

2. Forest resources and woody biomass

The availability of forest resources to meet the future demand for fuel and fibre will require the implementation of sustainable forest management, the better use of residues and waste, and the balancing of supply and demand across the various types of forests and other wood-based biomass resources. The high rates of deforestation that occurred in the second half of the twentieth century have raised concerns about the future use of forests for bioenergy. Much of that deforestation, however, was related to agro-industrial expansion. Local and community use of forest resources can often be more ecologically sound, since those who live in or near forests are more likely to recognize the need to preserve them for future use (Leach and Mearns, 1988). This chapter defines several types of forest and presents data on their extent, the availability of woody biomass and past and current use.

FORESTED AREA

Table 8 shows the area of forest, by region, over time. Roughly half the world's forests are in South and Central America and Europe (with the Russian Federation counted as part of Europe). In the period 1993–2007 the greatest rates of forest loss were in Africa and South America, while Asia, Europe and North America gained forest. The gain in Asia was due primarily to an expansion in the area of planted forests.

FAO (2006a) defines forest as land spanning more than 0.5 hectares with trees higher than five metres and a canopy cover of more than 10 percent, or trees able

TABLE 8
Global forested area, by region

Region	Forest area (million ha)				Share of global total (%)	Average annual rate of change, 1993–2007 (%)
	1993	1998	2003	2007		
Africa	686	664	643	627	16	-0.64
Asia	572	568	570	574	15	0.02
Europe	992	996	1 000	1 003	25	0.08
North America	610	612	613	614	16	0.04
South and Central America	979	957	934	915	23	-0.49
Oceania	211	209	207	206	5	-0.19
World	4 051	4 006	3 967	3 937		-0.20

Source: FAO, 2010a.

to reach these thresholds in situ. This definition does not include land that is predominantly under agricultural or urban land use, such as tree stands in fruit plantations, agroforestry systems and urban parks and gardens.

Natural forest is forest comprising native forest tree species only, with the possible exception of small areas of natural regeneration of introduced or naturalized species.

Forest plantations comprise forests of native or introduced species that have been established through planting or seeding, mainly for the production of wood or non-wood products or the provision of environmental services. It includes all stands of introduced species established for soil and water protection, pest control and the conservation of biological diversity, and areas of native species characterized by few species, straight lines of trees and even-aged stands.

Planted forests are those forests predominantly composed of trees established through planting and/or deliberate seeding of native or introduced species. This definition specifically recognizes the planted component of semi-natural forests comprising primarily native species, and forest plantations of primarily introduced species; thus, forest plantations are a subset of planted forests (Table 9).

Primary forests account for 36 percent of forest area but have decreased by more than 40 million hectares since 2000 (FAO 2010c). The decrease of primary forest area, 0.4 percent over a ten-year period, is largely due to reclassification of primary forest to “other naturally regenerated forest” because of selective logging and other human interventions.

Planted forests account for 7 percent of total forest area or 264 million hectares. During 2005–2010, the area of planted forest increased by about 5 million hectares per year. Most of this was established through afforestation, i.e. planting of areas not forested in recent times, particularly in China.

TABLE 9
Forest categories showing the planted forest subgroup

Primary	Modified Natural	Semi-natural		Plantation		Trees outside forests
		Assisted natural regeneration	Planted component	Productive	Protective	
Planted forest subgroup						
Forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed	Forest of naturally regenerated native species where there are clearly visible indications of human activities	Silvicultural practices for intensive management (weeding, fertilizing, thinning, selective logging)	Forest of native species, established through planting, seeding, coppice	Forest of introduced species and in some cases native species, established through planting or seeding mainly for production of wood or non-wood products	Forest of native or introduced species, established through planting or seeding mainly for provision of services	Stands smaller than 0.5 ha; trees in agricultural land (agroforestry systems, home gardens, orchards); trees in urban environments and scattered along roads and in landscapes

Source: Modified from FAO, 2006b.

WOOD PRODUCTS

The primary wood-based uses of forest resources are the production of fuelwood, used directly in households and businesses, and industrial roundwood, which is processed to varying degrees to produce a range of wood and wood-fibre products. In 2008, nearly two-thirds (63 percent) of the production of industrial roundwood was in North America and Europe (including the Russian Federation) (Table 10). The biggest change between 1988 and 2008 was the emergence of South America (mainly Brazil) as a major global producer and exporter of industrial roundwood.

The production and use of woodfuel is concentrated in Africa and Asia, where the traditional use of biomass for heating and cooking still predominates; together, Africa and Asia account for 75 percent of global woodfuel production and consumption (Table 11). Nevertheless, there has been a considerable divergence between these two regions: consumption is decreasing in Asia due to urbanization and the switch to modern energy sources and increasing in much of Africa due to population increases.

