URBAN AND PERI-URBAN FORESTRY IN AFRICA: THE OUTLOOK FOR WOODFUEL



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FAO FIAT PANIS

Urban and peri-urban forestry in Africa: the outlook for woodfuel

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PREFACE

What do the Maamore forest in Morocco, the gallery forests of the Batékés highlands in the Republic of the Congo, the eucalyptus plantations of the Malagasy highlands in Madagascar, the dry forests and agroforestry systems of Mali and even the riparian forests of South Africa have in common? All these peri-urban forests play major roles in supplying Africa's urban areas with woodfuel.

All urban and peri-urban forest ecosystems of Africa are – to varying but steadily increasing degrees – under pressure from their city populations. The rural exodus and a largely uncontrolled demographic situation, together with often inadequate governance, are leading to the chaotic development of sprawling towns in which urban poverty is rife and getting worse, although the degree of the problem differs from country to country. These vulnerable and disadvantaged people frequently live in subsistence conditions. Natural spaces, even degraded ones, thus play a vital role in providing staple products and commodities.

Of prime importance amongst these necessities, woodfuel (as fuelwood or charcoal) represents more than 80 percent of all the domestic fuel used in Africa. It is drawn from urban and peri-urban forests and in some regions from agroforestry systems and shifting cultivation. Around each town, the size of the area involved depends on the demand for wood products and also the production and regeneration potential of the natural resources themselves. The presence of infrastructure allowing transport of the resource to urban consumption centres is also a determining factor in supply. Often exploited beyond the limits of any management system or model, use of the resource as woodfuel is the primary cause of the degradation of wooded ecosystems. Moreover, the pressure on land is exerted primarily on peri-urban natural areas and leads to even stronger pressure on any remaining wooded areas and their accelerated degradation.

The other goods and services (water quality, soil management, agriculture and livestock production, recreation, non-wood forest products etc.) traditionally provided by forests and urban and peri-urban natural and planted wooded ecosystems are generally endangered by the pressure on wood as a source of energy.

With all its ecological and human diversity, Africa is the continent where wood will continue to play a major role as a source of domestic energy in coming decades. It therefore seemed a good idea to propose a study of the complex relations between towns and urban and peri-urban forests in the "Africa" region, focusing on the woodfuel issue.

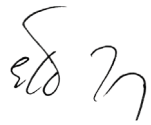
It will be helpful here to recall the context in which this study was initiated. The present document in fact continues and enriches some of the debates that took place during the international conference on "Trees connecting people: in action together", organized by FAO from 29 July to 1 August 2008 in Bogotá. This meeting, which brought together 50 experts from every part of the world (scientists, elected representatives and representatives of international institutions, the private sector and civil society), was intended to develop partnerships among the various stakeholders involved in the issue of urban and peri-urban forests, with particular

attention to developing countries. It thus enabled various experts to discuss the specific elements involved in urban and peri-urban forestry on the African continent.

The first part offers an overview of the woodfuel situation in Africa, addressing the key factors, the typology and the challenges and new issues involved in the sustainable management of urban and peri-urban forests in the face of the growing demand for woodfuel.

The second part presents four detailed case studies and is intended to be complementary inasmuch as it considers individual countries (Nigeria, Mali, South Africa, Republic of the Congo), expanding further on the issues highlighted in the first part.

This work thus provides an overview of the woodfuel situation in Africa, while laying the groundwork for further in-depth regional research. A formula that well illustrates the authors' position could serve as a motto for the whole of this report: "The future of forests lies in the towns."[1]



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[1] Trefon, 1997.

CONTENTS

ACKNOWLEDGEMENTS

Aware of the importance of the issues of woodfuel supplies and the unique place of Africa in relations between town and peri-urban forests, FAO asked the International Cooperation Centre on Agrarian Research for Development (CIRAD) to report on the issue. This report has been prepared in order to serve as a basis for reflection with special attention to Africa.

