charcoal into wider efforts across sectors to mitigate climate change, including by making the charcoal value chain a specific component of nationally determined contributions.
  4. Supporting national governments and other stakeholders in their efforts to green their charcoal value chains through research and the provision of reliable data.
  5. Disseminating the lessons learned from pilot projects, success stories and research that take into account the entire charcoal value chain.

Fuelwood and charcoal are important sources of energy for households and small industries in developing countries. More than 2.4 billion people – about one-third of the world's population – still rely on the traditional use of woodfuel for cooking, and many small enterprises use fuelwood and charcoal as the main energy carriers for purposes such as baking, tea processing and brickmaking. An estimated 50 percent of the wood extracted from forests worldwide is used as fuelwood and charcoal.

Charcoal production in particular has risen in recent decades as demand has grown among urban populations and enterprises. Where demand is high, mainly in sub-Saharan Africa (SSA) but also in Southeast Asia and South America (Figure S1), unsustainable wood harvesting and charcoal production contribute to forest degradation and deforestation and to greenhouse gas (GHG) emissions along the charcoal value chain, especially when charcoal is produced using inefficient technologies. Charcoal produced using sustainably managed resources and improved technologies, however, is a low net emitter of GHGs, thereby helping mitigate climate change while also increasing access to energy and food and providing income-generating opportunities.

World leaders have affirmed the urgency of climate-change mitigation in the 2015 Paris Agreement, and many new commitments to reduce GHG emissions – expressed in nationally determined contributions (NDCs) – refer to forestry and land-use measures. Opportunities for emission reductions in the charcoal sector are not well reflected in NDCs, however, and the potential role of the charcoal value chain in mitigating climate change – and how to realize this potential – is poorly understood.

A green charcoal value chain is the efficient and sustainable sourcing, production, transport, distribution and use of charcoal, resulting in improved human well-being and social equity and reducing environmental risks and ecological scarcities. It is low-carbon, resource-efficient, produced from sustainably sourced wood, and socially inclusive.

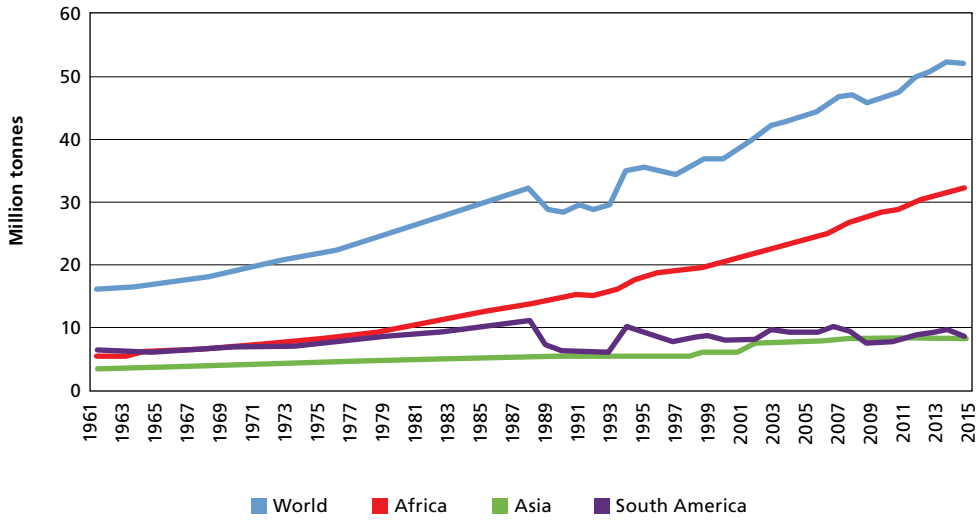
This report provides knowledge on existing charcoal production and use, GHG emissions along the charcoal value chain, technologies for increasing the efficiency of charcoal production and use, the costs and benefits of greening the charcoal value chain, and policy options for a climate-smart charcoal sector. **It assesses the potential contributions of a green charcoal value chain to climate-change mitigation and improved livelihoods with the aim of informing policy-makers and other stakeholders.** Annexes present a range of data on charcoal production and use and are intended for researchers and others with an interest in detailed information on aspects of the charcoal value chain.

THE CHARCOAL VALUE CHAIN

The charcoal value chain involves the collection or cutting of wood at the source (e.g. forests, woodlands, shrublands, agroforestry systems and woodlots, and from wood-processing operations), the carbonization of wood in kilns, the transportation, trade and distribution of charcoal, and consumption by households or enterprises.