TABLE 10
Industrial roundwood production, by region

Region	1988		2008		Average annual rate of change 1988–2008 (%)
	(million m ³)	(%)	(million m ³)	(%)	
Africa	53	3	70	5	1.41
Asia	267	16	243	16	-0.46
Europe	605	36	505	32	-0.90
North America	598	36	489	31	-1.00
South and Central America	116	7	197	13	2.70
Oceania	30	2	52	3	2.81
World	1 668	100	1 557	100	-0.35

Source: FAO, 2010a.

TABLE 11
Woodfuel production, by region

Region	1988		2008		Average annual rate of change 1988–2008 (%)
	(million m ³)	(%)	(million m ³)	(%)	
Africa	424	25	638	34	2.06
Asia	777	46	754	40	-0.16
Europe	134	8	152	8	0.65
North America	100	6	47	2	-3.74
South and Central America	230	14	286	15	1.08
Oceania	9	1	16	1	2.94
World	1 674	100	1 892	100	0.61

Source: FAO, 2010a.

In the last two decades a significant market has emerged for processed forms of solid bioenergy, especially wood pellets. The technology for the pelletization of wood matured in the 1980s and 1990s and wood pellets are now produced and traded internationally on a significant scale, with major markets in Europe and North America. The magnitude of wood pellet production and trade is difficult to estimate because the Harmonized Commodity Description and Coding System (often referred to as the Harmonized System or HS) does not (yet) have a dedicated code for wood pellets. In 2008 the estimated global production was 11.5 megatonnes (Mt) and the estimated amount traded was 4 Mt (IEA, 2010b). With an average energy density of 17.5 gigajoules (GJ) per tonne, this amounts to 200 terajoules (TJ) produced and 70 TJ traded.

PLANTED FORESTS

Planted forests are playing an increasingly important role as a source of wood products and bioenergy. They are concentrated in Asia and Northern, Central and Eastern Europe: combined, these regions account for more than 75 percent of the world total area of planted forests (Table 12). The data presented in Table 12 were obtained from a detailed survey of 61 countries on various species, summarized here as softwoods (e.g. *Pinus* spp.) and hardwoods (e.g. *Acacia* spp. and *Eucalyptus* spp.). An estimated 1.4 billion m³ of wood products were harvested from these planted forests in 2005, about 47 percent of which was devoted to industrial roundwood, 39 percent to pulp and paper and 10 percent to bioenergy (Carle and Holmgren, 2008).

The proportion of planted forests dedicated to bioenergy is likely to increase because second-generation (lignocellulosic) biofuels are likely to be sourced from planted forests (FAO, 2009). Moreover, those same planted forests could also serve feedstock markets for solid woodfuel applications, increasing their economic flexibility. The additional demand could, however, constrain efforts to achieve sustainable forest management. Thus, planted forests have strategic significance in terms of both energy security and environmental sustainability. Recognizing the

TABLE 12
Planted forest area, hardwoods and softwoods (million ha)

Region	Softwoods	Hardwoods	Total
Africa	1.7	7.8	9.5
Asia	34.2	90.6	124.8
Northern, Central and Eastern Europe	62.4	12.1	74.5
Southern Europe	4.6	4.7	9.3
North and Central America	26.1	1.7	27.8
South America	5.4	5.6	11.0
Oceania	2.9	0.7	3.6
World	137.3	123.2	260.7

Source: Carle and Holmgren, 2008.

growing importance of planted forests, FAO led a coordinated multi-stakeholder process to develop a set of guidelines for the management of planted forests (FAO, 2008). These provide decision-makers, investors and foresters with a tool for planning, managing and monitoring institutional, political, economic, social, cultural and environmental priorities.

WOODFUEL USE

Woodfuel consumption increased globally by 10 percent in the period 1989–2008, even though it decreased in both North America and Asia (Table 13). Recent increases in woodfuel use in Europe (in both total consumption and per capita consumption) are due to a combination of the increasing cost-effectiveness of biomass for combined heat and power production and incentives provided through the Directives on Renewable Energy of the European Union (EU) and related EU-wide strategies for increasing the use of renewable energy (European Commission, 2006, 2009).

Unprocessed fuelwood of various types constitutes by far the largest consumption category of woodfuels; together with charcoal, it forms the energy base of the world's poor. To a significant extent, the future use of wood energy to achieve climate and development goals thus depends on the pace of transformation in household and industrial uses of fuelwood and charcoal. Table 14 shows that per capita woodfuel consumption is declining in all listed regions except Europe.