We wish to thank CIRAD, and especially Jean-Noël Marien who drafted the first part of this work and contributed to the case studies, ensuring collegial work within CIRAD.

We also wish to acknowledge the authors of the second part, who contributed their special knowledge of the individual zones and helped give this work a regional dimension, covering the whole of Africa and Madagascar. They are Denis Gautier, Laurent Gazull, Michael Idowu, Amadou Kassambara, Méthode Nkoua, Jan Swart, Ben Du Toit and T.J. de Wall. The credit for finalizing the text goes to Anne-Gaëlle Abhervé-Quinquis.

In response to the multidisciplinary and intersectoral character of this issue, the Forest Conservation Service (FOMC) has relied on the contribution of colleagues in other units, especially Miguel Trossero, who is in charge of the Wood Energy Programme of the Forest Products and Industries Division (FOIE).

The preparation of the text was coordinated and supervised by Michelle Gauthier, who is responsible for the Urban Forestry Programme of the Forest Conservation Service (FOMC).

ACRONYMS AND ABBREVIATIONS

BEAGGES	Office of Experts for Self-Governance and Environmental Management of the Sahel
CBFP	Congo Basin Forest Partnership
CDM	Clean Development Mechanism
CFAF	CFA franc
CIRAD	International Cooperation Centre on Agrarian Research for Development
COMIFAC	Conference of Ministers in Charge of Central African Forests
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
GIS	Geographical Information System
GNESD	Global Network on Energy for Sustainable Development
ITTO	International Tropical Timber Organization
MDG	Millennium Development Goal
REDD	Reduced Emissions from Deforestation and Degradation
WISDOM	Woodfuels Integrated Supply/Demand Overview Mapping

DIAGRAMS, TABLES AND PHOTOGRAPHS

Diagrams

Tables

Photographs

EXECUTIVE SUMMARY

At the start of the twenty-first century, the relations between towns and forests are now one of the major issues in sustainable land management in very many countries, especially in tropical zones. With its great environmental, social and economic diversity, Africa is the continent where wood will continue to play a major role as a source of domestic energy over coming decades. Given this situation, it seemed useful to take the woodfuel issue as the main focus of this "Africa" regional study of the complex relations between towns and urban and peri-urban forests.

Some worrying observations

Taking Africa as a whole, the woodfuel value chain contributes more than 80 percent of all the household fuel consumed, while also accounting for more than 90 percent of all the wood extracted from forests and wooded areas. Moreover, in most African countries, demographic expansion and accelerated urbanization result in neither a reduction in poverty, nor any changes in the way energy is consumed, apart from a frequent switch from wood to charcoal where the standard of living allows this. And Africa is the only continent where the use of woodfuel for household purposes (especially in towns) is forecast to keep growing over coming decades.

In the absence of appropriate strategies and management plans, these factors lead to a degradation of natural wooded stands – forests, wooded parkland and bushy savannah – a situation particularly visible in the areas supplying towns and cities. This degradation of wooded ecosystems can go as far as complete deforestation, with all the widely recognized disastrous environmental, economic and social consequences.

Often, little is known about the growth dynamics, availability and management of **wood resources**, especially inasmuch as the peri-urban zones concerned are often left out of official forest policies and strategies, and tend to lack even the most cursory management tools. Their wood resources are included in overall management of the area, where other actors often disrupt relations concerned with woodfuel dynamics. Although demographic growth and accelerated urbanization in Africa are radically altering the **social reference points** of urban inhabitants, household fuel consumption habits are not changing as quickly. Woodfuel consumption, linked to persistent or growing urban poverty, is still the main means of cooking (and/or heating) in very many African towns. In such a situation, it is hard to provide a positive response to the challenges posed by the Millennium Development Goals. The predominance of the woodfuel value chain in supplying towns is also associated with a very significant informal **economic dimension**. Value chains, which are often very fragmented, grow up according to need. They are the source of employment and a major factor in the redistribution of forest revenue to urban markets. Woodfuel value chains develop in a wide range of **institutional contexts**. Some countries have adopted dynamic energy and taxation policies, resulting in a dramatic change in consumption patterns and the replacement of wood by alternative fuels, albeit often fossil fuels. Others, sometimes even exporters of fossil fuel, present very defective levels of governance. In the latter case, the private sector, whether formal or informal, very often takes the place of