The use of sustainably sourced wood for charcoal production is generally low. Most of the charcoal consumed in low-income countries is manufactured (i.e. carbonized)

FIGURE S1
Wood charcoal production worldwide and by region (Africa, Asia and South America), 1961–2015



using simple technologies with low efficiencies (10–22 percent). On the consumption side, the use of traditional stoves with low energy efficiency prevails. The extent to which charcoal production drives deforestation is not fully quantified and varies greatly among and within countries; it depends on the production method, the intensity of harvest and the regenerative capacity of the wood source, the availability of alternative wood sources, and the impacts of other deforestation drivers, such as agriculture.

Unsustainable charcoal production causes net GHG emissions and affects natural resources such as forests, water, biodiversity and soils. Charcoal production and consumption can have negative impacts on the respiratory health of people, but it also provides incomes, livelihoods and energy security.

GREENHOUSE GAS EMISSIONS FROM THE CHARCOAL VALUE CHAIN

It is estimated that traditional wood energy (fuelwood and charcoal) emits 1–2.4 Gt of carbon dioxide equivalent (CO_2e) per year, which is 2–7 percent of total anthropogenic GHG emissions; SSA accounts for one-third of GHG emissions from wood energy. The high level of uncertainty around the GHG emissions associated with wood energy reflects the wide range of underlying assumptions on wood regeneration rates and charcoal consumption.

GHG emissions are generated at various stages of the charcoal value chain, with the sustainability of wood harvesting and the efficiency of charcoal production technologies the greatest determinants of overall GHG emissions. In very inefficient operations,

the emission of GHGs in charcoal production (including due to forest degradation and deforestation) can be as high as 9 kg CO_2e per kg charcoal produced.

Given increasing demand for charcoal, a continuation of unsustainable charcoal production and use can be expected to exacerbate climate change, which, in turn, could affect the health and productivity of forests and woodlands and thereby reduce future wood-energy supplies in many places of the world. In the absence of realistic and renewable alternatives to charcoal in the near future, greening the charcoal value chain is essential for mitigating climate change while maintaining the access of households to renewable energy.

INTERVENTIONS IN THE CHARCOAL VALUE CHAIN TO MITIGATE CLIMATE CHANGE

A greener charcoal sector can reduce GHG emissions throughout its value chain (Figure S2) and play an important role in national low-carbon growth strategies. Seven key technical interventions can help reduce GHG emissions at various stages of the charcoal value chain (Table S1).

Wood sourcing

The sustainable production of wood almost fully avoids net GHG emissions, and replacing unsustainable wood with sustainably managed resources, therefore, can substantially reduce overall GHG emissions in the charcoal value chain. Multiple options are available, such as sustainable forest management; sustainable community-managed woodfuel plantations; integrated food and energy systems; agroforestry and urban forestry; and the optimal use of biomass residues and waste streams. Demand for sustainable charcoal production can provide opportunities for afforestation and reforestation. Further efficiencies can be gained by reducing charcoal waste, such as by transforming charcoal dust into briquettes.

TABLE S1
Technical interventions for cleaner and more efficient charcoal production and use

Stage of charcoal value chain		Intervention
Sourcing of wood/charcoal	1	Sustainably manage source (e.g. natural forests, planted forests and community forests)
	2	Switch to alternative sources, such as agricultural waste, wood residues and wood outside forests, including agroforestry
	3	Process charcoal dust into briquettes
Carbonization	4	Better manage traditional kilns to increase efficiency and use improved kilns with higher efficiencies
	5	Cogenerate charcoal and electricity (in the case of industrial-scale production)
Transportation and distribution	6	Reduce fossil-fuel consumption in transportation
End use	7	Use improved cook stoves

Carbonization

In charcoal production, simple measures can potentially deliver large reductions in GHG emissions. Based on data from the literature and modelling, a shift from traditional kilns to highly efficient modern kilns could reduce GHG emissions at this stage of the value chain by 80 percent;[1] improved kiln technology combined with the cogeneration of charcoal and electricity (in the case of industrial-scale production) could reduce emissions by 50 percent or more.

