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Criteria and indicators for sustainable woodfuels

IEA Bioenergy

Cover image:
Children who carry heavy loads of woodfuel, such as these in Myanmar, risk a range of injuries
FAO/FO-6814/M. Kashio

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Foreword

Wood energy is the dominant source of energy for over 2 billion people, particularly in households in developing countries. Biofuels, especially fuelwood and charcoal, currently provide more than 14 percent of the world's total primary energy. Social and economic scenarios indicate a continuous growth in the demand for woodfuels which is expected to continue for several decades.

The dependence on woodfuels is greatest in developing countries, where they provide about one-third of total energy. In some subregions of Africa, as much as 80 percent of energy is derived from biofuels. Fuelwood and charcoal, the most commonly used wood-based fuels, are vital to the nutrition of poor rural and urban households in developing countries. In addition to being used for domestic cooking and heating, they are often essential in food processing industries for baking, brewing, smoking, curing and producing electricity.

In developed countries, wood is increasingly used as an environmentally sound source of energy (mainly for heat and power generation). As a potential substitute for fossil fuels, wood energy can help reduce greenhouse gas emissions.

FAO's programme on wood energy promotes sustainable wood energy systems as a contribution to sustainable forest management, livelihoods and food security. To this end, FAO and the International Energy Agency (IEA) Bioenergy Task 31 developed a project to evaluate principles, criteria and indicators applicable to woodfuel systems to ensure sustainability. IEA Bioenergy Task 31, "Biomass production for energy from sustainable forestry", is an international collaboration of nine countries in Europe and North America and is one of 13 task groups under the auspices of the IEA Bioenergy Implementing Agreement.

This publication assesses the environmental, social and economic issues as well as the legal and institutional frameworks that can ensure the sustainable production of woodfuels from forests, trees outside forests and other sources. The study continues FAO's long interest in wood energy issues and complements the many other FAO reports on wood energy and sustainable forest management. It was funded in part by the FAO-Netherlands Partnership Programme and IEA Bioenergy Task 31. The publication was revised and edited by Alastair Sarre and prepared for publication by Andrea Perlis and Simmone Rose.

FAO trusts that this publication will raise awareness and understanding of the important role of woodfuels in energy systems and promote the sustainable management of these systems.

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Acronyms and abbreviations

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CDM	Clean Development Mechanism
EJ	exajoule(s)
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
G8	Group of Eight industrialized nations
HS	Harmonized Commodity Description and Coding System
IEA	International Energy Agency
MJ	megajoule(s)
OECD	Organisation for Economic Co-operation and Development
PEFC	Programme for the Endorsement of Forest Certification
PJ	petajoule(s)
RSB	Roundtable on Sustainable Biofuels
RWEDP	Regional Wood Energy Development Programme
TJ	terajoule(s)
UN	United Nations
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping model
WTO	World Trade Organization

1. Introduction

Reliable, secure and safe energy sources are fundamental to the well-being and social and economic development of all societies. In 2005, global energy demand was 467 exajoules (EJ), 88 percent of which was met by fossil fuels (IEA, 2007). With continuing population growth, global energy demand is expected to grow an additional 50 percent by 2030, mostly in rapidly industrializing countries such as China, India and Brazil (OECD/IEA, 2008). With growing pressures on energy resources, and such a heavy dependence on non-renewable fossil fuels, the world faces two key energy-related problems:

- the lack of a secure and affordable supply;
- the threat of overconsumption leading to irreversible environmental damage through climate change and the overexploitation of resources.

Many governments are developing renewable energy resources to offset fossil-fuel use, a phenomenon driven by three main factors (Silveira, 2005):

- the urgent need to provide developing nations with locally available, clean and reliable sources of energy to help reduce poverty and meet development goals;

In both developed and developing countries, wood-based biomass – woodfuel – is receiving increasing attention as a potentially renewable energy resource

D. MEAD

- global commitments to reducing greenhouse gas emissions;
- growing concerns for energy security and supply.

In some countries, increasing privatization of electricity and heat markets and a consequent shift to decentralized alternatives is also helping to drive a shift from fossil-fuel-based energy to renewable alternatives. One renewable energy option receiving attention is biomass because a wide variety of biomass feedstock sources and technologies is available at various scales. This publication focuses on one major source of biomass energy, woodfuels.

Woodfuels are any type of biofuel derived directly or indirectly from trees and shrubs grown on forest and non-forest land (FAO, 2004). They are gaining in popularity as awareness grows of their potential not only for energy but also for fostering rural development, reducing soil degradation, improving forest health through active management, revitalizing forest industries and offsetting carbon emissions from fossil fuels.

In many developing countries, woodfuels are still commonly used for household cooking and heating. Woodfuels are also important in many rural processing industries and village applications, such as those related to the processing of coffee, tea, tobacco and coconuts. Woodfuels are used in the local manufacture of bricks, lime, ceramics and certain textiles, and, in Brazil, charcoal is used on a large scale in the pig-iron, steel and cement industries. In addition, woodfuels are often an important component of the food supply chain, used, for example, for smoking fish and making bread, beverages and street food.

While woodfuels are still used for domestic heating in developed countries, industrial uses have grown in recent years. In particular, wood-processing

In developing countries, woodfuel is still commonly used in rural processing industries, such as this brick-making facility in Brazil

FAO/FO-5406/M. TROSSERO

industries often use their wood by-products for energy production and, in some countries, notably the Nordic countries, there has been rapid growth in the use of forest residues for industrial-scale electricity generation and heating.

Woodfuels are increasingly price-competitive with fossil-fuel alternatives and the environmental benefits of woodfuel are now being recognized and valued. In addition to these benefits, woodfuels provide social benefits, such as the creation of additional employment, especially in rural areas.

In most countries, policies and programmes to promote woodfuels specifically and bioenergy development in general are still in their early stages. Such policies and programmes tend to be limited in scope, with more attention being paid to regulatory measures than to investments in areas such as research and development, market liberalization, information and training. To date there has been relatively little transfer of technology or information about bioenergy from developed to developing countries.

Several developing countries have enormous potential to produce energy from forests and trees outside forests with relatively low investment and risk, but this potential is not properly reflected in national energy-development strategies. Poor forest management and a lack of reliable data – often exacerbated by widespread illegal forestry operations – frequently limit the assessment of the full economic and social potential of woodfuel production.

If woodfuels are to provide a viable alternative to fossil fuels in the long term, the sustainability of the production system is critical. This publication, which sets out principles, criteria and indicators designed to guide the sustainable use of woodfuels, including charcoal, is applicable to all systems for the production and use of woodfuels worldwide. It focuses on practices at the tree-management level, which constitutes the first link in the woodfuel supply chain.

GLOBAL WOODFUEL USE

Primary solid biomass accounts for almost 10 percent of the world's total energy production (Sims *et al.*, 2007). The percentage for developing countries is much higher, ranging from 13.5 percent of total energy production in Latin America to 19 percent in Asia and 26.2 percent in Africa. About 36 EJ of the energy obtained from solid biomass is collected as woodfuels from forests and trees outside forests in developing countries, of which about 3 EJ is used for charcoal production.

The world's woodfuel production amounted to 1.89 billion m^3 in 2007, almost 53 percent of the world's total roundwood production (FAO, 2009a). Most of the woodfuel production took place in Asia (42 percent of the world total), Africa (32 percent), and the Americas (18 percent) (mostly Latin America). Additionally, 102 million m^3 of wood residues were used for woodfuel; Europe and Asia produced most of this (59 percent and 26 percent, respectively). About 45 million tonnes of wood charcoal were produced worldwide in 2007. Africa, Latin America and Asia dominated this production, with 55 percent, 27 percent (29 percent in all the Americas) and 15 percent of total world output, respectively (Table 1).

An estimated 2.4 billion people use wood and other forms of biomass for

TABLE 1
World production of woodfuel, wood residues and charcoal, 2007

Region	Woodfuel (roundwood)		Wood residues		Charcoal	
	Quantity *('000 m^3)*	**Share** *(%)*	**Quantity** *('000 m^3)*	**Share** *(%)*	**Quantity** *('000 tonnes)*	**Share** *(%)*
Africa	603 089	32.0	625	0.6	24 765	54.8
America	332 800	17.6	12 535	12.3	13 033	28.9
Asia	786 648	41.7	26 555	26.0	6 659	14.7
Europe	152 604	8.1	59 969	58.8	689	1.5
Oceania	11 041	0.6	2 300	2.3	24	0.1
World	1 886 182	100	101 985	100	45 171	100

Note: Totals might not tally because of rounding.
Source: FAO, 2009a.

cooking and heating, mainly in developing countries (UN-Energy, 2007), and at least 34 developing countries derive more than 70 percent of their energy from woodfuels (Mead, 2005). In many African and Asian nations, virtually all people in rural areas rely on traditional biomass sources for their cooking, heating and other energy needs.

Although the demand for domestic woodfuels is leading to forest loss in a limited number of peri-urban areas, particularly in Africa, in most places this demand has not yet led to significant deforestation (Mead, 2005). Most domestic woodfuels used in developing countries today come not from forests but from scrub, bush fallow and the pruning of farmland or agroforestry trees. In contrast to domestic use, however, clearing associated with agriculture and the harvesting of fuelwood for small-scale industries such as brick-making, tea-curing and tobacco-drying is a significant agent of deforestation in many developing regions.

In addition to meeting national energy needs with woodfuels, it is likely that some developing countries will become major sources of biomass feedstock to meet the demands of growing bioenergy markets in industrialized countries. This trade could create opportunities for developing economies but will also bring with it concerns about environmental, social and economic sustainability. Sustainability standards are therefore important to ensure that the woodfuel trade does not benefit consuming countries at the expense of producing countries.

Currently, woodfuels meet much less of total energy demand in developed countries than they do in developing countries; in many developed countries woodfuel use is limited to rural areas, where it may have recreational, cultural or lifestyle values. Thirty percent of the wood harvested in developed countries (usually logging by-products such as tops, stems and branches, and industrial by-products such as black liquor from pulp and paper mills) is used for energy, but, on average, this meets only 2 percent of total energy demand (Mead, 2005).

Nevertheless, woodfuels are being used in some countries for industrial-scale energy production: half of the wood harvested in Finland, for example, is used as

In many developing countries, woodfuel is still the predominant source of domestic energy

woodfuel, providing 20 percent of the nation's overall energy demand (Statistics Finland, 2009), while 19 percent of the energy consumed in Sweden comes from biomass, largely from forests. In the European Union, markets for pellets and woodchips for use in household-scale to industrial-scale plants have been growing rapidly (Kaltschmitt and Weber, 2006). Given such success, the industrial-scale use of woodfuels may increase substantially in the future.

UNDERSTANDING THE TERMINOLOGY

The rapid development of the bioenergy sector has resulted in a lack of standardization that can sometimes lead to confusion. The FAO Forestry Department has therefore created a Unified Bioenergy Terminology to standardize terms for all stages of the forest-derived bioenergy supply chain, from feedstock production and handling through to energy conversion and use (FAO, 2004). This publication follows that terminology. For example, although the term "biofuel" is often used in European Union legislation and the popular media to refer to liquid fuels such as ethanol and bio-diesel derived from a biological (usually agricultural) source, a biofuel is defined here as "any fuel produced directly or indirectly from biomass" (FAO, 2004). The term "woodfuels" is used in this publication to encompass all types of biofuel derived directly and indirectly from trees and shrubs (i.e. "woody biomass") grown on forest and non-forest land. The term "fuelwood" is used to describe woodfuel where the original composition of the wood is preserved.

PATHWAYS AND PRODUCTS

This publication focuses primarily on the initial stages of feedstock procurement – that is, the management and harvesting of the resource. For this reason, discussion on woodfuel-conversion processes and sustainability issues beyond the initial stages of feedstock procurement is limited. It is useful, however, to know the energy products that can be derived from woodfuels and the various conversion pathways that connect these products to the raw materials from which they are derived. Table 2 sets out the basic terms, processes and pathways in woodfuel-based energy production. There are two main pathways for extracting products: biochemical, in which biological and chemical agents are used, and thermochemical, in which heat and chemical agents are used. More information on woodfuel-based energy production processes can be found in Hoekman (2009) and Cassidy (2008).

SOURCES OF WOODFUEL SUPPLY

Woody biomass for energy can be derived from a variety of primary sources, including natural and planted forests and trees outside forests.

Natural forests

Throughout the world and particularly in developing countries, a great deal of woodfuel is harvested – both formally and informally – from natural forests, including on public and private forest land and land for which there is no secure tenure, and also, in some instances, in protected areas.

Trees outside forests

Trees outside forests (e.g. urban trees, roadside trees, hedges and scrub) are often particularly important sources of woodfuels in developing countries. Trees in agroforestry systems are also classified as trees outside forests and are another major source. Agroforestry, defined as tree cover of greater than 10 percent on agricultural land, is found on 46 percent of the total agricultural land area globally (about 1 billion hectares) and on over 80 percent of agricultural land in Southeast Asia, Central America and South America (Zomer *et al.*, 2009). The tree component of agroforestry systems can range from relatively dense canopies of one or several species, to widely spaced trees with low canopy cover, to rows of trees or shrubs used primarily as shelter for livestock and the protection of crops, or as riparian buffers. Woodfuels can be derived from whole trees and also from pruning and trimming operations.

Plantations

Planted forests supply an estimated 15–20 percent of the world's woodfuels, whether in the form of residues from industrial timber and pulp plantations or as whole trees from dedicated bioenergy plantations (Mead, 2005). In 2005 there were an estimated 141 million hectares of plantations worldwide, almost 80 percent of which were established for production purposes as opposed to protection (FAO,

TABLE 2
Main energy conversion processes for woody biomass

Pathways	Process	Primary energy products
Biochemical	**Fermentation** Acid pre-treatment is used to break down hemi-cellulose and make remaining material accessible to saccharification (breakdown into sugars) Cellulase enzymes are introduced to hydrolyse carbohydrate material into sugars Sugars are fermented to produce ethanol Remaining lignin (unreacted) is recovered for use as fuel or thermochemical feedstock	Ethanol; methanol; residual cellulose and lignin used as a boiler fuel for generating heat and steam for electricity
	Anaerobic digestion Biomass is placed in a digester, where it is broken down by bacteria under fixed temperatures and anoxic conditions to produce gases that can be used to produce energy	Biogas, methane
Thermochemical	**Direct combustion** Unprocessed (raw wood, branches, etc.) biomass is burned directly for domestic cooking and heating Unprocessed or processed (e.g. chipped or pelletized) biomass is used for co-combustion or full combustion in steam plants, for heat production in small to medium-sized boilers, and for heat and steam production in small-scale combined heat and power plants	Heat, electricity
	Gasification High temperatures decompose lignocellulosic material Partial oxidation produces raw synthesis gas Syngas is cleaned, conditioned and catalytically reacted to produce either mixed alcohols or Fischer–Tropsch hydrocarbons Resultant hydrocarbons are refined to produce biodiesel	Combustible gases (carbon monoxide and hydrogen), biodiesel
	Pyrolysis Involves thermal decomposition similar to that involved in gasification but at lower temperatures and in the absence of oxygen	Liquid fuels (primarily bio-oil), charcoal

Source: Hoekman, 2009 and Bram, de Ruyck and Lavric, 2009.

2006). Of this area, 8.6 million hectares – including 6.7 million hectares in Asia – were being grown specifically for woodfuel, mostly consisting of fast-growing trees such as *Populus*, *Salix*, *Eucalyptus* and *Acacia* species. In Brazil, for example, 25 percent of *Eucalyptus* plantations (4 million tonnes of biomass annually) are grown specifically to provide charcoal for the pig-iron, steel and cement industries (Andersson *et al.*, 2002; Ceccon and Miramontes, 2008).

This Eucalyptus *plantation in Brazil is grown specifically for charcoal production*

Residues from forest harvesting

Any part of a tree can be used for energy, including the tops, branches, crowns, foliage, stumps and roots (Röser *et al*., 2008). Residual materials left behind in the forest after harvesting and generated by manufacturing operations constitute 24–50 percent of the total volume of harvested wood (Hall, 2002; Mead, 2005). Forest residues can provide a sustainable source of woodfuel provided that adequate quantities are left behind in the forest for ecological purposes. Residue harvesting can be integrated with timber-management operations to decrease interventions in the forest and to gain economic efficiencies. Nordic countries currently achieve the greatest integration between woodfuel harvesting and final felling operations using machines that compact residues into cylindrical bales. See Andersson *et al*. (2002) for more information on residue collection, storage and transportation.

Salvage harvesting

In some forests, sick, dying and dead trees in stands damaged by fire, wind, disease or insects can be removed for use as woodfuel (Hall, 2002). For example, 10 million hectares of forests in Canada have been badly affected by the mountain pine beetle epidemic; some of the dead standing trees could be harvested for bioenergy (Stennes and McBeath, 2006). Forest stands degraded by poor harvesting and management or natural disturbances can also be rehabilitated by salvage harvesting and still leave behind enough material to support biodiversity. Lindenmayer, Burton and Franklin (2008) have reviewed the environmental impacts of salvage harvesting in forested ecosystems). Damaged or dead urban wood in developed countries can be a large source of biomass when salvaged; it has been estimated, for example, that 30 million tonnes per year is available in the United States of America (Richter *et al.*, 2009).

Silvicultural thinning

The periodic thinning of stands to reduce competition and replace natural self-thinning could increase overall stand yields by 15–30 percent (Hall, 2002). Thinning is also an important tool for fuel-load reduction in forest regions with a high fire risk (Andersson *et al.*, 2002). Otherwise unmerchantable trees and residues from such thinnings can be used as woodfuel, thereby increasing renewable energy potential and making thinning more cost-effective.