public policy and becomes the main actor in land management. Lastly, uncontrolled extraction often exceeds the regeneration potential of stands, especially since the distance from peri-urban forests to urban markets is often relatively short. The **environmental impacts** of the degradation – or even deforestation – of forest stands then become critical. These impacts occur at all levels, from the individual plot right up to a global level marked by climate change, biodiversity reduction, desertification or carbon-linked processes.

A complex picture

Relations among towns, peri-urban forests and woodfuel are complex and depend mainly on local contexts. This report presents brief examples from throughout the continent[2].

- Some cities (**Rabat, Cape Town**) have steadily shaken off the constraints of woodfuel needs thanks to proactive and voluntarist policies.
- Others (**Pointe-Noire, Antananarivo**) are in a fairly favourable position thanks to a large-scale production of timber and wood products from planted peri-urban forests, whether industrial or private.
- Although lying in dry zones, some cities (**Bamako, Ouagadougou**) have focused efforts on the development of household fuel strategies and of markets, allowing them to formalize the value chains, at least partially, albeit without ensuring sustainability of the resource. In **Mahajunga**, it has been proposed that the management of peri-urban wood resources should be transferred to local communities, with generally positive results.
- In some cities that are still in transition (**Bangui, Conakry**) woodfuel supply problems are still manageable, but the situation could deteriorate if appropriate measures are not taken.
- Medium-sized towns may have their own specific situations. **Ifrane**, for example, benefits from both a major local resource and a demand that has been redirected to other kinds of fuel. On the other hand, **Abéché**, which is located in an area close to conflicts and where the resource is scarce, has seen its fuel balance severely upset by the massive presence of refugees. The example of **Pokola** illustrates the still insufficiently explored potential of a greater use of woody biomass through techniques of varying degrees of sophistication.
- Lastly, some very large cities (**Kinshasa, Abuja**) present particularly delicate situations, with huge increases in urban populations because of conflicts and rural poverty, and large-scale degradation of peri-urban ecosystems in all their supply basins.

Sustainable management of forests and the peri-urban wood resource

The overview gives a good idea of the complexity of the interaction between urban forestry and woodfuel in Africa. The report seeks to identify the main criteria and indicators for systems to manage wood resources and ensure urban supplies. Nine recommendations are thus offered (see

[2] This overview is provided in the first part of the document. In addition, four of the towns used as examples (Abuja in Nigeria, Bamako in Mali, Cape Town in the Republic of South Africa and Pointe-Noire in the Republic of the Congo) are the subjects of fuller case studies in the second part.

page 40). The typology, which is still provisional, should in due course lead to the proposal of a rational categorization of cases encountered in the field, and the setting of the main questions that should be answered for each group with a view to improving the situation and establishing sustainable relations between peri-urban forests and woodfuel.

Sustainable management of degraded peri-urban natural forests should become a major element in national forest policies. Unfortunately, there is still the problem of the lack of knowledge about the forest and social dynamics associated with these areas, and only a better understanding of these phenomena can lead to more sustainable systems of managing peri-urban forests. Lastly, the creation of **planted peri-urban forests for woodfuel** would appear to be an instrument that has already proved itself throughout the continent. However, it is necessary to learn from past experience and projects in order to achieve more systematic successes, and this will entail greater coordination between institutional prerogatives and the development of a reactive private forestry that adapts to changes in urban markets.

Fresh challenges and opportunities

Apart from the various worrying observations and the complex picture, it is important to consider whether fresh opportunities and challenges could modify current trends. While some entail risks, others could mitigate deterioration of the situation, or indeed reverse trends in zones experiencing negative development. These new opportunities can certainly not take the place of a vital improvement in governance and a rational management of peri-urban areas, in particular with regard to socio-economic and institutional aspects.