Transportation and distribution

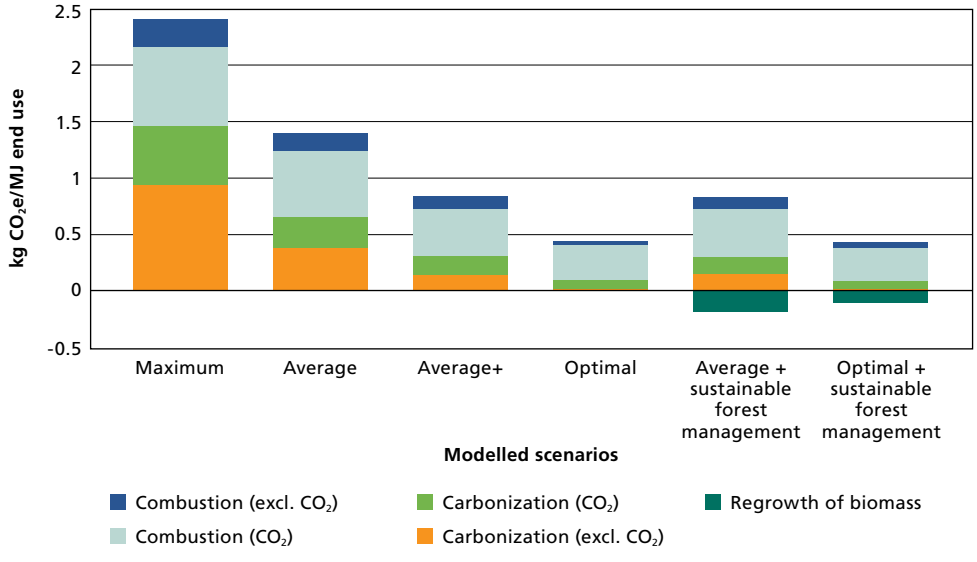
Transportation has relatively little impact on total GHG emissions in the charcoal production value chain. Reductions in fossil-fuel use could be achieved by optimizing the transport mode; reducing the distance between wood sources, carbonization plants and consumption centres; and the efficient handling of the product.

End use

The use of fuel-efficient stoves for cooking and heating at the household level increases charcoal use efficiency and reduces GHG emissions. Based on data from the literature and modelling, a transition from traditional stoves to improved (state-of-the-art) stoves could reduce GHG emissions by 63 percent.[1] The introduction of more efficient furnaces for (small-scale) industries would also result in lower emissions.

FIGURE S2

Modelled estimates of greenhouse gas emissions in the charcoal value chain, for various scenarios and underlying assumptions, based on 100-year global warming potential



[1] Based on 100-year global warming potential, including CO_2.

The climate-change mitigation impacts of a greener charcoal value chain can be optimized by the simultaneous introduction of multiple interventions, and the impacts will be especially high when interventions contribute to biomass regrowth. Modelled scenarios for miombo woodlands, for example, indicate that the introduction of multiple interventions could reduce GHG emissions in the overall charcoal value chain from 2.4 kg CO_2e per megajoule (MJ) end use to 0.4 kg CO_2e per MJ end use, and to 0.3 kg CO_2e per MJ end use when biomass regrowth is considered – a reduction of 86 percent.[2]

Despite this potential and the efforts made so far, the uptake of interventions to green the charcoal value chain is relatively low and largely project-based. Substantial efforts are required to create an enabling environment for the scaling up of interventions, including the introduction of favourable policies and the creation of an attractive investment climate for a green charcoal sector.

ECONOMIC COSTS AND BENEFITS OF GREENING THE CHARCOAL VALUE CHAIN

The charcoal sector has considerable economic value (for example, an estimated US$650 million and US$1.6 billion annually for the United Republic of Tanzania and Kenya, respectively), and there are opportunities for generating revenues – for example through taxation and licensing fees – that could be partly reinvested to create a more sustainable charcoal value chain, including by encouraging forest restoration and sustainable charcoal sourcing. At present, however, dedicated wood resources for sustainable charcoal production are rarely considered economically viable due to the undervaluing of resources and their consequent overharvesting and unsustainable management and inefficiencies in carbonization and end use. At the national level, the charcoal sector is characterized by lost revenue opportunities in the form of foregone taxation and licensing fees and by hidden costs associated with environmental and human-health externalities.

The financial viability of greening the charcoal value chain compared with business as usual requires that a price is placed on (currently often open-access) resources and that sufficient economic incentives are in place for sustainably managing those and other wood resources; sustainably managed forests may be too expensive when de facto open-access sources of wood are also available. The use of waste wood from timber production will become more viable as the price of charcoal increases. The change from traditional to improved kilns and the more effective management of traditional kilns requires investment but will also generate higher charcoal outputs per tonne of feedstock. The use of improved stoves for cooking and heating is most cost-effective in places where charcoal (and alternative energy) prices are high.

The greening of the charcoal sector would increase the sustainability of income for the more than 40 million people globally involved in commercial fuelwood and charcoal

[2] Based on 100-year global warming potential. Note that results are illustrative; they are based on a scenario involving many underlying assumptions and should not be used to define the climate-change mitigation impacts of different options.

production. African countries could potentially reinvest US$1.5 billion–3.9 billion in greening the charcoal value chain from annual revenues they currently forego because of the sector's informality. Countries could also attract climate-change-related funds for avoided deforestation and GHG emissions, including by using their NDCs to provide long-term policy signals and developing pipelines of viable projects. Another less visible but important benefit of a greener charcoal sector is a reduction in the cost of health care and environmental remediation, especially in the longer term.