THE SUSTAINABILITY OF WOODFUELS, AND TOOLS FOR ASSESSMENT

Demand for woodfuels is growing. This is due partly to population growth, particularly in developing countries, and partly, in the European Union, the United States and some other countries, to ambitious targets for the increased use of bioenergy (Commission of the European Communities, 2008; Sissine, 2008). Policy incentives, carbon taxes, carbon trading schemes and technological developments will likely continue to accelerate demand. The result will be increased pressure on forests and trees outside forests as a source of feedstock. Without guidelines and standards to protect environmental, social and economic values, the environmental, social and economic costs of woodfuel production could outweigh the benefits. Moreover, developing countries may have to bear

Compacted spruce residue bundles ready for use as fuelwood, Finland

M. KUKKOLA

These debris piles from salvage logging of mountain pine beetle-killed lodgepole pine, British Columbia, could be used as woodfuel

a disproportionate amount of these costs because of their rapid population growth and likely role as major woodfuel suppliers for much of the demand from developed countries. There is already an international woodfuel trade (mainly in the form of ethanol and wood pellets), and flows are likely to increase as new suppliers and consumers are brought into the fold (Kaditi, 2008).

Consumers are starting to demand that the bioenergy industry be sustainable. The European Commission's Biomass Action Plan, for example, states that liquid biofuels produced to meet European Union targets must meet minimum sustainability requirements if they are to be counted as renewable (Commission of the European Communities, 2008).

Global standards for the management and production of woodfuels that can be adapted at local and national scales, therefore, are critical. A standard bioenergy certification scheme is being investigated as one method for helping to ensure sustainability in both producing and consuming countries. Recent initiatives to develop criteria and indicators that could be used to certify sustainable biomass production include criteria developed in the Netherlands by the Cramer Commission (Cramer, Wissema and Lammers, 2006), those of the Roundtable on Sustainable Palm Oil (2005, 2009), and a preliminary version of criteria for bioenergy certification in the European Union developed by the Roundtable on Sustainable Biofuels (2008).

Growing public interest in forests has led to the development of the concept of sustainable forest management to govern their management. A number of definitions of sustainable forest management exist, but the term is used here to mean the management of forests for maximum social and economic benefits without compromising (and, ideally, even enhancing), over time, environmental values such as forest health, productive capacity, biodiversity, soil, water and carbon sequestration. Sustainable forest management should encompass all activities in a forest, including woodfuel production and harvesting. A number of tools and frameworks for designing, implementing and monitoring sustainable forest management have been developed that can be applied to woodfuel production, including:

- legislative and voluntary standards generated by governing bodies (including regulatory policies, guidelines and best management practices);
- criteria and indicators;
- market-based forest certification systems;
- adaptive management.

Adaptive management and criteria and indicators are conceptual frameworks, while legislative and voluntary standards and certification systems are formalized tools designed to put conceptual frameworks into effect.

CRITERIA AND INDICATORS

Forest certification is used by forest management entities to establish proof of sustainable forest management in the market, while international criteria and indicator processes are used by national governments to monitor and report on the implementation of sustainable forest management.

Criteria serve to define and describe management goals, while indicators act as quantitative or qualitative variables that can be measured or described and which can show trends over time (Montreal Process Working Group, 2005).

Criteria and indicator frameworks can be implemented at a number of levels, including local, provincial, national and international. They can help to organize and transmit existing information, identify gaps in knowledge, and structure the gathering of new information to feed back into forest management frameworks. Criteria and indicators are therefore a potentially useful tool for the rapidly changing and growing woodfuel industry.

Criteria and indicators can be implemented through national programmes, international processes or certification systems. In some regions and for small-scale operations, however, the adoption of criteria and indicators and the implementation of certification systems can be constrained by cost and by a lack of capacity: currently, the majority of the world's certified forests are found in developed countries. If criteria and indicators are to play a major role in ensuring sustainable woodfuel production globally, they must be flexible and adaptable for application in different regions, by different types of operations and at different scales.

The two sets of criteria and indicators contained in this publication are designed to be easy to understand, enforceable, quantifiable, specific, and flexible enough to be adapted according to region and capacity (van Dam *et al.*, 2008).

They are based on the following structure (after Lammerts van Beuren and Blom, 1997 and CIFOR, 1999):

- Principle: a "fundamental truth or law as the basis of reasoning or action"; principles justify the chosen criteria, indicators and verifiers.
- Criterion: a "standard that a thing is judged by"; criteria enhance the meaning and operability of principles, but do not measure performance.
- Indicator: "any variable or component of the forest ecosystem or management system used to infer the status of a particular criterion"; indicators describe specific information about a criterion, and can be measured by verifiers.

STRUCTURE OF THIS BOOK

Chapter 2 examines international certification processes and schemes with relevance to woodfuels. Chapter 3 reviews existing policies and institutional frameworks for sustainable woodfuels at the international level, uses the frameworks of some countries to illustrate the options available at the national or sub-national level, and describes some of the policy and institutional challenges associated with woodfuel production. Chapter 4 canvasses social and cultural aspects of woodfuel production, Chapter 5 looks at economic aspects, and Chapter 6 examines key environmental issues. Chapter 7 sets out four principles for sustainable woodfuels and, under each, a number of criteria and indicators. Chapter 8 presents a set of principles, criteria and indicators specific to charcoal production, and Chapter 9 makes two recommendations for further progress in the development of effective policies for sustainable woodfuels.

2. Existing criteria and indicator systems

Forest certification schemes, and also other types of certification schemes, could be applied to or integrated into a certification system for sustainable woodfuels. Several fundamental conditions must exist, however, before such schemes make an effective contribution to the sustainability of woodfuels. They would need to:

- apply to the most important sources of woodfuels and include operational definitions of them;
- identify and define relevant forest-derived and other woodfuels;
- include the unique impacts associated with woodfuel production and harvesting;
- require that monitoring, assessment, management and auditing systems exist;
- be dynamic and operate within an adaptive management framework;
- interact synergistically and cooperatively with other governing bodies;
- be accessible to a wide range of woodfuel producers.

This chapter reviews how various sustainability systems fit with these requirements and identifies needed improvements.

OVERVIEW OF INTERNATIONAL PROCESSES AND SCHEMES

Forest certification is dominated by two global systems. The Forest Stewardship Council (FSC) accounts for about one-third of the total global area of certified forest (113 million hectares; FSC, 2009a), while the Programme for the Endorsement of Forest Certification (PEFC), an umbrella organization that endorses otherwise independent national schemes, covers about two-thirds (211 million hectares; PEFC, 2009). Only about 8 percent of the world's forests is certified, mostly in North America and Europe.

In typical certification schemes, core documents set out the various elements of the certification process, including standards for sustainable forest management and the chain of custody, requirements for standard-setting, certification procedures, the accreditation of certification bodies, and mechanisms to control sustainability claims.

Forest management standards are expressed as a hierarchical system of principles, criteria and indicators and are usually valid at a national level; in some cases, sub-national standards are used for specific regions or forest types within a country. The international FSC principles and criteria (FSC, 2002) form the basis of all FSC forest management standards. The standards of PEFC-endorsed schemes are more diverse but must meet minimum requirements. About half of European-country PEFC schemes are structured according to the criteria and indicators of the Ministerial Conferences on the Protection of Forests in Europe

("Pan-European Process"); a few schemes follow the international FSC standard, and others have a unique structure. Several market-based certification schemes for green electricity or sustainable biomass also include sustainability requirements for forest biomass and forest management.

Nine international processes for developing criteria and indicators for sustainable forest management currently exist for different regions or groups of countries worldwide. Each of these processes uses between one and three sets of criteria and indicators, which may be valid for a subset of member countries or at different scales (FAO, 2001a).

The more thoroughly the strengths and weaknesses of current forest certification schemes are understood in relation to woodfuels and the closer their linkages with legislation and other governance tools along the supply chain, the greater the likelihood that existing forest certification schemes can be expanded to play an effective role in supporting societies' sustainable energy supplies. The following discussion of forest certification schemes is based on a review of more than 125 forest management standards from more than 50 countries on five continents, as well as other relevant documents produced by FSC, PEFC, certification schemes for green electricity and sustainable biomass, and international processes for the development of criteria and indicators. Most of these standards are fully accredited by the relevant scheme, but some are interim standards or drafts. Further information on the review is available in Stupak *et al.* (2010).

FOREST CERTIFICATION SCHEMES

Woodfuel sources

Confusion over woodfuels in statistics and forest certification can be caused by a lack of clarity about various potential sources. Woodfuel may be harvested in a forest (the definition of which may be subject to argument or interpretation), either natural or planted, and also outside the forest. The extent of natural forests is often unclear: in the Philippines, for example, the official definition of forest land (land with a slope greater than 18 degrees) suggests that over 50 percent of the country is forested, but actual forest cover is much less than half that (FAO, 2009c). The certification of plantations can be controversial, with critics arguing that they are not "true" forests and should not be certified (Lohmann, 2003); there is also considerable variation in the ways in which plantations are treated in certification schemes. Woodfuel from sources outside forests, including open woodlands, savannas and agroforestry systems, are often important but are rarely quantified with any accuracy. Finally, secondary and tertiary woodfuel sources, such as the by-products of industrial processes and wood reclaimed after other uses, should be considered, even if the original sustainability properties of such wood sources are unknown or cannot easily be traced.

Terms such as "forest", "plantation" and "woodland" are sometimes defined in FSC and PEFC glossaries, but generally not in an operational manner. Occasionally, national standards include definitions that are more operational, but woodfuel sources outside forests are usually not addressed or their sustainability considered. On the other hand, the FSC and PEFC chain-of-custody certification and logo usage rules allow sustainability claims not only for recycled wood of certified origin but also for certain reclaimed materials of unknown origin. The Rainforest Alliance's SmartWood programme offers verification services for recovered wood according to its sustainability standard (SmartWood, 2009).

Identification of woodfuels

Confusion may also arise if forest-derived woodfuels are not explicitly defined or categorized. In principle, forest certification schemes apply to all forest goods and to the management practices employed in their production and harvesting. Such schemes, however, are generally most concerned with logging for timber production. Some schemes explicitly define and address non-timber forest products, but woodfuels are rarely a major focus.

Environmental issues related to woodfuel production and use

Environmental issues that need to be addressed in the production and use of woodfuels include:

- the loss of productivity and soil fertility and the use of compensatory forest fertilization;
- the minimization of harvesting residue and fire risk while maintaining adequate amounts of deadwood for biodiversity purposes;
- the risk to forest health and biodiversity posed by temporary woodfuel storage in the forest;
- physical soil damage and loss of water quality due to an increased number and new types of forest operations;
- the loss of biodiversity and other environmental values due to the conversion of forests to fuelwood plantations;
- changes in greenhouse gas emissions and carbon sequestration due to fossil-fuel substitution, land-use change and plantation establishment.

These and other issues, including those relating to economic and social costs and benefits, are addressed by forest certification schemes under a variety of general criteria. Box 1 presents some environmental arguments for and against woodfuel harvesting in forests.

Monitoring, assessment, management, certification and auditing

Forest management plans and monitoring and assessment systems are used to ensure that criteria and indicators are met or not violated. Based on monitoring and assessment results, new and more sustainable practices can be developed, with third-party certification and auditing providing an independent control. The effectiveness and credibility of the auditing depends on the verifiability of the indicators, the types of verifiers used (e.g. field visits, reporting, and documents), the frequency of the auditing, and the practices and independence of the certification and auditing companies.

Monitoring and assessment is covered in one of the ten FSC principles. FSC

BOX 1

Debatable issues in woodfuel production and harvesting in forests

Argument	Counter-argument
Leaving residues in the forest as substrates for biodiversity and ecological functions and to provide a protective skid-trail mat	Removing residues to ensure the efficient use of harvested resources and to protect against pests and wildfire
Avoiding the use of chemicals in the forest	Applying compensatory fertilization, liming or wood-ash recycling to offset increased nutrient removals and accelerated soil and water acidification
Avoiding storage in the forest because of the risk of pest insects or the loss of rare species that use dead biomass as habitat	Storing biomass in the forest to shed nutrient-rich needles and reduce moisture content
Avoiding soil disturbances, including ploughing, deep tillage, scarification and operations causing erosion	Stump-harvesting for energy purposes and root-rot abatement
Maintaining genetic diversity for resilience	Improving yield and efficiency through the use of exotic species and genetically modified organisms
Restoring degraded forest lands for subsistence use by local communities and to improve environmental conditions	Establishing energy plantations on degraded forest lands to produce sustainable biomass for industrial energy needs
Limiting the collection of fuelwood to prevent overuse	Giving local people the right to collect fuelwood in the forest

national standards often indicate the level of research and data needed to monitor a minimum number of indicators, including, for example, changes in the composition of the flora and fauna and the environmental and social impacts of harvesting. PEFC standards that are structured according to FSC principles also include specific criteria and indicators for monitoring and assessment. Another of the ten FSC principles concerns forest management plans, and national FSC standards often specify what a management plan should include (e.g. objectives, resources, ownership status, profile of adjacent lands, silvicultural and management systems, annual harvest rates, environmental safeguards, monitoring, protected areas, and the consideration of rare, threatened and endangered species). PEFC-endorsed schemes also include requirements on management planning, either in the criteria of the forest management standard or separately.

Both FSC and PEFC requirements for the accreditation of certification bodies and the quality of the certification and auditing are based on the standards and guidelines of the International Organization for Standardization. Both the FSC scheme and the PEFC scheme include three main types of audit: initial, surveillance, and reassessment. The initial audit is carried out in connection with the original certification and, thereafter, surveillance audits are carried out with a maximum period of one year between them. The certificate is valid for three to five years, after which a reassessment audit must be performed.

Adaptive management

Adaptive approaches are fundamental to forest certification. Thus, national FSC and PEFC forest management standards and individual certificates must be reassessed within a three- to five-year period. While there are no formal requirements for the revision of their core documents, both FSC and PEFC are currently performing governance reviews aimed at doing so.

Interactions with other governance tools

Forest certification schemes already draw directly on a large body of governance tools (Box 2). Both FSC and PEFC require that all national laws and regulations are respected. A list of key legislation and international agreements is sometimes annexed to standards, or relevant legislation is referred to under individual criteria.

Both FSC and PEFC require that the eight core conventions of the International Labour Organization are respected. FSC requires that other international

BOX 2

Synergy between forest certification and other governance tools

There is general consensus in Brazil that certified forest operations fulfil legal requirements and are in line with national forest policies and, for this reason, certified companies there are subject to fewer governmental audits (Purbawiyatna and Simula, 2008). A similar situation applies in other countries, such as the Plurinational State of Bolivia, where there is a high compatibility between legislation and the requirements of forest certification (Contreras-Hermosilla and Rios, 2002) It has also been shown that forest operations taking place in those states in the United States with mandatory best management practices require fewer changes during forest certification processes than in those states where adherence to best management practices is voluntary (Newsom, Bahn and Cashore, 2006).

agreements are respected by signatory countries, while PEFC relies on the implementation of ratified conventions through national legislation. Non-ratified conventions must be followed if they are expressed in the Pan-European Operational Level Guidelines and adherence to existing recommendations and guidelines may be specified in forest certification standards. On the other hand, various types of market-based certification schemes, such as schemes for sustainable biomass or green electricity, occasionally rely on forest certification schemes as proof of sustainable raw material production.

ACCESSIBILITY

Various initiatives have been taken by forest certification schemes to increase accessibility to forest certification, particularly for smallholders and community-forest enterprises. PEFC is actively working to include new member countries and to establish certification schemes in them. FSC offers a special standard for small-scale or low-intensity-managed forests, and both FSC and PEFC offer group certification. Group certification allows the joint certification of several small-scale forests so that each operator can benefit from the savings of scale while retaining control of their own forest and its management. FSC and PEFC also have policies on phased approaches to certification, and the Rainforest Alliance's SmartWood programme offers such an approach to FSC certification. The purpose is to provide opportunities for forest management enterprises that are pursuing the certification of their operations to gain access to potential market benefits as they do so.

Recognizing that significant volumes of wood are harvested in forests that do not have management plans, the SmartWood programme has also developed a standard and verification service to encourage better harvesting practices in such forests (SmartWood, 2009). Since 2005, the programme has also offered a phased ("stepwise") approach to certification.

INTERNATIONAL PROCESSES FOR SUSTAINABLE FOREST MANAGEMENT

The definitions of key terms and concepts, and the criteria and indicators themselves, may vary between countries and processes. There are, however, attempts to harmonize both definitions and criteria and indicators.

As is the case for forest certification standards, the criteria and indicators of international processes contain a wide range of general criteria for sustainable forest management that are relevant to the production and harvesting of woodfuels, which, nonetheless, are rarely addressed explicitly. An exception is the Pan-European Process, which encourages the development of supporting frameworks to enhance the use of wood for energy.

In some processes, indicators specific to woodfuels appear under criteria for the maintenance of productive functions or socioeconomic benefits. Usually they require that the availability, harvested amounts, value and share in total energy consumption of woodfuels be identified and reported.

Monitoring of the implementation and validation of criteria and indicators takes place via national reporting and regional summaries. Recently, the Pan-European Process added an external review and subsequent self-evaluation to its requirements. It is currently examining the possibility of establishing a legally binding agreement on sustainable forest management in the Pan-European region, which may lead to stronger enforcement and validation tools.