RISKS

Among the risks, the availability and cost of **alternative fuels** could prove major challenges. These fuels are often fossil (with all the consequences) and have a higher environmental cost than that of a sustainably managed wood resource. In some cases, the persistence of woodfuel can be explained by the unavailability of alternative fuels.

Another risk identified concerns competition between **food and fuel**. Although such competition is at present more theoretical than real, it could become extremely real in the very near future if the world's agricultural economies continue to fluctuate because of imbalances in supply and demand and uncontrolled speculation. In peri-urban zones, it would be seen in changes in the consumption patterns of the poorest inhabitants, leading to significant changes in practices in peri-urban zones and modifications in the environmental footprint, to the detriment of forest areas.

OPPORTUNITIES

Among the opportunities, the **carbon market** may sooner or later take a centre-stage place. As can be imagined, the woodfuel value chain is responsible for more than 80 percent of forest carbon emissions in Africa. International processes – the Clean Development Mechanism (CDM) and Reduced Emissions from Deforestation and Forest Degradation (REDD) – can take account of changes in carbon stocks, both at the resource level, whether the forest is planted or natural, and also right along the value chain. **Payments for environmental services** should in due course make urban and peri-urban forests more financially attractive through incorporation of their global environmental value.

Peri-urban forests in Africa are thus at the heart of major development challenges, which must be the focus of integrated land management processes, encompassing all urban, forest and rural components and stakeholders. This type of approach would allow each stakeholder to assume responsibility for these spaces, which constitute a common asset to be handed down to future generations and not a collective asset to be used solely for unsustainable extraction.

Part 1. Overview

PART 1 - THE URBAN WOODFUEL VALUE CHAIN IN AFRICA

DETERMINING FACTORS

For many decades now, woodfuel has been a determining element in the management, conservation or degradation of forests and wooded areas in Africa. Many development programmes were mounted in the 1980s, but were subsequently curtailed when the anticipated catastrophes (massive deforestation, poverty) did not in fact occur. However, problems over supplies, especially for urban markets, are now becoming more critical. Outside Africa, consumption will either decrease or remain steady, but more for industrial purposes.[3] The use of woodfuel in Africa is increasingly linked to urban poverty, governed directly by household income and the capacity to make the gradual switch to other domestic fuels.

Despite considerable diversity, this broad picture indicates the presence of generalized determining factors for the organization, importance and sustainability of the woodfuel value chain in Africa, especially for towns. The fuelwood extraction zones to supply towns are mainly located in peri-urban areas. Fossil fuels and hydroelectric or alternative energies are underexploited in central Africa for many reasons (problems regarding processing, transport and distribution). On the other hand, biomass fuel from wood is directly usable and works with an uncoordinated and mainly informal system of production, transport and distribution.

This chapter presents a synthesis of a certain number of bibliographic references dealing with the woodfuel value chain or urbanization.[4]

Management of the resource

Renewable fuels represent 7 percent of the total fuel in the world (13 percent in the medium term), but biomass represents 70 percent of household consumption in developing countries (and 50 percent of total fuel consumption in Africa) – and 90 percent of biomass fuel is used in developing countries.[5] Wood and charcoal account for 80 percent of total household fuel consumption in Africa (1 m^3/person/year).[6] The increase anticipated over the next 30 years will be concentrated on biofuels, with fuelwood and charcoal confined mainly to household use.[7]

[3] Arnold, Köhlin and Persson, 2006.
[4] Cf. Bibliogaphy, pp. 43-45.
[5] FAO, 2007a.
[6] Debroux *et al.*, 2007.
[7] FAO, 2007b.