The transition from unsustainable to sustainable sourcing and from informal to formal institutions can impose costs on the charcoal value chain, such as those associated with sustainable resource management. The transition will require the transfer of capacity and knowledge on efficient carbonization and end-use practices and technologies. A cost–benefit analysis in Kenya, for example, estimated that a transition to efficient charcoal production would require an investment of US$15.6 million per year (excluding upfront costs). On the other hand, it would generate US$20.7 million in benefits and therefore would have an overall positive economic impact.

POLICY OPTIONS FOR A CLIMATE-SMART CHARCOAL SECTOR

The charcoal value chain operates in a multilayered, multisectoral regulatory environment. Appropriate government policies are required to attract the investments needed to introduce improved charcoal-production technologies at scale, within the overall context of national forest, energy and land-use planning.

Given that charcoal consumption is expected to increase in some countries in coming decades, charcoal – and its integration into development, energy, environment, land-use and food-security strategies – must be afforded high priority in national development agendas. A long-term policy vision is required to both improve the sustainability of the charcoal value chain and diversify and democratize clean-energy options to reduce pressure on forests caused by soaring charcoal demand. The coherence of charcoal policies with globally recognized principles and regimes increases the legitimacy and effectiveness of the sector and helps align it with other national efforts. Developing countries with high levels of charcoal use should consider options for greening the charcoal value chain in their NDCs and development strategies.

The greening of the charcoal value chain will require enabling policies related to incentives, benefit distribution, the sustainable management of wood resources, land-use planning, landscape management, and a green economy. Differentiated taxation can incentivize the sustainable sourcing and production of charcoal, and revenues from fees and licences can be reinvested in technological improvements. Subsidies can cover start-up costs and encourage producers and end users to transition to more efficient technologies. International financial mechanisms linked to climate-change mitigation, such as the Clean Development Mechanism and reducing emissions from deforestation and forest degradation (known as REDD+), can provide additional financial incentives.

Improved forest law enforcement and governance can help increase government revenue collection and investments in sustainable forest management and efficient wood conversion technologies. Providing local people with greater tenure security can increase their willingness and ability to invest in sustainable approaches. Transferring responsibilities and financial and human resources to local authorities can help in the introduction of sustainable forest management and charcoal production.

Certification initiatives can guide the implementation of a sustainable charcoal value chain and help in monitoring. Policies can be put in place to encourage the involvement of private-sector actors in disseminating improved technologies and establishing marketing systems for sustainable products.

Planning and decision-making processes for charcoal governance will benefit from the participation of all stakeholders – government, the private sector, producers and consumers. Transparency in revenue streams and the accountability of all actors are crucial for optimizing the contributions of the charcoal sector to national economies and local communities. A sound institutional framework – including organizations of forest managers, tree-growers, charcoal processors and traders – is needed to coordinate initiatives to develop a sustainable charcoal value chain and to clarify the mandates of stakeholders. The development of such a framework requires strong collaboration among stakeholders, sectors and levels of government.

The reform of the charcoal value chain should encourage strong relationships among key stakeholders and should be sensitive to the risk of corruption and the exclusion of minorities. Policies for regulating and improving the value chain must ensure that measures are taken to secure and protect the energy access rights of those who lack other options.

RECOMMENDATIONS FOR GREENING THE CHARCOAL VALUE CHAIN

1. Promote multiple simultaneous interventions at scale across the entire value chain to substantially reduce GHG emissions.
2. Ensure the financial viability of a green charcoal value chain by improving tenure arrangements and legal access to resources for growing and purchasing wood and other biomass for charcoal production, generating evidence-based assessments of the benefits of a green charcoal value chain for national economies, putting a fair price on wood resources, incentivizing sustainable practices, and attracting investments for the transition to a green charcoal value chain.
3. Develop comprehensive national policy frameworks for the sustainable management of the charcoal value chain and integrate charcoal into wider efforts across sectors to mitigate climate change, including by making the charcoal value chain a specific component of NDCs.
4. Support national governments and other stakeholders in their efforts to green the charcoal value chain by contributing to research in the following areas:
    - systematic life-cycle assessments of the charcoal value chain in the main charcoal-producing countries;
    - systematic data on GHG emissions in the various stages of the charcoal value chain;
    - the role of charcoal production in deforestation and forest degradation, including in combination with other deforestation and forest degradation drivers in the vicinity of cities; and
    - the socio-economic and environmental outcomes and trade-offs of a green charcoal value chain at the local, subnational, national and regional levels.
5. Disseminate the lessons learned from pilot projects, success stories and research that take into account the entire charcoal value chain.

The full report, *The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods*, is available at **www.fao.org/forestry/energy**

COVER PHOTO: © CIFOR/M.EDLIADI

Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00153 Rome, Italy
www.fao.org

I6934EN/1/03.17