CERTIFICATION SCHEMES FOR SUSTAINABLE BIOMASS, BIOENERGY AND CARBON OFFSETS

Certification systems other than those for sustainable forest management also sometimes include sustainability requirements for woodfuels. For example, some green electricity certification schemes include criteria requiring that woodfuels are derived from local or national sources, or that forests should have environmental management systems, or that harvesting levels in forests should ensure that soil fertility is maintained in the long term. Some criteria also require that woodfuels do not originate from forests with high conservation values or sensitive ecosystems, or from plantations created after the clearing of old-growth or native forests. Some specify that material from endangered species or genetically modified organisms may not be used as woodfuel.

Schemes for the certification of green electricity or sustainable biomass may refer to forest certification as proof of woodfuel sustainability. The Green Gold Label, for example, includes a specific standard with criteria for forest management based on existing criteria of the FSC scheme and selected PEFC-endorsed schemes. Under this standard, biomass may be approved as eligible for the first four years but, beyond that time, approval may only be given if the forest is certified by an independent forest certification scheme approved by Green Gold Label. The Belgian Laborelec scheme accepts wood certified under FSC, some PEFC-endorsed schemes, and the Green Gold Label standard. It also accepts non-certified woody biomass as long as sustainability principles comparable to those of existing forest certification schemes are met and reported.

A crucial element in schemes for sustainable biomass is the reduction of greenhouse gas emissions along the supply chain. In contrast, greenhouse gas emissions criteria are generally lacking in forest certification. However, the use of the chain of custody to verify carbon footprints of forest products is currently being explored by the FSC Carbon Working Group (FSC, 2009b) and this may lead to useful solutions for inputs to greenhouse gas accounting at the supply-chain level.

CHALLENGES FOR THE DEVELOPMENT OF CRITERIA AND INDICATORS FOR SUSTAINABLE WOODFUELS

Systems that can ensure the sustainability of woodfuels are developing rapidly. Current forest certification systems already address several sustainability aspects relevant to woodfuels harvested in forests, but opportunities to develop better systems still exist. In summary, the challenges for schemes and systems aiming to ensure the sustainability of woodfuels are as follows:

- The definitions of woodfuel sources (i.e. forest, plantation, etc.) need to be harmonized and should be more operational. This is also the case for those categories of forest (e.g. high-conservation-value forests) in which woodfuel production should be prohibited or restricted.

- Sustainability issues associated with the primary, secondary and tertiary sources of woodfuels outside forests need to be clarified.
- The most important woodfuels should be defined as products or product groups in their own right, or should be assigned explicitly to an existing, well-defined product group, such as "non-timber forest products".
- Criteria and indicators for sustainable forest management need to be evaluated and updated to address specific aspects of woodfuel production and harvesting. National and sub-national impact analyses that have already been carried out in some countries would be useful tools.
- Criteria and indicators for greenhouse gas balances, including the effects of direct and indirect land-use change, need to be developed. Partnerships might be established between forest certification schemes and other schemes or tools that include such criteria.
- Criteria should require that the production and harvesting of woodfuels be addressed in management plans.
- Current monitoring and assessment systems need to be tailored to address specific woodfuel production and harvesting impacts.
- The risks of fraud, corruption and other illegal practices need to be examined and systems adjusted, as necessary, to combat them.
- Certification schemes need to use adaptive approaches.
- Benefits from partnerships with other certification schemes and other types of relevant governance tools should be pursued.
- Forest certification schemes need to identify the main obstacles to forest certification, especially in developing countries and countries with economies in transition, and further develop methods and initiatives that will increase their accessibility, particularly for smallholders and community-forest enterprises.

3. Policy and institutional frameworks for sustainable woodfuels

Although, globally, the consumption of woodfuel is greater than the consumption of industrial roundwood (FAO, 2009a), this is not reflected in the size and strength of the institutions, policies and laws designed to govern production. Great petroleum-producing nations have ministers for oil, but great wood-producing nations do not have ministers for woodfuel. Universities have faculties of engineering and forestry, but few professors or classes devote themselves to woodfuel. Major international agreements govern energy, trade and the environment, but there is no multilateral agreement that focuses on woodfuel.

This disparity between the importance of the woodfuel sector and the associated policy footprint usually has three common explanations. First, there may be a formal policy on woodfuels but it is divided up and appears under other headings (e.g. forests, energy, land tenure and trade). Second, the policies, institutions and rules may exist but are informal – embodied in rural community rules and customs, for example. Third, there may be a policy gap – an unfilled need for better planning and governance. This chapter examines the institutional, policy and legal frameworks with relevance to woodfuels, and identifies inadequacies.

RELEVANT INTERNATIONAL FRAMEWORKS AND AGREEMENTS

Environment

Woodfuels are produced mainly in natural forests and plantations and, therefore, any agreement that affects the management or use of forests or plantations could also affect woodfuel production. One United Nations (UN) agreement, the non-binding "Forest Principles" (UN, 1992), asserts that nations have a sovereign right to use and manage their forests but that such use should be sustainable and should serve social, economic and cultural needs. Principle 6(a) states that demand for fuels from forests should be met sustainably.

Chapter 11 of Agenda 21 (ECOSOC, 1992), another UN agreement, calls for the improved management of forests to produce a range of outputs, including "wood-based energy". Chapter 14 urges the greater development of renewable energy from forests and agriculture. Chapter 16, on biotechnology, calls for the identification of faster-growing strains of tree for woodfuel.

Chapter 12 of Agenda 21 sets out an agenda for combating desertification, including by improving the "management of forest resources, including woodfuel" and by reducing "woodfuel consumption through more efficient utilization,


FAO/FO-5701/P. DURST

Plantations are increasingly used for fuelwood production; a Leucaena leucocephala *plantation in India produced these sacks of charcoal and wood offcuts*

conservation and the enhancement, development and use of other sources of energy, including alternative sources of energy". The UN Convention to Combat Desertification came into force in 1996 and now has over 190 parties. It calls for the protection of forests and woodlands and capacity-building and public-awareness efforts aimed at reducing dependence on wood for fuel.

The Convention on Biological Diversity makes no specific mention of woodfuels or energy but deals with the use of biological resources generally. This binding convention requires that nations use biological resources sustainably. Its Article 10 calls for the sustainable use of biological resources and support for customary uses, Article 11 encourages the use of incentives to protect resources, and Article 14 calls for environmental impact assessment as part of planning. The parties to the Convention have adopted a set of implementing principles (the Addis Ababa Guidelines and Principles on Sustainable Use) that support the expansion of knowledge on biological resources; participatory management; and the equitable sharing of benefits.

The ninth session of the UN Commission on Sustainable Development, held in 2001, called for the expansion of "alternative" energy sources. The 2002 UN World Summit on Sustainable Development produced the Johannesburg Plan of Implementation, which, among other things, called for the increased use of renewable sources of energy and improved access to energy as a means of reducing poverty.

In the near term, climate change is the area of international policy development that will probably have the biggest impact on woodfuel use. The UN Framework Convention on Climate Change's Kyoto Protocol directs Annex I nations (roughly, developed nations) to pursue "research on, and promotion, development and increased use of, new and renewable forms of energy", and all parties to develop climate-change programs that address a broad spectrum of sectors, including energy and forestry. The Kyoto Protocol also established the Clean Development Mechanism (CDM), which encourages developed nations to offset some of their greenhouse gas emissions by promoting the use of improved technologies in developing nations. As international arrangements on climate change continue to evolve, forest management and woodfuels are likely to play increasing roles in climate-change mitigation programmes.

Energy

The close link between climate change and energy use has increased international interest in renewable energy. The 2004 International Conference for Renewable Energies, held in Bonn, Germany, produced, among other things, the following policy recommendations:

- It should be a policy priority to integrate renewable energy market policy into other aspects of policy (e.g. into forest policy).
- National governments should consider energy issues in non-energy-sector and cross-sectoral policies (e.g. in forest policies).
- Local authorities should address energy issues in their activities (e.g. forestry activities).

In 2005, at Gleneagles, Scotland, the Group of Eight industrialized nations (G8) adopted a Plan of Action on Climate Change, Clean Energy, and Sustainable Development which recognized the need to promote renewable energy and bioenergy (Gleneagles Dialogue, 2005). It also established the Gleneagles Dialogue on Climate Change, Clean Energy, and Sustainable Development. This process entailed four ministerial meetings (with the participation of 19 countries and the European Union) and interchange with businesses (through the World Economic Forum) and agencies such as the International Energy Agency (IEA) and the World Bank. The Gleneagles Dialogue report to the 2008 G8 summit mentioned, among other things, the need to consider forests and deforestation in energy and climate-change policies and the importance of promoting renewable energy (Gleneagles Dialogue, 2008).

The IEA, which operates within the framework of the Organisation for Economic Co-operation and Development (OECD) and advises the OECD's 28 member countries on energy policy, produced a report in support of the Gleneagles Dialogue (IEA, 2008). The report noted the importance of emerging technologies such as second-generation biofuels, which are liquid biofuels made from non-food sources (including short-rotation forests).

Trade

Historically, the majority of woodfuel trade has been informal and relatively local, but that is changing. Volatile prices for fossil fuels, increased demand for fuels that have low net emissions of greenhouse gases, and new technologies have all contributed to an increase in the international trade of woodfuels. The Commission of the European Communities (2006) observed that, in some cases, developing countries can produce woodfuels more cheaply than developed countries; the international trade of woodfuels, therefore, seems likely to grow significantly.

The World Trade Organization (WTO) will play a central role in key international decisions affecting the woodfuel trade. The WTO's 153 member nations have pledged to grant each other their lowest tariff rates ("most-favoured-nation status") on certain classes of commodities. They have also pledged not to compete unfairly against international trade through the use of tariffs and subsidies. In recent rounds of WTO negotiations, a group of large forest-products enterprises urged WTO members to reduce or eliminate tariffs on forest products. WTO members are considering the trade treatment of agriculturally produced biofuels, which may compete with woodfuels in the world marketplace.

In part, the treatment of woodfuels in world trade will also depend on how the World Customs Organization's Harmonized Commodity Description and Coding System (HS) classifies various woodfuels. Over 200 countries and the WTO use this system for classifying products and assessing tariffs. Wood, wood pellets and charcoal fall within Chapter 44 of the HS – "Wood and articles of wood, wood charcoal" – but further processing could move them to other chapters, such as Chapter 29, "Organic chemicals", or Chapter 36, which includes "certain combustible preparations" (charcoal, for example, may be traded as a component of gunpowder, a Chapter 36 item). The World Customs Organization classifies products new to trade on a case-by-case basis, through classification opinions.

If countries trade in minimally processed woodfuels, phytosanitation is also a concern. The International Plant Protection Convention may require surveillance and the certification of exports as pest-free – for example, the federal and state governments of the United States have placed quarantines on the movement of fuelwood from areas affected by the emerald ash borer, a destructive and invasive alien beetle (United States Department of Agriculture, 2009). The WTO, under its Agreement on the Application of Sanitary and Phytosanitary Measures, can limit the application of member-imposed phytosanitary measures if the measures arbitrarily hamper trade without an underlying scientific plant-protection justification.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which places restrictions on the sale of specimens of endangered species, could also affect the international woodfuel trade. Fuelwood, charcoal and other minimally processed woodfuels comprising tree species listed in the CITES appendices could not be traded internationally without certificates; enforcement would require a reliable certification system and the capacity among enforcement and customs agencies to identify the wood of such species. If the woodfuel was more processed – to produce a "second-generation" liquid woodfuel, for example – determining its species of origin would be more difficult.

FAO/FO-6963/A. LEBEDYS

The international trade of woodfuels, such as these Liberian rubberwood chips, seems likely to grow significantly

INSTITUTIONS AND POLICIES

Since many agencies are potentially involved in woodfuel production, processing, trade, marketing and use, it is important that there is coordination and collaboration among them. Some countries have institutionalized collaboration: for example, Mexico's recent Law for the Promotion and Development of Biofuels, which explicitly includes fuels derived from forestry activities in its definition of biofuels, mandates coordination through the creation of a new institution, Comisión Intersecretarial para el Desarrollo de los Bioenergéticos, made up of five ministries – those of Energy; Environment and Natural Resources; Agriculture, Livestock, Rural Development, Fisheries and Food; Economy; and Finance and Administration (Government of Mexico, 2008).

In Nepal, 33 district forest-products-supply committees – part of the Department of Forests – are responsible for local woodfuel supplies. The Forest Products Development Board and the Timber Corporation of Nepal, both national entities under the Ministry of Forests and Soil Conservation, run large-scale forestry enterprises and supply woodfuels to the market (FAO, 2009b). Authority is also divided among many agencies at the national level in the Philippines, where there are four resource-management and four energy agencies with influence over woodfuel use (FAO, 2009b).

In many countries, informal institutions, centred in tribes and communities, play a large role in determining access to forest resources (e.g. Pacheco *et al.*, 2008). In some countries, formal institutions are subverted by corruption or a lack of capacity, and forest use is subject to informal illegal structures.

POLICY TOOLS AND LAWS

Governments hoping to influence the use of woodfuels take regulatory, information-based, economic-based, or enforcement approaches, or, in most cases, a combination of these.

Regulation

A common approach is to regulate who can harvest woodfuels. Kenya's 2005 Forests Act, for example, includes fuelwood and charcoal in its definition of "forest produce" and makes it illegal to harvest forest produce from a state forest without a licence (Government of Kenya, 2005). Regulation may also be used to control the harvesting method and the transport of forest products: under Kenya's 2008 Forest (Harvesting) Rules, for example, a permit is required to transport charcoal, and loads are limited to five bags totalling 200 kilograms (Government of Kenya, 2008).

Government may regulate the processing of woodfuels, such as the place and manner of charcoal production. They may also regulate the use of woodfuels: in the United States, for example, there are detailed rules on papermaking processes that limit air and water pollution from mills producing and using black liquor (Government of the United States of America, 2009; United States Environmental Protection Agency, 2009). Some states of the United States regulate the sale of wood stoves to ensure they are equipped with pollution-control features (e.g. State of Oregon Department of Environmental Quality, 2009). Governments may regulate the disposal of wood ash, typically in industrial settings, and its recycling on forest or other lands. Finland, for example, treats wood ash applied to land as a fertilizer and sets limits on permissible concentrations of heavy metals, while Sweden has advisory guidelines on metal concentrations (Vesterinen, 2003).

Information

Governments realise that accurate information is essential for a robust and sustainable woodfuels sector. The Woodfuels Strategy for England (Forestry Commission undated), for example, calls for the creation of an information clearinghouse to promote good practice. In Sweden, landowners must give the Swedish Forest Agency notice of planned woodfuel harvests so that the agency may offer advice. The Liberia National Forestry Reform Law of 2006 mandates public access to most information held by the Forest Development Authority. Governments may require private entities to keep and disclose data and industrial woodfuel producers to maintain and provide records of production (Government of Liberia, 2006).

Governments can also assist the sector by providing a strategic framework for its development: the European Union directive on renewable energy, for example, mandates planning by member governments (EU, 2009); the Woodfuel Strategy for

England is an example of such a plan. FAO has developed a Woodfuel Integrated Supply/Demand Overview Mapping model (WISDOM) to support strategic planning and policy formulation. This geographic information system-based tool analyses woodfuel demand-and-supply spatial patterns to assess the sustainability of woodfuels as a renewable energy source (Masera *et al.*, 2006; FAO, 2008a).

Economic tools

A wide range of economic tools is available to governments to promote the woodfuels sector, including direct investment in the production of woodfuels on public lands, the construction of electricity-generation facilities that use woodfuels, and the provision of goods and services to private producers of woodfuels. Governments can also provide tax-based incentives (or disincentives) for woodfuels. Denmark, for example, exempts woodfuels (and other renewable fuels) from energy and carbon-dioxide taxes (Polito, 2000). In the United States there is a tax subsidy for blending biofuels with fossil fuels (see below). Governments can adjust tariffs up or down to promote local production or encourage imports and lower prices, and they can offer payments or low-interest loans to woodfuel producers or users. Finland offers direct subsidies when woodfuel is harvested during pre-commercial thinning (Government of Finland, 1996). Denmark subsidizes the conversion of residential heating from fossil fuels to renewable-energy sources (Polito, 2000). Governments can combine regulation with economic tools to create new forms of property, such as carbon credits for forest management or the displacement of fossil-fuel use. Governments can also recognize or assign property rights over a woodfuel resource, including to communities, with the aim of stimulating greater productivity and higher standards of management and bringing the resource under tighter control.

Enforcement

Governments may influence the woodfuel sector by the enforcement of existing or new laws and regulations. The phytosanitation quarantine provision in the United States, for example, carries a maximum civil fine of US$250 000 for violations, and potential criminal sanctions.

EXTERNAL STANDARDS FOR NATIONAL POLICIES

The various sets of criteria and indicators for sustainable forest management all include criteria and indicators related to policy and governance. Criterion 1 of the International Tropical Timber Organization's criteria and indicators for the sustainable management of tropical forests (ITTO, 2005), for example, focuses on planning, policies and institutions, and one of the seven criteria of the Montréal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests deals with legal, policy and institutional frameworks (Montréal Process Working Group, 2007).

The International Institute for Environment and Development has developed a diagnostic tool for good forest governance that considers rights, policies and processes, including the roles of stakeholders and institutions (Mayers, Bass and Macqueen, 2002). The Center for International Forestry Research has a "toolbox" of criteria and indicators for the sustainability of forest management generally, including those related to policies, planning and institutional frameworks (CIFOR, 1999). The Governance of Forests Initiative, led by the World Resources Institute, the Instituto do Homen e Meio Ambiente da Amazonia, and the Instituto Centro de Viva, has developed a draft set of land-tenure indicators (Governance of Forests Initiative, undated).