Evolution of woodfuel consumption[8]

FAO Projection	1970	2000	2030
Fuelwood (millions of m^3)	261	440	544
Charcoal (millions of tonnes)	8	23	46

A FUNDAMENTAL BUT LITTLE RECOGNIZED RESOURCE

Basic data on the wood resource[9]

Africa (FAO divisions)	central	Central (pays COMIFAC)	east	south	west	north
Country						
• area (millions of ha)	529	398	399	590	503	940
• population (millions)	105	81	200	120	252	184
Forests						
• area (millions of ha)	236	223	77	171	74	77
• percentage	45	56	19	29	21	8
• area/person (ha)	2,2	2,8	0,4	1,4	0,7	0,4
• change (2000/2005	- 0,3	-0,2	-1,0	-0,7	-0,6	-0,7
Standing stocks						
• volume (m^3/ha)	194	203	58	36	91	18
• total volume (millions of m^3)	46760	45450	4351	6102	6254	1390
• biomass (m^3/ha)	315	330	172	99	175	51
• total biomass (millions of m^3)	74199	73631	13006	17015	12039	3880
• charcoal (t/ha)	157	165	86	50	85	25
• total charcoal (millions of t)	37099	36815	6503	8507	5875	1939
Production						
• woodfuel (x 1000 m^3)	103673	83920	194816	55908	145291	46371
• industrial wood	12979	11876	10526	26356	17128	3458
• sawnwood	1250	1080	1296	2905	3145	200

Some calculated ratios						
Woodfuel consumption (m^3/person)	**0,99**	**1,04**	**0,47**	**0,47**	**0,58**	**0,25**
Woodfuel production/total wood production (%)	**90**	**87**	**95**	**67**	**88**	**92**

Woodfuel consumption per person depends to a high degree on the availability of the resource and the presence of alternative fuels. The two extreme regions (central Africa with 0.99 m^3/person/year and north Africa with 0.25 m^3/person/year) are a good illustration of this division. Paradoxically, countries rich in fossil fuels (kerosene, gas) have not succeeded in effecting a change in practices and are still very dependent on woodfuel (as seen in central Africa).

[8] *Ibid.*
[9] *Ibid.*

Wood destined for fuel accounts for about 90 percent of extractions from all wooded stands (natural and planted) in Africa. This ratio is virtually the same in all zones, except for the southern cone, where industrial plantations significantly modify the quantities, flows and types of wood product.

ORIGIN AND MANAGEMENT OF THE RESOURCE

All forests and wooded areas in Africa contribute to woodfuel supplies, whether they are closed forests, gallery forests, savannah, fallow land or wooded parkland (which is often underestimated).[10] In addition, there is the residue from logging. Woodfuel extraction can be the primary cause of forest degradation. Woodfuel supplies for towns often come from deforestation for peri-urban agriculture. Further, there is a steady degradation of wooded areas in ever-widening rings, although regeneration can modify or camouflage this process. Many unresolved questions concern the resilience of ecosystems, the ecology of rehabilitation and the future of particularly favoured species.[11] The scale of analysis of the resource as an integral part of the rural sector (region, territory, village, farm) must be well thought out (the consistency of the determining factors) and the use of space governed by access to land.

In dry Africa, shifting cultivation and informal wood extraction (including for woodfuel) represent a direct threat to ecosystems, with a potential impact in terms of deforestation, fragmentation or general degradation.[12] An accurate estimate of the resource of shrubland and savannah and its productivity is needed. It ranges on average from 0.5 m^3/ha/year with 600 millimetres of rain to 1.5 m^3/ha/year with 1 200 millimetres, although there are some major variations. The concept of productivity covers a wide range of elements and is a very generic term.[13] Volume tables have for example been produced for the four species of acacia most used for woodfuel, and the figures provide a good basis for further knowledge and evaluation of the resource.[14]

In central Africa, forested areas total some 180 million hectares: 37 million hectares of protected areas, 137 million hectares of production forests (including 49 million hectares of managed or unmanaged forest concessions). The bulk of woodfuel comes from zones that are neither protected nor under concession. The priority agenda for the Democratic Republic of the Congo especially recommends a participatory multi-use zoning for forests, the development of community forests and support for small and medium-sized family enterprises.[15] The dynamics of natural forests and the management or rehabilitation methods adopted for degraded forest and agroforestry ecosystems are key factors in achieving sustainable management of forest ecosystems.