CHARCOAL USE

In developing countries charcoal is generally produced at small-scale facilities in rural areas, traditionally in earth-pits or above-ground mounds. An earth-pit kiln involves placing wood in a pit dug into the ground and lighting it from the bottom; the pit is then covered with green leaves or metal sheets and earth to prevent

TABLE 13
Average annual consumption of woodfuel, by region^a

Region	1989–1993		1994–1998		1999–2003		2004–2008	
	Volume (million m ³)	Share of world total (%)	Volume (million m ³)	Share of world total (%)	Volume (million m ³)	Share of world total (%)	Volume (million m ³)	Share of world total (%)
Africa	452	27	505	29	528	30	596	32
North America	96	6	86	5	48	3	47	3
South America	164	10	175	10	186	10	194	10
Asia	787	46	798	46	822	46	784	42
Europe	121	7	85	5	107	6	144	8
Oceania	10	1	11	1	12	1	12	1
World	1 705		1 740		1 785		1 862	

Source: FAO, 2010a.

^a Includes fuelwood, wood wastes, pellets, chips and other woody sources. A small volume of woodfuels may fall under other reporting categories and thus are not reflected here.

TABLE 14
Woodfuel use in selected regions

Region	Woodfuel consumption (m ³ /1 000 persons)				Average annual rate of change, 1992–2007 (%)
	1992	1997	2002	2007	
Sub-Saharan Africa	804	797	726	766	-0.33
South America	543	529	524	510	-0.41
Asia	240	228	213	194	-1.41
Europe	163	145	149	203	1.45
Oceania	355	427	355	320	-0.69
World	315	302	283	285	-0.67

Source: FAO, 2010a.

complete burning. Mound kilns consist of an arranged pile of wood that is lit and covered by earth to reduce air flow. The efficiency of charcoal production in such traditional pits and mounds is low – about 20 percent of the original weight of wood is converted to charcoal and the remaining mass is released in the form of vapours and gases, including black smoke. A skilled charcoal producer who uses well-dried wood can reach efficiencies of up to 30 percent (Wiskerke, 2008). The species can also have an effect: slower-growing species with a high wood density are preferred, but in some species water is locked up so that it cannot be released by heating the wood, reducing the efficiency and quality of the charcoal. The age of the wood and its moisture content also influence quality and efficiency (Malimbwi, Zahabu and Mchome, 2007).

In modern kilns, about 35 percent of the original weight of wood can be converted to charcoal and the evolved gases and vapours flared to avoid local air pollution.

Globally, charcoal consumption increased by more than 50 percent between 1989 and 2008, with a large part of the increase in Africa, which accounts for more than half of all charcoal consumed (Table 15). Migration to urban and peri-urban areas has contributed to this expansion because charcoal is easier and cheaper to transport and trade than fuelwood. Charcoal production and transport are important sources of cash income in some rural and peri-urban areas; the economic value (real and/or perceived) of the charcoal industry is exemplified by the fact that it thrives even in many areas of sub-Saharan Africa, where there are many legal prohibitions against it.

Unlike in Africa, where the household use of charcoal is widespread, the expansion of charcoal use in South America and Europe has been largely for industrial purposes (FAO, 2010b). To some extent this is reflected in the changes in per capita use of charcoal shown in Table 16; in the period 1992–2007 per capita use increased moderately in sub-Saharan Africa (by 0.89 percent) compared with South America (3.12 percent) and Europe (1.6 percent). The use of charcoal as a substitute for fossil fuel can serve both economic and environmental goals, with carbon finance providing incentives for some small-scale industries to switch to charcoal.

TABLE 15
Average annual use of charcoal per five-year period, 1989–2008

Region	1989–1993		1994–1998		1999–2003		2004–2008	
	Volume (Mt)	Share of world total (%)	Volume (Mt)	Share of world total (%)	Volume (Mt)	Share of world total (%)	Volume (Mt)	Share of world total (%)
Africa	15.0	52	18.1	46	20.3	46	24.3	53
North America	0.5	2	0.8	2	0.9	2	0.9	2
South America	6.8	24	13.4	34	14.6	33	12.8	28
Asia	5.8	20	6.1	15	7.0	16	7.1	15
Europe	0.4	2	0.5	1	0.4	1	0.6	1
Oceania	0.0	0	0.0	0	0.0	0	0.0	0
World	28.9		39.1		43.6		46.1	

Source: FAO, 2010a.

TABLE 16
Per capita use of charcoal, selected regions

Region	Per capita charcoal consumption (kg per person per year)				Average annual rate of change, 1992–2007 (%)
	1992	1997	2002	2007	
Sub-Saharan Africa	25	27	26	28	0.89
South America	21	41	41	33	3.12
Asia	2	2	2	2	0.24
Europe	1	1	1	1	1.60
Oceania	1	1	1	1	-1.30
World	5	7	7	7	1.94

Source: FAO, 2010a.

There are significant differences in household charcoal use, even among countries with similar levels of economic development. For example, Zambia and Tanzania, two countries in Southern Africa, are among the highest per capita users of charcoal (71 and 65 kg per capita, respectively), whereas many West African countries have much lower per capita consumption (e.g. Ghana and Mali, 29 and 8 kg per capita, respectively) (NationMaster, 2010) because woody biomass is less available and/or other fuels have been promoted. Moreover, cultural and social preferences may be a factor.