FAO has sponsored studies to develop criteria and indicators for woodfuel production and use in specific countries (FAO, 2009b). In the Philippines, for example, 183 specific indicators were devised for the sustainable production and management of woodfuels, while smaller sets were developed for Nepal and United Republic of Tanzania.

CHALLENGES

Data

The development of a database on woodfuel production is a complex process for a number of reasons, including the diversity of consumption patterns; variation in the heat contents of different woodfuel species; differences in the measurement of volume and weight; a lack of regular surveys on woodfuel supply and consumption; and divergence in the way woodfuel data are presented (FAO, 1997). In addition, the following may complicate the task:

- Despite efforts at standardization, data-collectors do not all use the same definitions of concepts such as "forest" or "woodfuel", leading to inconsistencies.
- Forest inventories may be biased towards the collection of information related to the production of fibre rather than woodfuels.
- Woodfuels come not only from forests but also from orchards, windbreaks, urban street trees and other sources that are often not assessed in inventories or surveys of wood production.
- The activities of some woodfuel harvesters, such as those operating informally or exercising customary rights, may be difficult to monitor.
- Some woodfuel harvesters operate illegally and seek to hide their activities.

The above difficulties relate mostly to data on the woodfuel resource base, but there are also problems in the collection of data on energy production because, for woodfuels, it often involves complex pathways and perhaps millions of users. In contrast, most fossil fuels are centrally distributed and/or consumed. A lack of data on woodfuel-based energy production is common, even in countries where woodfuel is a major resource (e.g. Brazil – FAO, 2009b).

Coordination

A wide range of government agencies may have responsibilities for aspects of woodfuel use. The production of woodfuel, for example, may be the primary responsibility of a forestry agency, but agencies dealing with agriculture, land reform, indigenous peoples and industrial practices (for wood waste) may also be involved. The supply, trade and use of woodfuel would usually fall within the remit of an energy authority, but it may also concern agencies dealing with environmental quality, public health (see Smith, 2006), industrial practices, consumer protection, weights and measures, and phytosanitation. Moreover, while national government agencies often play a leading role, local governments are also likely to be involved, requiring coordination between two or more levels of government.

A lack of coordination can put the woodfuel sector at a disadvantage. In the United States, for example, the definition of biofuels in production-oriented agricultural legislation is broad but the definition of biofuels in use-oriented energy legislation excludes much of the woodfuel that could be harvested in public forests, with the result that producers and users of such woodfuels miss out on the favourable treatment afforded to the producers and users of other types of biofuel. This omission is inadvertent and reflects a failure to coordinate policies. A major energy and climate-change bill before the United States Congress at the time of writing would, if passed, apparently address this problem (Tucker, 2009).

Legislation

Legislation should capture policy accurately, but this is not always the case. A woodfuels-related legislative error has come to light recently in the United States (Baucus, 2009). The United States has a policy of encouraging the blending of biofuels with fossil fuels to reduce the overall use of fossil fuels. The United States Congress enacted a tax credit of half a dollar per gallon for producers and industrial users of such fuel at an estimated total cost of US$60 million. The legislation was written, however, so that the tax credit also applied if a small amount of fossil fuel was added to existing biofuels. Paper companies using black liquor began to add small amounts of diesel fuel and claim the tax credit. Congress now estimates that the failure to capture the policy accurately will cost the United States Treasury several billions of dollars in tax credits in 2009.

Besides accurately capturing policy, legislation should be consistent between the various levels of government. Thus, national policies should harmonize with obligations under international agreements, and sub-national policies should not conflict with national policy. In addition, good forest legislation, for example, should:

- fit the national capacity for implementation; avoid restrictions and requirements that are unnecessary to reach legitimate goals;
- not grant officials arbitrary discretion;
- be equitable and socially acceptable;
- enhance the stake of local, forest-dependent people in the sustainable management of the forest (Lindsay, Mekouar and Christy, 2002).

CONCLUSIONS

Criteria and indicators for sustainable woodfuels relevant to policies, laws and institutions should be based on the following major requirements:

- Laws and policies affecting woodfuels should be consistent across all levels of government.
- Woodfuel policies must apply to all relevant disciplines and sectors, and should be consistent across sectors.
- Laws should follow policies, and be well drafted.
- Government institutions should have the requisite tools and capacities to manage, or oversee the management of, the woodfuel resource.
- Laws and institutions should include adequate planning for foreseeable changes, and should enable a rapid response to unforeseen changes.
- The participation of stakeholders in policymaking is necessary, both to improve the resultant policy and to build public support.
- Policy is most likely to succeed (and improve) where its implementation is transparent and those implementing it can be held accountable.

The indicators presented in this document related to policy and institutional factors draw on the extensive list of governance factors provided in Appendix A of Kaufmann, Kraay and Mastruzzi (2008), which also formed the basis of the World Bank Institute's Aggregated Governance Indicators (World Bank undated). The draft study of forest performance indicators prepared for the World Bank by Kishor *et al.* (2009) has also been drawn upon.

4. Social and cultural aspects of sustainable woodfuels

While the environmental and economic sustainability of woodfuel production systems has come under increasing scrutiny, their social and cultural aspects have received comparatively little attention (Domac, Richards and Risovic 2005). This chapter examines some of the important social and cultural issues associated with woodfuel production and use, and some of the potential risks to livelihoods, especially in rural households, that criteria and indicators for sustainable woodfuels need to take into account.

END-USER DYNAMICS

End-user decisions or preferences for woodfuels are influenced by many local and supply-related factors, such as accessibility and affordability.

In developing countries, access to woodfuels can be restricted by the location of the resource relative to where it will be consumed, by land tenure and ownership, and by the designated land use (UN-Energy, 2007). A lack of accessibility can limit the availability of fuelwood in an area, even if the area is near large tracts of

Woodfuel is integral to the social and cultural lives of billions of people

D. MEAD

FAO/FO-6847/M. FRANCE-LANORD

A woman sorts charcoal for sale: in many rural areas, charcoal production, marketing and distribution are important sources of employment

forest or substantial resources of trees outside forests. For example, people living close to a national park, wildlife reserve, strict nature reserve or other biodiversity conservation area, or in important catchment areas or watersheds, sometimes have no or only limited rights to collect woodfuel. Availability and access may even vary within a village because of kinship, class or patron–client relationships. Access is strongly related to ownership, with small landowners and the landless often at a disadvantage. Village location may also be important – particularly in hilly areas, where resources often vary with elevation, and in areas with widespread deforestation (FAO, 2008b).

In developing countries, affordability is linked to the time or money required for the collection or acquisition of woodfuels compared to the price of other energy options. The pattern of woodfuel consumption, therefore, is determined by factors such as income level, the price of woodfuels, and the distance between home and the collection site and the time spent to traverse it. For many rural households, the availability and security of the supply of alternative fuels is also an important consideration. In some areas, the scarcity of fuelwood may lead to substitution by other biofuels, such as crop residues and animal waste, which could adversely affect the sustainability of farming systems (RWEDP, 1996).

In many countries, large portions of forests are controlled by government departments and there is little or no legal access to them for fuelwood collection and/or charcoal production, even if enforcement is limited. In other cases, the resource may be nominally under state ownership, but control resides with local public authorities. Such local bodies may be vulnerable to influence by wealthy elites and may not distribute access rights equitably.

In developed countries, the use of woodfuels by households is driven mainly by price and cultural factors (such as environmental awareness), while ready access and affordability are the main drivers in rural areas. Often, urban people have little understanding of the technology behind the production and use of woodfuels, but their marketing as "green energy" is attractive. In many countries, new buildings, especially apartment blocks, are using woodfuels, in combination with other renewable energy, for heating and electricity.

EMPLOYMENT AND RURAL DEVELOPMENT

Policies governing woodfuel production should ensure that they address social priorities. They could, for example, ensure that woodfuel production helps to create, maintain and expand sustainable livelihoods for local people. In developing countries, woodfuel harvesting generates many jobs in rural areas, where poverty is often highest (Domac, Richards and Risovic, 2005). Charcoal production, sales and distribution is also a major source of livelihood in both rural and peri-urban areas.

Experience in various countries – such as Brazil, the Philippines, Nepal and Tanzania – has shown that wood-based energy production can help promote development, especially in rural areas where most investment is needed and where alternative employment opportunities are least common (FAO, 2009b). The use of wood and other biomass resources in energy production can generate 20 times more local employment per unit energy than other energy sources (Table 3) due to the large amount of unskilled labour required for the harvesting, processing, transporting and trading of woodfuels. In India, for example, the woodfuel sector employs between 3 million and 4 million people (Domac, Richards and Risovic, 2005). Woodfuel trade, however, occurs mostly at a small scale in the informal sector and data on its magnitude and the extent of employment are very poor. Moreover, as is the case in many informal sectors, unscrupulous practices often mean that rural workers are poorly remunerated or otherwise subject to unfair treatment. In many countries, addressing this problem is a critical issue for the sector.

TABLE 3
Estimated employment associated with the use of various fuel types in the Philippines

Fuel type	Amount of fuel per TJ of energy	Employment per TJ energy in person days
Kerosene	29 kilolitres	10
LPG	22 tonnes	10-20
Coal	43 tonnes	20-40
Electricity	228 megawatt hours	80-110
Fuelwood	62 tonnes	100-170
Charcoal	33 tonnes	200-350

Source: FAO, 2001b.

FAO/FO-5699/P. DURST

Woodfuel trade still occurs mostly at a small scale

Woodfuel production is usually integrated into larger, multi-purpose production systems (such as agroforestry) within forests or agricultural areas (Hector, 2000). Such systems can generate multiple benefits for poor rural communities, including the provision of food, fodder and shelter for livestock; timber and non-timber forest products; and traditional medicines. Most of the value of village-scale woodfuel production is retained locally and helps to reduce poverty – in contrast to fossil fuels (and also most other renewable energy options). Therefore, appropriately harnessed woodfuel production systems can contribute significantly to sustainable development.

In many developing countries, unused residues from forests and forest industries represent a large untapped woodfuel resource. This could assist the economic viability of the forestry sector and could help reduce fuel imports, leading to the redistribution of national income and macroeconomic benefits. Modern woodfuel systems would provide cleaner fuels and electricity and improve the status and wages of workers (Domac, Richards and Risovic, 2005). Moreover, the greater use of local woodfuel sources would improve energy self-reliance and generate microeconomic benefits.

In the formal sector, woodfuel production can provide substantial direct and indirect employment. Direct employment comprises jobs involved in woodfuel production and transport and the construction, operation and maintenance of conversion plants. Indirect employment includes jobs generated within the economy as a result of expenditure related to woodfuel production (FAO, 2003; Domac, Richards and Risovic, 2005). The overall increase in economic activity can also lead to induced employment. In Croatia, for example, it has been estimated that each petajoule (PJ) of energy generated from forest residue would result in 12, 7 and 8 direct, indirect and induced jobs, respectively (Domac, Richards and Risovic, 2005).

Direct employment generated in Sweden by the use of logging residues as woodfuel may be double that for Croatia (Borsboom *et al.*, 2002). Employment opportunities vary with the scale of the operation. Landowners who heat the family home or farm buildings with a wood-fired system will often harvest fuel on their own land using family labour. No wages are paid but the amount of labour can be high; in Sweden it has been estimated that the equivalent of 63 jobs are generated for each PJ of energy (Borsboom *et al.*, 2002). There may be additional benefits from the sale of wood or from renting out equipment.

The renewable energy industry is one of Europe's fastest-growing sectors and employment opportunities seem set to grow. One 1999 study predicted that the use of renewable energy technologies, including bioenergy, in the European Union will more than double by 2020, and that this increase will lead to the creation of more than 800 000 jobs in the bioenergy sector (European Commission, 1999).

HEALTH AND SAFETY

The health impacts of domestic woodfuel production and use can be significant. In developing countries in particular, many woodfuel stoves are of poor quality and emit substantial amounts of pollutants such as carbon monoxide, methane and particulates due to incomplete combustion. Women and small children may be exposed to these for many hours a day, which can lead to respiratory diseases

Unused biomass from forests and forest industries is a significant and largely untapped woodfuel resource: here, a woman collects pine needles and twigs from beneath pine trees in China

FAO/FO-6942/J. CARLE

(such as pneumonia) and cancer. Globally, pneumonia is the most common respiratory infection and the most important cause of death for children under five years old. Exposure to carbon monoxide from biomass burning during pregnancy has been linked to low birth weight. Other major health hazards posed by woodfuel use, mostly to women and children, include unintentional kitchen fires, the poor ergonomics of stoves, and the injuries associated with carrying heavy loads of fuelwood.

Fuel scarcity also has implications for the nutritional status of households because it can reduce the capacity for cooking high-quality foods, such as beans, and lead to an increase in the consumption of less nutritious foods that can be cooked more quickly or eaten raw. The general reduction in the number of cooked meals may also increase the consumption of stale or leftover food, which may be contaminated. This can have adverse effects on family nutrition and, therefore, major health repercussions, especially for children and the elderly (WHO, 2006).

Large-scale woodfuel production and use, especially in industrialized countries, also poses occupational health and safety risks. The harvesting and transport of wood from plantations and natural forests (whether for fuel or other uses), for example, is an inherently risky business involving powerful and potentially dangerous equipment. The handling of woodchip stockpiles poses health risks from airborne fungal spores and hyphal fragments (Andersson *et al.*, 2002)

Women sort charcoal by size in the Lao People's Democratic Republic; the health hazards associated with charcoal production include the inhalation of charcoal dust, which can cause respiratory illnesses

FAO/FO-6848/M. FRANCE-LANORD

The industrial-scale harvesting of woodfuel is an inherently risky business involving powerful and potentially dangerous equipment

GENDER

A relationship between gender and energy use has been identified since the early 1970s (Boserup, 1970; Eckholm, 1975; Agarwal, 1986; FAO, 1996; Cecelski, 1998). In rural areas throughout the developing world, women collect most of the woodfuel consumed by households, sometimes assisted by children, and they are also responsible for most domestic cooking. Thus, women often largely determine the energy consumption patterns of households. A scarcity of fuelwood (and, hence, longer collection times) can have many negative implications: for example, women have less time for other important tasks, such as agriculture, cooking and child-caring, with negative impacts on the nutrition and health of families.

DEMOGRAPHICS

Urbanization has important implications for woodfuel use. Urban energy is supplied in a formal market in which fuels are commodities that are traded and bought and which compete with substitutes. Price is not always the only factor influencing consumer behaviour. Even if fuelwood is the cheapest option, many urban households prefer other cleaner and more convenient and efficient fuels.

Population growth in both urban and rural areas is likely to lead to increased competition for available resources (Domac, Richards and Risovic, 2005). A more significant problem, however, could be increasing inequity in the distribution of woodfuel resources between the rich and poor.

FAO/CFU000279/R. FAIDUTTI

Women often largely determine the energy consumption patterns of their households

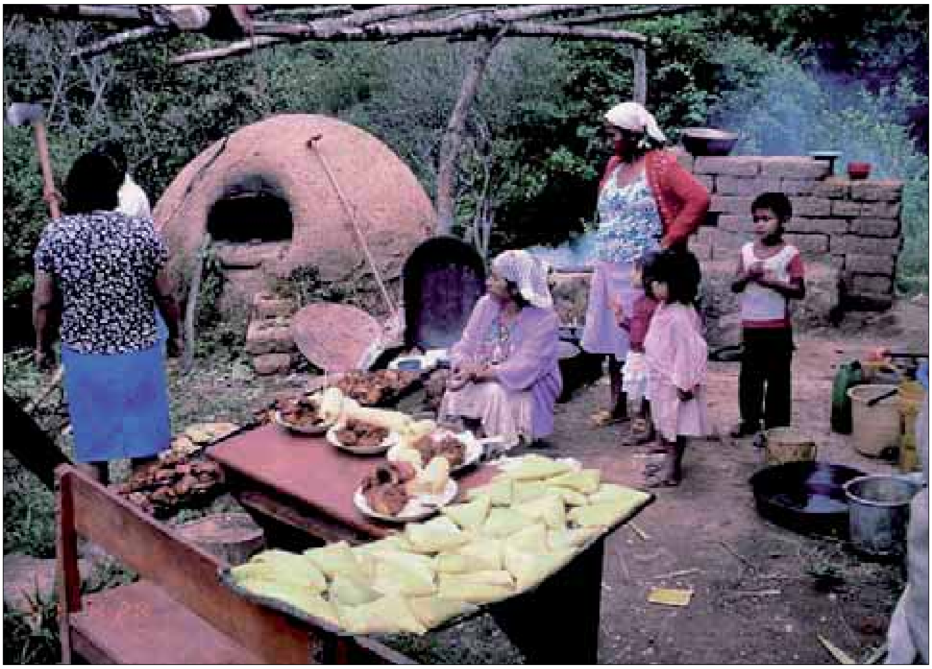
A growing population could, in the short term, increase reliance on woodfuels and other traditional fuels (leading to scarcity) until people can afford to shift to other fuels. Localized fuelwood shortages, resulting from increased demand, could increase the cost of securing woodfuel by increasing the time and effort needed to collect it, and it could also stimulate a shift towards alternative but more expensive fuels, with negative implications for the poor.

CULTURAL ASPECTS

The techniques and practices of producing fuelwood and charcoal vary according to local culture. Moreover, culture can influence the choice of fuel. In some rural communities in Africa, for example, it is a cultural belief among elders that some foods (such as porridge) taste better when cooked using wood than when cooked by other means (such as electricity).