There is much degraded land that could be planted with trees and help to meet the demand for woodfuel.[16] The varying circumstances and aims of their establishment mean that planted forests[17] are a particularly appropriate tool for territorial development in the case of a targeted demand (for example for woodfuel, with dedicated plantations). Forest rehabilitation is

[10] Bazile, 1998.
[11] *Ibid.*
[12] CBFP, 2006.
[13] Sylla and Picard, 2005.
[14] Smektala *et al.*, 2003.
[15] Debroux *et al.*, 2007.
[16] FAO, 2007a.
[17] Mallet and Marien, 2005.

promoted with current international processes for its multiple benefits. Planted areas are increasing throughout the world, except in Africa, despite the existence of still available land, even on the outskirts of some major cities. As degradation from uncontrolled urbanization increases, the role of urban and peri-urban forests is expanding.[18]

FAO[19] has adopted an analysis and strategic planning methodology, the Woodfuels Integrated Supply/Demand Overview Mapping (WISDOM) platform. Supply and demand are analysed using the geographical information system (GIS) at the level of town supply catchment area, then the scenario approach, so that intervention priorities can be established. Case studies have been carried out, including some in east Africa for the cities of Dar es Salaam, Arusha and Khartoum. These analyses highlight the extreme diversity of resources and the complexity of supply systems. The results contribute elements for strategic and operational planning.

In peri-urban zones, there is intense competition among the various land uses. Food crop cultivation, infrastructure, buildings and forests share the territory, depending on urban demand. Forest areas, which often have no specific allocation, act as a reserve for other uses, thus contributing to their reduction. The radius of degradation depends on the abundance of the resource, the size of the town and the transport situation. The impact of the expansion of cultivated areas on the evolution of peri-urban forest cover can clearly be seen around Dar es Salaam.[20] The pressures exercised by agriculture (including livestock production) and woodfuel extraction have different but sometimes combined effects, with very varied impacts on ecosystems.[21]

The woodfuel sector encompasses very different situations.[22] While it is being increasingly accepted as a clean and renewable fuel in developed countries, the value chain has not always solved the problems associated with resource management, marketing and use in the poorest countries. In Africa more than 80 percent of wood extractions are connected with the fuel value chain, although the situation and impact must be analysed on a case-by-case basis.

Batékés highlands in central Africa (Democratic Republic of the Congo): the majority of woodfuel comes from the harvesting of natural peri-urban forests and shifting cultivation.

(Photo : R. Peltier.)

[18] FAO, 2007a.
[19] Drigo and Salbitano, 2008.
[20] Arnold, Köhlin and Persson, 2006.
[21] Bazile, 1998.
[22] Trossero, 2002.

Leopard bush in dry Africa east of Bamako (Mali) provides a significant percentage of woodfuel for urban zones.

(Photo : L. Gazull.)

Social factors

DEMOGRAPHY AND URBANIZATION

People are becoming increasingly concentrated in towns. In sub-Saharan Africa there were 18 cities with more than one million inhabitants in 1990, while the figure forecast for 2020 is 70.[23] In the Republic of the Congo two cities have more than one million inhabitants and account for more than 70 percent of the country's total population. In the Democratic Republic of the Congo, 15 cities have more than one million inhabitants (making 20 million inhabitants out of the country's total of 53 million), exerting heavy pressure on the imbalance between extraction and natural regeneration.