Not only the choice for woodfuels but also the efficiency with which they are used is influenced by culture. The fireplace is an important location in the social life of many rural and indigenous communities. In regions where plenty of fuelwood is available, people like to keep the fire going longer than is needed for cooking – it is common in Africa and in many other cultures to sit around a domestic fire. Fuelwood can also be important for ceremonial and religious purposes (Borsboom *et al*., 2002). For example, Hindu and Buddhist rites include cremation on funeral pyres that use approximately 200–300 kilograms of wood each.

Woodfuel use at the household level is also partly governed by culture in developed countries. In some such countries, for example, awareness of issues such



FAO/FO-0099

Woodfuels are part of the culture of many communities, such as this one in Bolivia

as the need to reduce greenhouse gas emissions is seen as a sign of being modern and educated. This, in turn, may influence the type of woodfuel used. Trendy city-dwellers, for example, have adopted wood-pellet heating systems for heating because, compared with conventional fuelwood, they are more convenient, more energy-efficient, easier to transport and store, and less polluting. The use of wood pellets has risen sharply in Sweden and Austria (Kaltschmitt and Weber, 2006) and is likely to become more widespread elsewhere in Europe.

FOOD SECURITY

Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. In some developing countries, food security could be reduced by shortages in the supply of fuelwood and charcoal, which could reduce the capacity of households to prepare nutritious foods. Well-established production chains for fuelwood and charcoal, and well-organized markets for their commercialization, are therefore vital for maintaining food security.

OTHER ISSUES

In some countries, the noise associated with the mechanical harvesting, processing and transport of woodfuels can be a cause of community concern (Borsboom *et al.*, 2002). It is likely to be most contentious in densely populated countries or where people have moved into the forest for lifestyle reasons.

The use of wood-pellet heating systems is rising sharply in Europe

Changes to the visual landscape in areas where new woodfuel plantations are being considered can also generate community concern. The establishment of large blocks of trees on farmland, for example, can change landscapes in disconcerting ways, as can their eventual harvest.

Both these issues may affect recreation and tourism and therefore can have significant economic effects for local communities. Consultation with stakeholders and careful management planning may reduce conflict and help local people to accept woodfuel production as an important and valuable activity in their communities.

CONCLUSIONS

Woodfuels have become firmly established in the renewable energy markets of industrialized countries as a clean source of energy (Domac, Richards and Risovic, 2005). Meanwhile, in developing countries woodfuels remain the dominant source of energy for over 2 billion poor people. In these countries, woodfuels are not only vital to the nutrition of rural and urban households, they are also often essential in food-processing industries. Smeets *et al.* (1996) have projected that the demand for woodfuels will increase as all countries seek to find clean, green, efficient and cheaper alternatives to fossil fuels.

In most countries, policies and programmes to promote wood-energy development specifically and bioenergy development in general are still in their early stages. These policies and programmes tend to be limited in scope, paying more attention to regulatory measures than to investments in areas such as research and development, market liberalization, information and training. To date there has been relatively little transfer of bioenergy technology or information about bioenergy from developed to developing countries.

Several developing countries have enormous potential to produce energy from forests and trees outside forests with relatively little investment and risk, but this potential is not properly reflected in national energy development strategies. Poor forest management and a lack of proper data collection – often the result of widespread illegal forestry operations – frequently prevents assessment of the full economic and social potential of forestry and of wood energy production. Putting forestry on a sustainable and transparent footing will provide multiple benefits, including improved energy production and improved livelihoods for the rural poor.

To this end, criteria and indicators can assist in monitoring and assessing woodfuel projects and in providing governance for mitigating the impacts of such projects on food security and social structures. The involvement of all stakeholders in the development of wood-energy strategies is also of great importance to balance trade-offs between economic, social and environmental impacts and benefits.

5. Economic aspects of sustainable woodfuels

This chapter addresses the issues associated with and mechanisms for ensuring the economic sustainability of woodfuel production. In particular it examines how the major drivers of woodfuel production and use of woodfuels will interact with market forces and other existing systems to regulate the sector. It also addresses issues related to ensuring economic efficiency and equity.

Woodfuels can provide a variety of economic benefits including employment and revenues from the sale of woodfuels and greenhouse gas credits. Yet woodfuel production, if not properly executed or regulated, may have adverse consequences (Boxes 3 and 4).

BOX 3

Some economic issues in fuelwood production

For fuelwood, no energy conversion ("value-adding") is involved in the production process. Most fuelwood is collected by women, children and elderly people for their own consumption (FAO, 2009b). In such cases, the agents harvesting and transporting the fuelwood are also the direct receivers of the economic outcome.

Externalities (such as the degradation of the resource) most commonly arise from fuelwood production when the harvested trees are not owned by the fuelwood collector. Although the direct costs of household fuelwood collection are generally low, its indirect costs – such as the opportunity costs forgone by women, children and elderly people because of the time they spend collecting fuelwood – may be substantial.

FAO/FO-6066/R. BILLINGS

Even the very young may be involved in fuelwood gathering, such as this child in a peri-urban barrio in Honduras

BOX 4

Some economic issues in charcoal production

Charcoal is usually made on or near the site where the wood is harvested. The wood is converted to charcoal using pyrolysis, which, in many developing countries, is still largely carried out using simple technologies. A common method involves the use of earth pits; these are popular because of their low cost, despite their low efficiency as well as environmental concerns. More efficient portable or masonry kilns are available, but the higher cost restricts their use by small producers (FAO, 2009b).

Although most charcoal is used by rural households for cooking and heating, a significant amount is also used by urban households and industries (such as the pig-iron and steel industries in Brazil) (FAO, 2009b). The agents involved in the manufacture of charcoal are often socially or economically disadvantaged and may lack the power to negotiate a fair share of the income from charcoal sales.

DRIVERS OF WOODFUEL PRODUCTION

The main recent drivers of woodfuel production worldwide include energy supply and security, greenhouse gas emission mitigation, and economic development.

Energy supply and security

For energy-importing countries (both developed and developing countries), reducing dependence on foreign energy is a major driving force for increasing domestic woodfuel production. Additionally, recent increases in fossil-fuel prices and concern that oil production has peaked, or will peak soon, have also stimulated countries to seek alternative energy sources, including woodfuels. For many developing countries, providing accessible and economically viable energy is vital for sustaining and enhancing the livelihoods of rural communities. For many such countries, woodfuels remain the most affordable energy source for most rural residents.

Greenhouse gas mitigation

Woodfuels generate fewer net greenhouse gas emissions over their life cycle than do fossil fuels or many other alternative energy sources. Thus, there is an opportunity to reduce greenhouse gas emissions by substituting fossil fuels with woodfuels. Although the mechanisms for mitigating greenhouse gas emissions are still being developed, it is likely that greenhouse gas sequestration credits or emission taxes and emissions cap–and-trade schemes will have an important influence on woodfuel production.

Economic development

The need to generate income to sustain rural economic prosperity and/or alleviate poverty is another key driver of woodfuel production. Income can be derived

Woodfuel production has a high "ripple" economic and employment effect

from the direct sale of woodfuels and from greenhouse gas credits. The fair distribution of this income is not only important socially, it is also essential to ensure that all agents along the woodfuel supply chain continue participating in the production process. Constrained by its relatively high transportation costs, woody biomass must be processed to some degree near its production site, thus creating and maintaining jobs at the local level. In addition to its direct role in job creation and income generation, woodfuel production has a high ripple economic and employment effect (Gan and Smith, 2007).

CONCERNS ABOUT WOODFUEL PRODUCTION

Woodfuel production can have adverse environmental or socioeconomic impacts. Concerns include:

- the overuse of forest resources, leading to deforestation or forest degradation;
- the loss of soil productivity due to excessive biomass removals;
- uncertainties and possibly negative impacts on biodiversity;
- increases in the price of traditional wood products because of increased competition for biomass;
- reduced accessibility to and affordability of woodfuels for rural residents as a result of expanded commercial woodfuel production.

THE NEED FOR PRINCIPLES, CRITERIA AND INDICATORS TO ADDRESS ECONOMIC ASPECTS

There are several justifications for a non-market or market-based mechanism, along with market forces and other existing systems or institutions, to safeguard the economic sustainability of woodfuel production. One is to correct for market failure. The objectives of woodfuel production are multifaceted: markets do not and cannot capture all these aspects. Some aspects, such as greenhouse gas mitigation, may be subject to governance through market mechanisms, but greenhouse gas accounting and valuation are yet to be validated internationally and markets are still only nascent. Inaccuracy in greenhouse gas accounting and valuation could lead to the misallocation of forest and other resources. The potential negative environmental and socioeconomic impacts of woodfuel production are externalities that are unlikely to be mitigated by market forces. Since markets tend to emphasize short-term rather than long-term outcomes, ensuring the long-term economic sustainability of woodfuel production needs the assistance of non-market mechanisms. On their own, markets do not ensure the fair allocation of the benefits and costs of woodfuel production among all parties involved or affected. The complexity of woodfuel supply chains and the multiple benefits and costs or consequences of woodfuel development suggest additional complications for equity assurance.

There is also a need to correct for policy distortions. To promote renewable energy, some countries have required or are considering requiring that a certain portion of the national energy budget be produced from renewable sources. Mechanisms such as "renewable obligations" and "renewable portfolio/fuels/electricity standards", which have been adopted in several countries, aim to bring domestic renewable energy output to a level that reflects a social optimum. Such national optimal production levels, however, are very difficult to determine due to their complexity and a lack of complete information. If the predetermined output quota is above the true national optimum, it may lead to a forfeiting of economic viability in order to meet the output requirement. This situation is likely to occur because forest biomass used for energy production (particularly in developed countries) is usually a by-product of timber production and forest protection. These materials have a low value but can be costly to use. As a result, woodfuel production tends to be less profitable than the production of timber, pulp and paper products or fossil fuels. Too high a production quota could result directly in the poor financial performance of woodfuel production systems. Thus, measures may be required to safeguard the economic viability of woodfuel production.

Similar to output quotas, inappropriately designed incentives and tax programmes can also skew economic viability and distort the cost-competitiveness of various energy sources. Such policy distortions may lead to inefficiency and inequality. For instance, inappropriately stimulated woodfuel production could affect the availability of forest resources for other competing uses, leading to increased prices or costs of wood products and ecological services.

Besides their role in correcting for market failures and policy distortions, economic principles, criteria and indicators for woodfuels are also necessary for other reasons. First, fostering economic development, including poverty alleviation and rural economic prosperity, is a key driver of woodfuel production. This is an economic goal and thus entails the use of economic standards and measurements.

Second, all energy sources have pros and cons, and forest resources have multiple and competing uses. Without proper trade-off analyses it is impossible to make informed energy choices or to determine the most efficient use of wood materials in particular and of forest resources in general. Such trade-off analyses rely on economic indicators and standards.

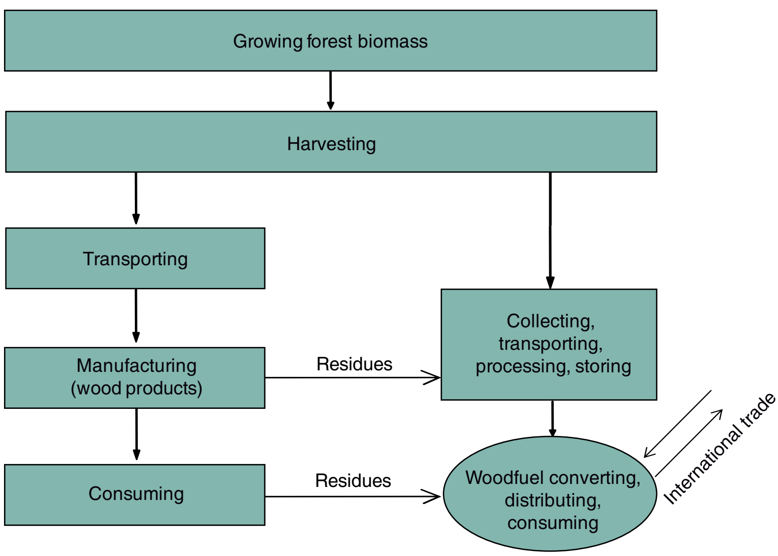
For these reasons, principles, criteria and indicators for the economic sustainability of woodfuels are important and necessary and should be integrated systematically with environmental and social principles, criteria and indicators in a certification system.

WOODFUEL SUPPLY CHAINS AND PRODUCTION COSTS

Woodfuel supply chains generally consist of three interrelated segments: feedstock production, feedstock-to-woodfuel conversion, and woodfuel distribution. The feedstock production segment, which is the main focus of the criteria and indicators presented in this publication, generally involves the growing, harvesting, collection, transport, processing and storage of wood, although the sequence in which these activities are carried out may vary between supply chains depending on the feedstock source and the production process used. The number of economic agents involved and the relationships between them also differ. The structure of a supply chain and the interrelations among the involved agents affect its operational efficiency and the distribution of costs and benefits and thus have implications for the economic viability of the actors involved. Figure 1 depicts a simple woodfuel supply chain.

The cost-competiveness of woodfuels varies between energy products and regions. In many rural communities in developing countries, woodfuels are still

FIGURE 1
Generalized woodfuel supply chain




FAO/FO-5405/M. TROSSERO

The cost of electricity generated from woodfuels depends on a wide range of factors, including the cost of feedstock and the technology employed; here, wood scraps fuel a boiler for electricity production in Honduras

the cheapest fuel for cooking and heating, although as living standards rise there is often a switch to fossil fuels. The cost of heat and electricity generated from woodfuels can vary widely depending on factors such as the technology being employed and the cost of the feedstock. Electricity produced from low-cost biomass feedstock is cost-competitive with that produced using fossil fuels (IEA, 2007). The by-products of the pulp-and-paper industry (i.e. black liquor) and the sawmill industry (i.e. bark, sawdust and chips) have been cost-competitive fuels for several decades, partly because the cost of production is covered by the main product.

The extensive use of forest residues and other primary-level forest woodfuels (such as thinnings, or purpose-grown plantation wood) in heat and electricity generation in Nordic countries and other parts of the world indicates that such woodfuels can be cost-competitive (IEA, 2009a), particularly when co-benefits, such as cost sharing or savings in forest management practices, greenhouse gas credits and job creation, are valued. Yet the situation varies greatly between countries depending on their forest resources, energy-generation infrastructure and the cost and availability of competing fuels (Asikainen *et al.*, 2007). In European Union countries, where oil and natural gas are the main fossil fuels being replaced by biomass, the competitiveness of woodfuel feedstock is often good, particularly given recent rises in oil and gas prices. However, the cost of the combustion technology needed for woodfuel feedstock is higher than that required for oil and gas, entailing a relatively large investment. In countries where coal is the main fuel to be replaced there is little difference in the cost of the combustion technology, but the woodfuel feedstock may be comparatively more expensive.

P. TAMMINEN

Machinery used in industrial-scale wood harvesting is being adapted to woodfuel harvesting, such as the harvesting of stumps

In North America, mill residues have been used extensively by the forest-products industry for electricity and heat generation, demonstrating its economic feasibility when the opportunity and disposal costs of forest residues are accounted for. Under current technology and market conditions, however, production costs remain a major barrier to the commercial production of woodfuels, particularly liquid woodfuels (Biomass Research and Development Board, 2008). Liquid woodfuels will become more cost-competitive in the transportation-fuel markets of developed countries if greenhouse gas benefits are accounted for, if significant advances in the technology can be achieved, and if fossil-fuel prices continue to increase.

Factors affecting the cost of woodfuel supply fall into two main groups: the availability and quality of woody biomass near the woodfuel plant; and the costs associated with the purchase, harvesting, processing, transportation and storage of feedstock. In areas where the use of primary-level forest residues is starting, the net annual increment and the volume of the harvest determine the available resources (e.g. Asikainen *et al.*, 2007).

The increasing use of wood for energy will have important effects on the wood market. In Central Finland, for example, a large share of primary forest residues is already used for energy production and the increasing demand has led to calls for the transportation of forest residues from eastern Finland.

Various technologies have been used in the production of woodfuels. In Finland and Sweden, for example, the trend has been to use the same base machinery for both conventional and woodfuel harvesting – this allows the efficient, year-round use of the machinery and lowers the economic risk of investment. Base machines have been equipped with relatively low-cost attachments, such as accumulating felling heads, to enable the effective handling of whole trees. The forwarding of the biomass to landings is done using a standard forwarder.

Another option has been to develop purpose-built forest energy machines, where, for example, chip-harvesters fell and chip the tree in the forest and forward the chips to the roadside landing or container.

The potential benefits of an expanding woodfuel sector for employment are discussed in Chapter 4.

CONCLUSIONS

The set of criteria and indicators for the economic sustainability of woodfuel production presented in this publication has four major criteria:

- beneficial use;
- economic viability;
- economic equity;
- property rights.

Under each criterion, several indicators are suggested. These can be made more specific – or expanded – for regional or national-level purposes, and the priorities may also vary.

The beneficial-use criterion is designed to ensure that woodfuel production is the most beneficial use of the woody biomass and the overall resource. It should also ensure that the production of woodfuels is avoided where such production would come at an undue cost to timber production or to the ecosystem services provided by the resource.

The criterion on economic viability addresses both the short-term and long-term economic viability of woodfuel production. It is measured in terms of cost-competitiveness with other energy sources and the profitability of production (when all direct and indirect benefits and costs are accounted for).

The equity criterion addresses the fair distribution of the economic benefits among all stakeholders along the woodfuel supply chain, particularly landowners and local or rural residents and communities. Some indicators measure direct economic benefits while others gauge the economic and institutional structures that influence long-term economic sustainability.

Finally, the property-rights criterion represents an institutional requirement to avoid illegal harvesting and the overexploitation of the forest.

6. Environmental aspects of sustainable woodfuels

Woodfuel production and harvesting systems can be integrated with an existing management regime (e.g. the collection of residues for energy during conventional timber harvesting) or occur independently such as through casual collection in forests or from trees outside forests, or they can be based on a purpose-grown resource. The environmental impacts of these practices vary in nature and extent according to the scale, intensity and type of production and harvesting system used, and can be either positive or negative.

Perhaps the greatest environmental benefit of woodfuels is that, when produced and harvested sustainably, they provide a renewable source of energy with low net carbon emissions. Woodfuels are derived from vegetation that sequesters atmospheric carbon during growth, releases it to the atmosphere when converted to energy, and takes it back up as it re-grows. The use of woodfuels can offset fossil-fuel use and contribute to society's efforts to reduce greenhouse gas emissions and associated climate change. Other potential environmental benefits

The timber and woodfuel components are separated in this integrated harvesting operation in Sweden

I. STUPAK

In Sweden, wood ash is spread in the forest to help fertilize soils depleted by intensive harvesting

include improvements in biodiversity, soils and water through the creation of a woodfuel resource (such as tree-planting on degraded agricultural land); the reduction of forest fuel loads (and therefore the risk of wildfire) through thinning or the removal of logging residues; and improved forest ecosystem health through the rehabilitation of degraded forests and woodlands.

There is also a range of environmental risks associated with woodfuel production because management may be more intensive than that required for conventional timber production. Overharvesting of forests and of trees outside forests is another potential risk. Woodfuel production systems, therefore, should be designed so that they do not diminish the quantity and quality of soils and water; decrease site productivity; adversely affect biodiversity; create excessive carbon emissions or other air pollution; or decrease the ecological integrity of landscapes.

SOILS, HYDROLOGY AND SITE PRODUCTIVITY

Woodfuel production and harvesting activities can have both positive and negative impacts on soils, hydrology and site productivity (Lattimore *et al.* 2009). Poor management can give rise to the following negative impacts, among others (Burger, 2002; Grigal, 2000; Neary, 2002; Lundborg, 1994):

- changes in soil nutrient balances and availability, especially on low-nutrient sites, and reduced soil organic matter;
- base cation reductions, leading to soil acidification;
- changes in soil physical properties from the use of heavy machinery and reductions in groundcover;
- changes in site hydrology and water quality because of alterations to the

landscape and vegetation (e.g. the establishment of fast-growing plantations may reduce water flows while clearcutting may increase peak flows; harvesting in streamside zones can increase erosion and sedimentation);
- overall reductions in site productivity and tree growth due to the above factors.

Adequate quantities of decomposing biomass are critical to the maintenance of soil organic matter, nutrient cycling processes, soil moisture levels, soil structure and soil microbial processes (Burger, 2002; Powers *et al.*, 2005; Scott *et al.*, 2004).

The loss of important soil nutrients as a result of woodfuel production and harvesting is a major concern (Albrecht, 1991; Mitchell and Bridgwater, 1994; Raulund-Rasmussen *et al.*, 2008). Reductions in phosphorus, potassium and calcium may, over time, lead to a loss of productivity because they are not easily replenished, while reductions in base cations may lead to soil acidification (Olsson, Bengtsson and Lundkvist, 1996; Burger, 2002; Egnell *et al.*, 1998, 2006). Given that the effects of intensive biomass removal on nutrient levels are site-specific and may vary widely, soil surveys should precede any large-scale woodfuel production projects.

Judicious management can greatly mitigate nutrient losses (Hakkila, 2002). For example, encouraging plant diversity, intercropping with leguminous shrubs, leaving biomass to dry on-site, carrying out compensatory fertilization, and lengthening subsequent rotations can all help to combat nutrient losses (Burger, 2002; Hakkila, 2002; Kimmins, 1974).

Woodfuel extraction should be avoided or practised with great care where soils are nutrient-poor or susceptible to desertification. Human-induced desertification occurs when soils become so degraded that vegetation can no longer grow, creating bare expanses of inhospitable soils that are susceptible to wind and water erosion. This is a concern in northeastern Brazil, for example, where woodfuel harvesting for gypsum production is threatening fragile ecosystems (Box 5).

Negative impacts on soil physical properties, including compaction and erosion, can occur during intensive woodfuel production as a result of increased machine or human traffic in the forest, the removal of protective layers of harvesting residues, the harvesting of stumps and coarse roots, and changes to soil moisture and organic matter (Grigal, 2000). These issues can, in turn, affect site hydrology and water quality. Streams and other water bodies in and around areas of intensive woodfuel production and harvesting can experience changes in water yield and peak flow, increased sedimentation, changes in stream temperature and light infiltration, increased concentrations of nitrogen and other nutrients, and the accumulation of toxic substances (Olsson, Bengtsson and Lundkvist, 1996; Dyck and Mees, 1990; Keim and Shoenholtz, 1999; Neary, 2002). These reductions in water quality can affect aquatic organisms and, together with soil impacts, may adversely affect overall site productivity in both the short and long terms. In Guyana, for example, fuelwood-cutting poses a threat to fragile white-sand and mangrove-fringe ecosystems, and measures are being explored to help protect them (Box 6). Knowledge of watershed characteristics, the use of appropriate

BOX 5

The link between woodfuel harvesting and environmental degradation in northeastern Brazil

The natural vegetation (*caatinga*) of the semi-arid northeast region of Brazil consists of a sparse covering of small trees, cacti and shrubs and is under serious threat from deforestation. The demand for woodfuel for inefficient gypsum kilns is the biggest cause of elevated rates of deforestation in the region (although agricultural expansion is also a contributing factor). Ninety percent of all the gypsum used in Brazil is produced in this region, requiring an annual input of 360 000 m^3 of woodfuel and the corresponding clearance of 10 000 hectares of *caatinga* each year. In addition to general concerns about the impacts of deforestation, the edapho-climatic conditions of the region require special attention because of the risk of desertification: in the south of the state of Piauí, for example, large tracts of *caatinga* have already been converted to unproductive land.

FAO has been involved in activities to mitigate this problem since the 1980s. Strategies have included finding ways to increase the area of forest planted with fuelwood species (e.g. Eucalyptus and *Leucaena*) and introducing more efficient equipment and good management practices to reduce woodfuel demand from the natural *caatinga* ecosystem.

Source: FAO, 2009c.

The increased used of heavy machinery (such as this feller-buncher) in woodfuel harvesting can cause soil compaction and affect site productivity

D. MEAD

BOX 6

Woodfuel harvesting in fragile ecosystems in Guyana

Because of its small population (<1 million people), tropical climate and the ready availability of fossil fuels for cooking, Guyana is not a major producer or consumer of woodfuels. Nevertheless, woodfuels account for 7 percent of domestic energy use and are also used in some commercial operations: in 2006, for example, 18 000 m^3 of fuelwood were used for commercial purposes (e.g. to fuel steam boilers on sugar estates). Fuelwood collected for personal use does not need to be officially declared and therefore often goes unrecorded.

Despite the country's high forest cover and relatively low levels of woodfuel harvest, ecological issues do arise from the concentration of harvesting in fragile ecosystems. The main sources of woodfuel are *wallaba* (*Eperua* spp.) and *dakama* (*Dimorphandra conjugata*) in secondary forests that have been logged or high-graded over a period of years and whose full restoration is prevented by continued exploitation and recurrent fires. These forests, which are globally unique, grow on white-sand soils that are highly sensitive to disturbance. Fuelwood cutting is also common in another sensitive ecosystem, the mangrove fringe, and can have negative effects on sediment stabilization, shoreline anchoring, flood control, food-chain support, fisheries and wildlife habitat.

Specific recommendations for protecting sensitive white-sand forests include: exploring the feasibility of establishing protection areas; the rehabilitation of forest cover and the recovery of site productivity; and the development of a plan for forest-fire protection. Possible actions for protecting sensitive mangrove forests include: the comprehensive mapping of the resource; reforestation and protection of the forest under integrated coastal zone management; the provision of alternative woodfuel sources; and the involvement of communities in the sustainable management of the resource. In the medium term, further baseline studies, development of a national policy and plan for these sensitive forests, and criteria and indicators for woodfuel production areas should be developed, along with protocols for monitoring and feedback.

planning, and the incorporation of streamside or coastal management zones can all help to mitigate negative impacts to local hydrological systems.

BIODIVERSITY

Woodfuel production systems can have both positive and negative impacts on biodiversity at the level of landscapes, ecosystems, habitats, species and genes. Negative impacts on biodiversity usually result from the following (Angelstam, Mikusinski and Breuss, 2002; Christian *et al.*, 1998; Dyck and Maclaren, 1994; Egnell *et al.*, 1998, 2006; UN-Energy, 2007; Jonsell, 2008; Gustafsson, 1994; Lundborg, 1994; Paine *et al.*, 1996):

- the clearing of natural habitats and the replacement of native tree species with faster-growing species: for example, unsustainable woodfuel gathering has caused significant deforestation in the *miombo* woodlands in Tanzania (Box 7);
- the removal of niche habitats, such as dead and downed wood (e.g. in intensively managed Nordic forests);
- an increase in forest access and human–wildlife conflicts;
- encroachment into protected areas and the proliferation of invasive and pest species;
- overall changes in ecosystem health and potential off-site impacts.

Woodfuel production systems also have the potential to increase biodiversity. Tree-planting on agricultural lands creates new habitat, while the thinning or replacement of degraded stands can improve existing habitats. In the Philippines, for example, tree cover has increased as landowners afforest steep or abandoned agricultural lands for reclamation and woodfuel-production purposes (Box 8).

BOX 7

Deforestation in Tanzania

Charcoal and fuelwood are the dominant sources of fuel used in Tanzania, accounting for 91 percent of total energy consumption. Primary consumers include households (95 percent), rural industries (3 percent, largely for curing tea and tobacco), and agriculture (1 percent). Overall, 97 percent of all wood products consumed in Tanzania are in the form of woodfuel, and woodfuel collection is cited as the main cause of deforestation in the country.

Sixty to seventy percent of woodfuel collected in Tanzania comes from natural *miombo* woodlands, which typically regenerate after harvesting through coppicing and sapling recruitment. However, without adequate replanting and in the presence of other human disturbances such as grazing, fire and extended cultivation periods, this regeneration can be temporarily or permanently delayed. The unsustainable management of miombo woodlands and harvesting for charcoal production has resulted in the degradation and deforestation of approximately 52 600 hectares (44 percent) of closed woodland and 92 800 hectares (51 percent) of open woodland to the north and west of Dar es Salaam, as well as the degradation and deforestation of most woodlands within 30 km of the Morogoro Highway leading to the city. Without improved management it is estimated that the remaining woodlands around Dar es Salaam will be reduced to just 40 percent of their present area by 2015.

Creating a sustainable woodfuel industry in Tanzania is of crucial importance, with the vast majority of the country's population still dependent on charcoal and fuelwood for their energy needs. Sustainably growing sufficient wood to meet the needs of Tanzania's population is possible with proper standards and enforcement and the involvement of local people.

Source: FAO, 2009c.

BOX 8

Woodfuel production and use: increasing forest cover in the Philippines?

Wood is a primary source of energy in the Philippines, with 41.2 million tonnes of woodfuel harvested and consumed each year. Although there is evidence of increasing commercial harvesting in mangroves, a number of studies suggest that only a limited amount of overall woodfuel production comes from primary forests. Most appears to come instead from either agricultural lands or "wastelands", where large plantations have been established in response to concentrated commercial demand for fuelwood and charcoal in nearby industries or cities.

Wastelands, or "in-between lands", make up close to 30 percent of the land area in the Philippines and consist largely of private land, primarily in agricultural areas or areas of natural forest re-growth after logging or agricultural abandonment. In most of these areas, fast-growing trees such as *Leucaena* and *Gliricidia* species have been planted with the aims of out-competing cogon grass (*Imperata cylindrica*), fixing nitrogen, and providing woodfuel on a regular coppice rotation. A report from 1916 states that large areas of tree/shrub forests in places like Cebu, Panay and Ilocos came about as a result of deliberate planting and continuous management by private landowners. A more recent study indicated that planting occurred over a large area (10 000 hectares) of steep central uplands between the 1920s and the 1960s, primarily to produce woodfuel for urban markets.

These marginal lands have often been ignored by forestry interests because they are not considered forests and by the agricultural community because they are often too steep for commercial agriculture. However, these lands appear to be a vital source of woodfuel production in the Philippines and it is likely that, if sustainably managed, they will be adequate to meet national residential and commercial woodfuel requirements.

Source: FAO, 2009c.

GREENHOUSE GAS EMISSIONS

When woodfuels are produced sustainably and used as an alternative to fossil fuels, the net emissions of greenhouse gases such as carbon dioxide are minimal because a similar volume of gases emitted during combustion is sequestered by the next crop of trees. This benefit is recognized in CDM initiatives to promote greenhouse gas reductions through afforestation and renewable energy projects (Box 9).

However, in order to accurately assess the overall impacts on greenhouse gas emissions of woodfuel production and harvesting systems, a number of other factors must be considered, including (Heller, Keoleian and Volk, 2003; Marland and Schlamadinger, 1995, 1997; Marland and Marland, 1992; IEA 2009b):

- changes in carbon stored in soil, litter and trees as a result of changes in land use and management regime;

BOX 9

Encouraging sustainable charcoal production with climate-mitigation incentives in Brazil

CDM incentive programmes, such as those proposed for the charcoal-based pig-iron and steel industries in Brazil, recognize the greenhouse gas benefits of sustainable woodfuel and charcoal production and provide support for projects that increase those benefits and promote overall project sustainability. Such programmes should have two benefits: increased carbon sequestration and concomitant greenhouse gas reductions through afforestation; and the replacement of unsustainable and non-renewable fuels with sustainable bioenergy to power one of Brazil's major industrial sectors. Incentives to produce sustainable woodfuels should also help to curb woodfuel deficits and help industries become self-sufficient in supplying their energy needs.

Under a sustainable management regime, the use of charcoal in pig-iron and steel production can offset greenhouse gas emissions that would otherwise occur if the steel was produced using fossil fuels. Under one CDM initiative, funds from the sale of carbon credits are being used to encourage sustainable charcoal production at the mills of a pig-iron producer, Plantar, in Minas Gerais.

The Plantar project, largely funded through the World Bank Prototype Carbon Fund, involves the planting of over 23 000 hectares of FSC-certified plantations of high-yielding clonal *Eucalyptus* trees. These will be harvested sustainably and converted to charcoal to provide energy for the pig-iron industry. In addition to certified plantations, Plantar will also initiate a pilot project for landscape-scale biodiversity management involving the regeneration of native vegetation in areas previously covered by plantations. It is estimated that, over a 28-year period, the project has the capacity to offset 12 million tonnes of carbon-dioxide emissions that would otherwise be produced from fossil fuels.

Similar initiatives are being developed elsewhere, including a project by V&M Tubes do Brasil, the only steel-pipe manufacturer in the world to use 100 percent renewable energy for the production of pig iron and steel. Its forestry division (V&M Florestal) produces all the charcoal required to fuel its mills from 120 000 hectares of plantation forests certified by FSC. It is estimated that, over the next 27 years, this will offset 45 million tonnes of carbon-dioxide emissions that would otherwise be produced from fossil fuels.

While such projects in Brazil provide a number of economic and environmental benefits, environmental and civil-society non-government organizations have accused such initiatives of displacing local people and polluting water resources.

Source: FAO, 2009c.

- the consumption of fossil fuels during woodfuel production, transport, conversion and waste disposal;
- temporal variations in carbon stock and fluxes;
- overall effects on the range of greenhouse gases, which includes carbon dioxide, methane and nitrous oxides;
- complete life-cycle analyses of products and systems.

To maximize the positive impacts of woodfuel production on greenhouse gas emissions, management plans should consider the impacts of land-use change on the carbon balance and incorporate the most energy-efficient methods available at each stage of production.

GLOBAL SUPPLY CHAIN ISSUES

While woodfuel production for export can provide positive economic opportunities, it can also have negative environmental impacts along the supply chain. For example, the rapid expansion of export-oriented palm-oil plantations in Southeast Asia has led to deforestation in the region (Danielsen *et al*., 2009). Supply chain issues are not the focus of this publication, but consideration of their environmental impacts is warranted given the potential growth in international trade. When determining the sustainability of various energy production systems it is important that environmental impacts are considered along the entire woodfuel supply chain.

CONCLUSIONS

A number of potential environmental impacts can occur from woodfuel production and harvesting. Mitigating these impacts will require careful planning using the best available knowledge. In countries where little knowledge about local environmental conditions exists, efforts should be made to gather scientific and indigenous knowledge to help determine which of the issues identified in this chapter are of major concern and which woodfuel-related activities pose the greatest threats. Management plans can then be devised to address these issues and to specify practices that encourage positive environmental impacts and mitigate negative ones.

As discussed in Chapter 2, sustainable forest management criteria and indicators can provide a framework for conceptualizing, applying and monitoring sustainable forest management for woodfuel production. The issues presented in this chapter have been translated into a set of widely applicable and regionally adaptable principles, criteria and indicators for environmentally sustainable woodfuel production in Chapter 7. With the use of these criteria and indicators, issues can be addressed more easily through tools such as sustainable forest management certification schemes and other mechanisms such as government policies and voluntary guidelines.

7. Principles, criteria and indicators for sustainable woodfuels

Previous chapters have provided an overview of the potential policy, institutional, social, economic and environmental issues that can arise from woodfuel production and harvesting. Taking such issues into account, this chapter presents a set of principles, criteria and indicators to structure the implementation and monitoring of sustainable woodfuel production. These principles, criteria and indicators are applicable at national, regional and local levels. Nevertheless, they are not designed to be adopted in a standardized fashion in all regions and for all operations. Rather, they are designed to serve as a reference for the development of locally adapted criteria and indicators using local knowledge and broad stakeholder input.

Woodfuel production has unique features that are not fully addressed in existing policies, international processes and certification schemes – such as the complexity of woodfuel production systems, multi-stakeholder involvement, interactions with livelihoods and food security, climate-change mitigation and environmental impacts. Addressing such complexities in whatever policies or systems of monitoring and assessment are adopted is vital to ensuring that woodfuel production is economically, environmentally and socially sustainable while conserving biomass resources and contributing to energy security and climate-change mitigation. The principles, criteria and indicators presented in this chapter provide a basis for the development of policies or frameworks that take these complexities into account.

SELECTION OF PRINCIPLES, CRITERIA AND INDICATORS FOR SUSTAINABLE WOODFUELS

Creating an adaptable set of principles, criteria and indicators is challenging. In developing the set presented here, major international and national criteria and indicator processes were reviewed. Relevant criteria and indicators were then adapted to address specific features of woodfuel production, as identified in Chapters 3–6. New criteria and indicators were created where necessary.

This set of principles, criteria and indicators is applicable at national, regional and local levels. The four principles are:

- *Principle 1*. Policies, laws, institutional frameworks and capacity exist and are clear and consistent (based on Chapter 3);
- *Principle 2*. Human and labour rights are respected and social and cultural values are maintained or enhanced (based on Chapter 4);
- *Principle 3*. Economic sustainability is ensured (based on Chapter 5);
- *Principle 4*. Landscape and site productivity and environmental values are sustained (based on Chapter 6).

Principles, criteria and indicators for sustainable woodfuels

PRINCIPLE 1 POLICIES, LAWS, INSTITUTIONAL FRAMEWORKS AND CAPACITY EXIST AND ARE CLEAR AND CONSISTENT.

For effective governance, laws and policies specifically addressing woodfuels must be in place and must be consistent across the various levels of government and relevant institutions (e.g. those relating to energy and forestry). There must be sufficient institutional capacity within regions and operations to adequately implement and monitor such laws and policies.

CRITERION 1.1 Woodfuel production is consistent with international commitments and follows domestic laws.

Indicators

- Where governments have acceded to sustainable forest management or energy-related agreements at an international level, the existence of specific domestic laws and policies to support these commitments.
- The existence of specific laws and policies to provide for sustained woodfuel supply

CRITERION 1.2 Forest and energy policies address woodfuel issues.

Indicators

- The extent to which forest management policies recognize woodfuel production as one of the uses of forests and trees.
- The extent to which energy policies include components specific to woodfuels.

CRITERION 1.3 The instruments of woodfuel policies are consistent across and within ministries, agencies and levels of government.

Indicators

- The existence of mechanisms to ensure regular communication between forest and energy agencies to coordinate woodfuel policies.
- The extent to which the policies and laws administered by revenue, pollution-control, industrial-development, agriculture and other agencies are consistent with woodfuel policies.
- The extent to which applicable policies at the national, regional and local levels are consistent with each other.
- The extent to which local or traditional knowledge informs management planning and is consistent and compatible with national, regional and local policies.

CRITERION 1.4 Information on the status and use of woodfuel resources is available.

Indicators

- The extent to which accurate forest-cover and land-use data are available.
- The extent to which woodfuel production and consumption data are available.
- The extent to which data on the sale of woodfuels from public lands, including volumes and prices, are publicly available.
- The effectiveness of government monitoring and evaluation of national, regional and local programmes and initiatives affecting woodfuels.

CRITERION 1.5 The capacity to manage and regulate woodfuel production and consumption exists.

Indicators

- The extent to which national, regional and local agencies have the human and financial resources to implement existing policies and laws affecting woodfuels.
- The extent to which woodfuel producers are trained in sustainable woodfuel production practices.
- The extent to which programmes to sensitize stakeholders on the importance of sustainable woodfuel management are available.

PRINCIPLE 2 HUMAN AND LABOUR RIGHTS ARE RESPECTED AND SOCIAL AND CULTURAL VALUES ARE MAINTAINED OR ENHANCED.

Local people should benefit from woodfuel production, and the social and cultural values and the rights of local people should be respected. Criteria and indicators under this principle include requirements for the baseline assessment of existing social conditions so that strategies can be developed through stakeholder participation that will ensure social equity and provide opportunities for local people. Under this principle, woodfuel production should have no negative impacts on food security.

CRITERION 2.1 Land-use rights and ownership are clearly defined and established.

Indicators

- The extent to which stakeholder tenure rights are stated and acknowledged, and are secure.
- The existence of mechanisms for land acquisition, and the extent to which they are implemented.
- The existence of mechanisms for resolving disputes over land rights, and their effectiveness.

CRITERION 2.2 Woodfuel production is planned and implemented in a transparent and participatory manner involving all relevant stakeholders.

Indicators

- The existence of communication mechanisms for dialogue and conflict resolution between various stakeholders, and their effectiveness.
- The extent to which the needs of the population are taken into account by woodfuel producers.
- The extent to which there is equitable sharing of benefits.

CRITERION 2.3 Workers' wages and working conditions comply with all applicable laws, international conventions and collective agreements.

Indicators

- The extent to which woodfuel producers adhere to international labour conventions.
- The number of employees, contracted labour and small-scale producers/growers involved in woodfuel production.
- The nature of the salaries and benefits of employees in the woodfuel sector.
- The rates of injuries of employees in the woodfuel sector.

CRITERION 2.4 Woodfuel production contributes to the social and cultural development of local, rural and indigenous communities.

Indicators

- The extent of improvement in community access to energy.
- The extent of improvement in the economic conditions of communities.
- The extent of involvement and representation of stakeholders in decision-making processes involving woodfuel production.
- The extent to which programmes designed for women and marginalized communities are developed and implemented.
- The area and percentage of forests used for the purpose of supporting women and marginalized communities.

CRITERION 2.5 Woodfuel production minimizes negative impacts on food security.

Indicators

- The extent to which forest-dependent communities retain access to forest lands for food.
- The effect of management of the woodfuel resource on the density of species that are important sources of food.

PRINCIPLE 3 ECONOMIC SUSTAINABILITY IS ENSURED.

If woodfuel production is to be sustainable, the costs of producing woodfuels must not outweigh the benefits. Under this principle, the direct and indirect economic benefits of woodfuels should be maximized and long-term economic viability should be maintained.

CRITERION 3.1 Woodfuels represent the most beneficial use of woody biomass resources.

Indicators

- The extent to which the direct and indirect benefits of woodfuel production outweigh the direct and indirect costs.
- The efficiency with which woodfuels in particular and forest resources in general are used.

CRITERION 3.2 Woodfuels are economically viable.

Indicators

- The cost-competitiveness of woodfuels compared with alternative energy sources.
- The profitability of woodfuels, when the full benefits and costs are taken into account.

CRITERION 3.3 Woodfuels contribute to local/rural economic prosperity and the livelihoods of local residents.

Indicators

- The fairness of the distribution of income generated by woodfuel production among woodfuel producers and workers.
- The extent of employment opportunities, value-added products and credit facilities available to rural communities as a result of woodfuel production.

- The contribution of woodfuels to economic diversity and resilience.
- The accessibility and affordability of woodfuels to local residents.

PRINCIPLE 4 LANDSCAPE AND SITE PRODUCTIVITY AND ENVIRONMENTAL VALUES ARE SUSTAINED.

This principle addresses the potential impacts of woodfuel production systems on soils, hydrological systems, water quality, site productivity, biodiversity and greenhouse gas emissions.

CRITERION 4.1 Ecological resistance and resilience at the landscape level is maintained or enhanced.

Indicators

- The existence of measures to maintain or enhance diversity at the landscape and ecosystem levels.
- The extent of degradation of sensitive or valuable ecosystems, high-conservation-value forests, or protected areas.
- The long-term sustainability of harvest levels.
- The existence of long-term management strategies to sustainably meet user demand, and the extent to which they are being implemented.

CRITERION 4.2 Woodfuel production does not degrade ecosystems and landscapes.

Indicators

- The extent to which the productive capacity of ecosystems and landscapes, including forests, is maintained or improved.
- The extent to which practices ensure soil conservation and improvement.
- The extent to which soil nutrient status, temperature, structure and processes are maintained or improved.
- The extent to which the quality and quantity of surface and groundwater is maintained or improved.
- The extent to which, where necessary, reforestation is carried out to replace harvested forests.

CRITERION 4.3 Biodiversity is maintained or enhanced at the landscape level.

Indicators

- The extent to which sufficient habitat is maintained to ensure the survival of endangered forest-dependent species.
- The extent to which key habitats (e.g. cavity trees, downed woody debris, nesting sites and other niches) within managed areas are maintained.
- The extent to which there is connectivity between habitats in the landscape (e.g. migration corridors, and the distribution of downed woody debris).
- The extent to which the conservation status of species is catalogued.
- The extent to which the population densities of threatened or endangered species are maintained.
- The extent to which negative ecological impacts from the use of genetically modified organisms are avoided.

CRITERION 4.4 Woodfuel production contributes to a net reduction in greenhouse gas emissions.

Indicators

- The extent to which life-cycle carbon and greenhouse gas assessments are available and taken into consideration in management planning.
- The extent to which a supply chain energy balance is available and is taken into consideration in management planning.

IMPLEMENTING CRITERIA AND INDICATORS FOR SUSTAINABLE WOODFUELS

Efforts to implement principles, criteria and indicators for sustainable woodfuels, whether through intergovernmental processes, national policies, certification systems, guidelines or other mechanisms, should consider:

- ***Taking advantage of market mechanisms and information.*** In some cases, market-based mechanisms, such as certification schemes, may be more cost-effective than mandatory ones. It is important, however, to ensure that the system chosen meets the desired goal of sustainability. Market prices for environmental services such as carbon sequestration may not accurately reflect their social value but may offer useful guidance.
- ***Coordinating with existing forest, energy and greenhouse gas policies/regulations, certification systems and ethical standards.*** For example, many of the concerns, criteria and guidelines for managing forests for timber production are similar to those pertaining to management for woodfuels. Where forest or energy certification systems are already in place, a woodfuel component could be built in.
- ***Avoiding duplication and promoting synergies among environmental, economic and social standards.***
- ***Allowing flexibility.*** Given differences in biomass sources, socioeconomic conditions and policy emphases, flexibility is needed when developing and implementing criteria and indicators for particular regions.
- ***Adopting incremental and adaptive approaches.*** Woodfuel production systems are complex and may compete with other forest uses such as timber production and the provision of ecosystem services. Such complex interrelationships suggest that care is needed in adapting and implementing criteria and indicators for sustainable woodfuel production.

Barriers to implementation in low-capacity regions and operations

The adaptation, development and implementation of criteria and indicators for sustainable woodfuels will present a range of challenges, especially for small-scale producers (Nussbaum, 2002). These include, but are not limited to the following.

- ***Availability of information.*** Many small-scale woodfuel producers in remote areas have little information about sustainability and the measures needed to achieve it. They may also lack access to specialized knowledge about environmental risks and mitigation techniques.

- ***Cost.*** The cost of achieving sustainability can be exorbitant and restrictive for small-scale or low-budget operations. This is less applicable to larger operations that benefit from economies of scale or a stronger economic and infrastructural base.
- ***Support.*** Small producers or low-capacity operations often have difficulty accessing support networks to help them through the process of implementing and monitoring criteria and indicators. For example, achieving certification can be more difficult in developing countries because third-party auditors are less available.
- ***Structure of forest policies and other sustainable forest management tools.*** In many developing countries, a great deal of woodfuel-gathering occurs outside forests (e.g. in woodlots or agroforestry operations, and from single trees in urban or farm settings). These resources are generally not covered by existing forest policies and other tools such as certification for ensuring sustainable forest management, which often deal only with in-forest activities.

The set of principles, criteria and indicators presented here has been designed to be locally adaptable and to be used for implementing and monitoring sustainable practices across different ecological regions, production types and scales, legislative frameworks, and economic and information capacities. It is expected that higher-capacity countries and larger operations should be able to adapt and follow the criteria and indicators more rigorously than less developed countries or smaller, low-capacity operations.

8. Principles, criteria and indicators for sustainable charcoal production

In 2007, 43.6 million tonnes of charcoal were consumed worldwide (Table 4). Developing countries accounted for nearly all this consumption, and Africa alone consumed more than half of total world production. Charcoal production increased by about 160 percent between 1992 and 2007 and is expected to continue to grow as populations expand, especially in low-income countries (Table 5).

At a local scale, the negative effects of charcoal use arise largely from the inefficiency of its production, poor forest and land management, which leads to degradation, and the long transportation distances involved. In many charcoal industries a large part of the energy stored in the feedstock – fuelwood – is lost in the production process; thus, charcoal-users ultimately consume more fuelwood

TABLE 4

Charcoal consumption patterns by region, 2003–2007 ('000 tonnes)

Region	2003	2004	2005	2006	2007
Africa	20 496	21 500	22 143	22 756	23 550
Americas	15 674	16 522	16 815	13 506	12 568
Asia	7 114	7 357	6 180	6 369	6 599
Europe	615	699	814	720	888
Oceania	24	23	21	21	21
World	**43 923**	**46 101**	**45 973**	**43 372**	**43 626**

Source: FAO, 2009a.

TABLE 5

Charcoal production by region, 1992–2007 ('000 tonnes)

Region	1992	1995	1998	2001	2004	2007
Africa	15 056	17 775	19 217	19 953	22 301	24 765
Americas	7 275	14 395	14 739	15 824	16 931	13 033
Asia	5 851	6 085	5 993	5 904	6 028	6 659
Europe	540	415	487	310	482	689
Oceania	24	25	15	27	24	24
World	**28 754**	**38 695**	**40 452**	**42 107**	**45 765**	**45 171**

Source: FAO, 2009a.

Small-diameter wood is trucked to a charcoal kiln in Brazil

than do those who consume fuelwood directly. Many charcoal businesses are unsustainable and, overall, the sector has a negative image. Nevertheless, charcoal production rarely attracts the attention of policy-makers.

Charcoal production and use can have global environmental effects. The unsustainable harvesting of the resource results in net carbon-dioxide emissions. The pyrolysis of the feedstock produces incomplete combustibles such as methane, which has a higher global-warming impact than carbon dioxide (Bailis, Ezzati and Kammen, 2003) – to the extent that the main global-warming impact of the charcoal cycle may result from feedstock pyrolysis and not from the burning of the charcoal itself.

Criteria and indicators are neutral assessment tools that measure, assess, monitor and demonstrate progress towards achieving the sustainable management of resources. This chapter presents criteria and indicators that may assist in the development of policies and regulations for charcoal production.

CHOOSING CHARCOAL AS A SOURCE OF ENERGY

Charcoal has many favourable characteristics compared with fuelwood, agricultural residues or dung. It has a higher energy density than other biomass fuels and can be stored without risk of insect or fungal attack. It has excellent cooking properties as it burns evenly, for a long time, and can be easily extinguished and reheated (Kammen and Lew, 2005). The conversion of fuelwood to charcoal creates a product that has double the energy per unit mass and is less bulky and more convenient to transport, store and sell than fuelwood (Foley, 1986). Even in developed countries, charcoal is highly desired for the flavours it imparts to grilled food.

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In many parts of the world, particularly in developing countries (as shown here in Brazil), charcoal is still a major source of energy

Factors influencing the choice of charcoal over fuelwood in urban areas include the following:

- Charcoal has a higher calorific value per unit weight (about 31.8 megajoules [MJ] per kilogram of completely carbonized charcoal with 5 percent moisture content, compared with about 16 MJ per kilogram of fuelwood at 15 percent moisture content).
- Due to its high calorific value per unit weight, charcoal is cheaper to transport.
- Charcoal requires less storage space per unit energy.
- Charcoal is not attacked by insects and fungi.
- Charcoal is almost smokeless and sulphur-free, making it more suitable for towns and cities.

Studies from around the world suggest that, as affluence increases, households tend to prefer cooking with fuels that are cleaner and more convenient than wood. The well-off see changes from fuelwood to charcoal, kerosene, gas or electricity as steps in the improvement of quality of life (Reddy, 1982). However, many poor households still cannot afford such fuels (or the devices needed for their use) and, usually, charcoal remains their main option. Other large users of charcoal include light industrial users, such as blacksmiths and ceramic and brick makers, and heavy industries such as pig-iron and steel production.

CHARCOAL PRODUCTION

World production of charcoal has been increasing steadily since 1992 in Africa and, to a lesser extent, Asia (Table 5). Within Asia, charcoal production is rising in India and Thailand but declining in China (FAO, 2009a).

In many places, including Liberia, charcoal is produced using simple earth pits

Charcoal is traditionally produced in earth-pits or earthen, brick or steel kilns in batches of 1–5 tonnes (Foley, 1986). Fuelwood is gathered and cut to size and placed in an earth-pit or an above-ground kiln. When the pit or kiln is fired the fuelwood heats up and undergoes pyrolysis, a process that may take a few weeks. About half of the energy in the fuelwood is typically lost in the process but the charcoal produced has higher energy content per unit mass.

The efficiency of charcoal production varies considerably. Efficiency is dependent on many factors, such as kiln type, moisture content, species, wood density, the arrangement of the wood inside the kiln, the skill and experience of the producer, and even the climatic conditions (RWEDP, 1997). The earth-pit method has a maximum efficiency of 15 percent (Agarwal, 1980). Kilns usually have higher yields, averaging around 25 percent on a wet or air-dry weight basis.

Charcoal retains 40–60 percent of the energy content of the wood feedstock and most of the remainder is released as gases. In most traditional methods, the recovery of these by-products is not economically feasible (Bailis *et. al.*, 2003). Nevertheless, charcoal has a higher heating efficiency than wood and some of the energy lost during manufacture is offset by a reduction in the energy needed to transport it to markets (FAO, 1983).

In recent years, more efficient charcoal production methods have been developed to meet environmental and energy norms and to improve carbonization yields (FAO, 2007; VITA, 1981). These include: batch-type retorts, where wood is carbonized by an external source of heat; metal kilns equipped with vapour incinerators; and Lambiotte-type continuous retorts, where wood is introduced at the top of the kiln, the charcoal is extracted at the bottom, and the vapours are burned to meet the heat requirements of the process (VITA, 1981). All these methods require significant investment and are usually unaffordable by small-scale charcoal-makers in developing countries.

CONCERNS ABOUT CHARCOAL PRODUCTION

Charcoal production has far-reaching impacts extending across a range of social and environmental issues. These include health problems associated with air pollution, environmental change associated with greenhouse gas emissions and the depletion of local forests and woodlands, and social problems related to migration, labour and gender. Nevertheless, such problems rarely arise as a result of charcoal production alone. Rather, they are the result of complex relationships between charcoal producers and consumers, the environment, and the larger political economy. Therefore, understanding the problems associated with charcoal production requires an understanding of the social, political, economic and environmental contexts in which they arise.

Policy issues

In many countries, forest policies emphasize forest use for timber production, and energy policies focus on fossil fuels. Charcoal production is therefore denied the comprehensive treatment it deserves in both the forestry and energy sectors. Where policies exist they often lack coherence. For example, although there are policies in Kenya promoting sustainable farm forestry for charcoal production and improved charcoal stoves, charcoal production is illegal (Karekezi and Ranja, 1997). Clear, integrated policies are needed to avoid such contradictions and to enable the development of urgently required, coordinated approaches to sustainable charcoal production.

National energy, forest and environment policies should be harmonized to foster inter-institutional collaboration, the transfer of technology and capacity building. In addition, a coherent wood-energy policy coordinated by a central institution could be developed. In many countries, land tenure is a key issue that must be addressed because only when land-use rights are clear can resource management be undertaken effectively.

Environmental and climate issues

A significant portion of wood used for charcoal production is harvested unsustainably, with emissions of greenhouse gases to the atmosphere. On the other hand, if the fuelwood resource for charcoal production is grown and harvested sustainably, charcoal has the potential to help mitigate climate change.

Charcoal production results in the formation of products such as methane (a potent greenhouse gas), carbon monoxide, alkanes, oxygenated compounds and particulate matter (Bailis *et. al.*, 2003). These by-products of kilns and pits are usually released into the atmosphere and pose an air-pollution problem. The local impacts of this pollution may be reduced by locating charcoal production sites at least 100 metres from villages (Mugo and Ong, 2006), although few data are available on the effectiveness of such a measure. The use of cleaner, more efficient technologies in charcoal production could also have huge health benefits.

Another pollutant produced in the charcoal-making process is charcoal dust, a black powdery residue that disperses quickly into the air and can cause respiratory illnesses. Many rural households use the dust for medicinal purposes, as an insect repellent and as a soil conditioner on farms, thus increasing their exposure to it.

The role of charcoal in land degradation and deforestation

The impact of charcoal production on forests is significant for several reasons. The charcoal-making process is resource-intensive as the harvesting of the feedstock is often concentrated in small areas over a short period of time (RWEDP, 1993). In contrast, fuelwood users typically collect relatively small quantities of wood on a regular basis and thus the forest impact is more dispersed and less intensive. Moreover, fuelwood-users usually collect twigs, branches and dead wood, which has less impact (at least in the short term) on forest productivity.

Charcoal producers often target specific species, and the concentrated exploitation of a few species can adversely affect biodiversity. The continued use of natural forests for charcoal production represents a threat to the future of the resource, especially in situations where there is high demand (such as in the periphery of large urban zones) and a lack of sustainable forest management (Hosier, 1993). In low-rainfall areas, where regenerative capacity is relatively low, unplanned and unmanaged charcoal production can accelerate desertification processes.

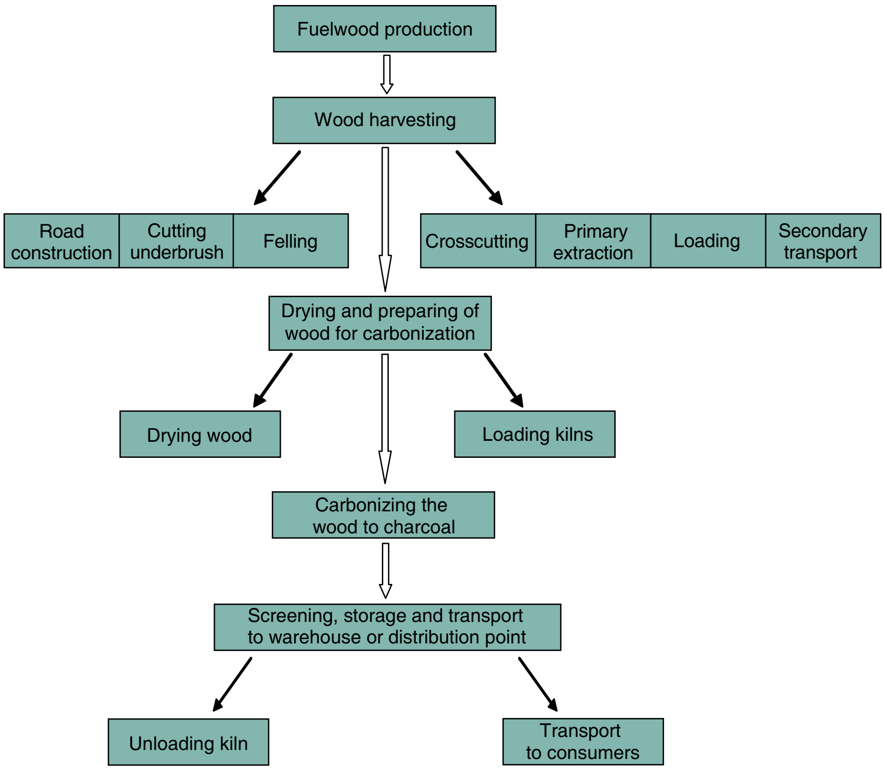
Socioeconomic considerations

Charcoal is often an important commodity produced by the rural poor to meet domestic energy needs. Cash income from charcoal may act as a form of insurance against crop failures (FAO, 1983). For many urban poor, charcoal provides a reliable, convenient and accessible source of energy for cooking at a stable cost. In addition, the charcoal trade provides small-scale retail opportunities for many people, including women.

A large number of people are employed in the various phases of charcoal-making and distribution, including: collection; sizing the wood; the preparation of kilns for converting wood to charcoal; loading the wood into kilns and unloading charcoal after conversion; unloading, bundling, packaging and transportation; and marketing (Figure 2). Additional employment is generated by the activities that use charcoal.

In many countries the charcoal industry is largely unregulated and thus informal (FAO, 2009c). This often means that rural communities do not reap the full benefits of the industry because of unscrupulous trading practices. In some cases, for example, rural charcoal workers are obliged to purchase supplies and equipment from their employers at exorbitant prices and thus fall into debt.

FIGURE 2
Processes involved in charcoal production



Despite the health issues associated with charcoal production and trading, charcoal use has significant health benefits compared to fuelwood because of reduced indoor levels of toxic air pollutants during use. However, when charcoal is used for heating purposes, special care is needed to avoid exposure to dangerous carbon-monoxide emissions.

PRINCIPLES, CRITERIA AND INDICATORS

Charcoal consumption is likely to continue to increase globally as the push towards renewable energy continues. Poorly managed, such an increase could have significant negative impacts at local to global scales, including forest degradation, the loss of environmental services, and issues related to human health. At the same time, charcoal production is an important livelihood option for many rural poor. Sound policies and strategies are vital, therefore, to ensure that charcoal production is not only environmentally sustainable but also increases its role as an agent of sustainable rural development.

Forest and energy agencies should give particular attention to:

- the establishment of forest management programmes to avoid forest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The charcoal trade provides small-scale retail opportunities for many people, including women

degradation and deforestation through overharvesting for charcoal production;
- the formalization and regulation of the charcoal industry;
- providing charcoal makers with a range of suitable technologies that best suit local conditions (rather than a single "best" technology);
- the promotion, through pricing and appropriate policies, of charcoal from residues and plantation timber;
- investment in improved charcoal-production technology;
- the training of forest planners, extension agents and charcoal makers.

The criteria and indicators presented here, which have been adapted from those presented in Chapter 7 under the same overarching principles, cover the entire charcoal production cycle. They may be used in the development of policy and guidance tools to ensure that charcoal production is carried out on a sustainable basis; contributes to energy security; and provides greater economic benefits for communities.

Principles, criteria and indicators for sustainable charcoal production

PRINCIPLE 1 POLICIES, LAWS, INSTITUTIONAL FRAMEWORKS AND CAPACITY EXIST AND ARE CLEAR AND CONSISTENT.

CRITERION 1.1 Policy statements and legislation for charcoal production are established and implemented.

Indicators

- The existence of policy statements supporting charcoal production.
- The existence of laws governing charcoal production, and the extent to which their implementation is monitored.

CRITERION 1.2 Effective institutional structures exist to govern charcoal production.

Indicators

- The effectiveness of capacity-building mechanisms in place.
- The extent to which agencies (e.g. forestry, environment and/or energy) responsible for monitoring and assessing forests are equipped with the staffing and financial resources needed to fulfil their mandate.

PRINCIPLE 2 HUMAN AND LABOUR RIGHTS ARE RESPECTED AND SOCIAL AND CULTURAL VALUES ARE MAINTAINED OR ENHANCED.

CRITERION 2.1 The relationship between human culture and forest management and charcoal production is recognized and respected.

Indicators

- The extent to which charcoal production respects local cultures.
- The existence of activities that degrade human culture, and the effectiveness of measures to combat them.

CRITERION 2.2 The health impact of common charcoal-making technologies is addressed.

Indicators

- The level of health-related complaints and the cost of medication for charcoal makers, transporters and traders.
- The nature and quantities of the chemical constituents of smoke emitted from charcoal kilns/pits, including greenhouse gases such as carbon dioxide and methane, and health-damaging emissions such as particulates and sulphur dioxide.

CRITERION 2.3 Livelihoods are improved through the sustainable production and consumption of charcoal.

Indicators

- The availability of and access to charcoal and other modern energy sources in rural areas.
- Employment generation from charcoal production activities in relation to total national employment.
- Average per capita income in various charcoal-production activities.

PRINCIPLE 3 ECONOMIC SUSTAINABILITY IS ENSURED.

CRITERION 3.1 There are adequate levels of investment in charcoal production, and the sector makes a commensurate contribution to economic growth.

Indicators

- The annual investment in sustainable resource management and charcoal production.
- The aggregate value of sustainable charcoal production and rate of return on investment in the sustainable production of charcoal compared with rates of return on investments in other sources of energy.

PRINCIPLE 4 LANDSCAPE AND SITE PRODUCTIVITY AND ENVIRONMENTAL VALUES ARE SUSTAINED.

CRITERION 4.1 Biodiversity is conserved in natural and planted forests across all tenure types.

Indicators

- The extent to which the diversity of species harvested for charcoal is maintained.
- The existence of specific management measures to maintain biodiversity, such as the retention of seed trees and the protection of nesting sites and keystone species.

CRITERION 4.2 The ecosystem and protective functions of the forest are maintained.

Indicators

- The extent to which ecologically sensitive and important areas (e.g. plains, stream banks and steep slopes) are identified and protected with appropriate measures.
- The extent to which soil and water restoration programmes, where necessary, are implemented.

CRITERION 4.3 The boundaries of public charcoal resources are known and respected.

Indicators

- The extent to which local users and other stakeholders recognize and respect the boundaries of public wood energy resources (e.g. the existence of boundary markers and conditions of access).
- Evidence of forest encroachment (visual observation and records).

CRITERION 4.4 Effective local management is in place for maintaining, assessing and monitoring forest resources for charcoal production.

Indicators

- The extent to which ownership and use rights to resources are established and respected.
- The extent to which regulations governing forest resource use for charcoal production are enforced and monitored.
- The availability of documentation and records of forest activities related to charcoal production.
- The existence of conflict-resolution mechanisms (number of cases resolved).

CRITERION 4.5 Management plans are documented and implemented.

Indicators

- The adequacy of stated management objectives (both long-term and short-term).
- The existence of processes to revise forest management and harvesting plans periodically.

CRITERION 4.6 Local stakeholders are aware of the woodfuel resources available for charcoal production.

Indicator

- The extent to which local stakeholders involved in charcoal production meet and interact with resource managers.

CRITERION 4.7 Charcoal supply sources are managed sustainably.

Indicators

- The extent to which supply sources (i.e. natural forests, plantations, and trees outside forests) are under sustainable management.
- The legality of the fuelwood procurement system for charcoal-making, and the reliability of records on the volumes of woodfuel harvested and charcoal produced.

CRITERION 4.8 There are inventories of the charcoal-making technologies currently in use and assessments of their average efficiency.

Indicator

- The existence of a list of prevailing charcoal-making technologies and assessments of their efficiencies (e.g. record/report, fuelwood-input to charcoal-output ratio).

CRITERION 4.9 User-friendly and environmentally friendly charcoal-production technologies are promoted, and research and development is under way to improve the efficiency and effectiveness of woodfuel production and use.

Indicators

- The extent to which environmentally friendly charcoal-making technologies are promoted and applied.
- The extent to which priority areas for research and development in charcoal-making are identified (i.e. technologies and end-uses).

CRITERION 4.10 There are guidelines for charcoal quality control.

Indicator

- The existence of a guide or code on charcoal production (e.g. species selection, technology, reducing emissions, packaging, and labelling).

9. Conclusions and recommendations

To ensure that the key issues related to the sustainability of woodfuel production are fully recognized and addressed they need to be analysed and organized within a rational framework. The criteria and indicators presented in this publication under four overarching principles provide such a framework.

The four principles are:

- Policies, laws, institutional frameworks and capacity exist and are clear and consistent.
- Human and labour rights are respected and social and cultural values are maintained or enhanced.
- Economic sustainability is ensured.
- Landscape and site productivity and environmental values are sustained.

The criteria and indicators based on these principles can be applied by incorporating them in guidelines or regulations for woodfuel production and use. The capacity to apply criteria and indicator schemes in an operation varies according to its scale, location and a range of other factors, including the accessibility and availability of information, the cost of production, the availability of technical and financial support, and, where they are to be applied, the structure and cost of certification schemes. The application of these criteria and indicators is intended to be flexible and locally adaptable.

Several approaches can be taken in the development of sustainable woodfuel-production systems that may facilitate a move towards certification:

- variable monitoring, in which the intensity of monitoring varies depending on capacity and the importance of specific criteria and indicators;
- tiered certification, in which compliance is based on capacity, ranging from adherence to a preliminary set of criteria and indicators to, eventually, full compliance;
- group certification, in which smaller operations cooperate to achieve the economies of scale of a larger group.

RECOMMENDATIONS

Two general recommendations can be drawn from this examination of the issues involved in woodfuel sustainability and the tools available to address these issues. They are that:

- policy-makers and decision-makers involved in decisions on woodfuel systems should recognize more clearly the benefits of sustainable woodfuel production and the range of issues and concerns associated with unsustainable woodfuel production;

- the issues, concerns and benefits associated with woodfuel production should be addressed with the aid of the criteria and indicators for woodfuel sustainability presented in this publication, adapted to suit local conditions.

Third-party certification schemes are one type of mechanism for monitoring adherence to standards associated with criteria and indicators and delivering market benefits for enterprises with sustainable production systems. These schemes are increasingly recognizing the specific requirements of sustainable woodfuels.

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FAO FORESTRY PAPER

Criteria and indicators for sustainable woodfuels

Reliable, secure and safe energy sources are fundamental to the well-being and social and economic development of all societies. With growing pressure on energy resources and a heavy dependence on non-renewable fossil fuels, the world faces two key energy-related problems: the lack of a secure and affordable supply, and the threat of overconsumption leading to irreversible environmental damage. As part of the solution to these problems, many countries are looking increasingly to their biomass-energy resources. This publication focuses on one major source of biomass energy – woodfuels. In many developing countries, woodfuels are still commonly used for household cooking and heating and are also important for local processing industries. In many developed countries, wood-processing industries often use their wood by-products for energy production. In some countries, notably the Nordic countries, forest residues are increasingly used for industrial-scale electricity generation and heating. Several developing countries have enormous potential to produce energy from forests and trees outside forests, for both domestic use and export. However this potential is not often properly reflected in national energy-development strategies. This publication sets out principles, criteria and indicators to guide the sustainable use of woodfuel resources and the sustainable production of charcoal. It is designed to help policy- and decision-makers in forestry, energy and environment agencies, non-governmental and other civil-society organizations and the private sector ensure that the woodfuel sector reaches its full potential as an agent of sustainable development.

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