Peri-urban areas are hybrids and provide clear examples of what is at stake in the interactions between town and country in Africa (with regard to the presence of the State, land tenure practices and resource management). They are also ambiguous (customary versus official land law). Interactions among stakeholders and resources are the source of potentially serious conflict, giving rise to a new hierarchy based on ground rent.[24]

The steady shift from analysis of urban consumption to that of the production capacity of the rural resource is a consequence of droughts and the major increase in urbanization.[25]

In Africa, the shift from the use of fuelwood to charcoal is a clear fact, linked mainly to urbanization and the difficulty over preserving rural ways of life.[26] The sources of woodfuel are increasingly varied (forests, trees outside forests, agricultural residue) and this diversity has gone some way toward meeting the increased needs and avoiding the "fuelwood crisis" that was being predicted in the 1970s and 1980s. Nevertheless, the pressure on natural environments is steadily growing. The shift from fuelwood to charcoal takes place at the expense of forest stands, for this

[23] Trefon, Cogels and Mutambwe, 2007.
[24] *Ibid.*
[25] Bazile, 1998.
[26] Girard, 2002.

is where most extraction and processing takes place. Good management of the resource and the woodfuel value chain can have very positive effects on natural resource management, job creation and the maintenance of rural activity, thus slowing the exodus to towns. The solution also involves improving processing and use techniques (charcoal kilns, ovens and stoves).

CONSUMPTION PATTERNS

Woodfuel consumption per inhabitant (0.99 m^3/person/year) in central Africa is double that in dry Africa, because of the apparent abundance of the resource and its still relatively low price. In central Africa, for example, the price of a beer is about the same as that of four or five bundles of fuelwood or kilograms of charcoal. Fuelwood is poor people's primary fuel, but when the standard of living rises or the distance from the resource becomes prohibitive, charcoal steadily replaces it.[27] This shift leads to substantial changes in behaviour, not only within value chains, but also in diet and cooking habits. As the resource becomes rarer, there is a change to more efficient cooking methods (improved stoves) and food requiring less cooking.[28]

Rapid urbanization processes bring a change in urban inhabitants' habits, leading to the use of charcoal (no smoke, less handling, an outward sign of undeniable success), with significant consequences for the resource, such as a doubling in the demand for wood per person as a result of low yields from carbonization, so that twice the amount of wood is needed for the same final amount of energy.[29]

The distance factor is important. One of the consequences of the increasing distance of the resource is the shift from fuelwood to charcoal, which uses more wood, but burns better and is cheaper to transport. There are examples backing up the advantage of having a dedicated and sustainable resource near to towns, but in this case it is noted that prices match the highest prices because demand is so high.

GENDER, HEALTH AND EMPLOYMENT

Health and gender issues are particularly affected by the woodfuel value chain and consumption. The division of roles varies from country to country. Harvesting and processing are often carried out by men, who work under very harsh, insecure conditions. Unlike agriculture, the priority activity, which needs inputs (products needed for the production of agricultural exports: fertilizer, pest control products, seed etc.), wood is harvested with no investment and no risks, making it attractive for poor people and the jobless. Women are more involved in markets and marketing, but in many countries they also carry the products on their backs, often carrying heavy loads over long distances. As regards consumers, smoke from charcoal or wood during cooking causes a number of diseases, which affect the poorest strata of the population and the weakest (children), who often lack the wherewithal to obtain treatment. The woodfuel value chain generates much employment (10 jobs created by TeraJoule with gasoline, as against 100 to 170 with fuelwood and 200 to 250 with charcoal).[30]

[27] Gautier, Gazull and Hautdidier, 2006; Gazull *et al.*, 2006.
[28] Bazile, 1998.
[29] Drigo, 2001.
[30] Trossero, 2002.

Woodfuel, the basis of household fuel, Abuja, Nigeria.

(Photo : M. Idowu.)

Economic factors

Prices do not always reflect the scarcity of the product and therefore cannot be used as an indicator of it. The importance of extraction outside forests is acknowledged in most places but is often hard to quantify.[31] The study on Charcoal Potential in Southern Africa (CHAPOSA) shows that charcoal consumption increased by 80 percent between 1990 and 2000 in Dar es Salaam, Lusaka and Maputo, but that the price stayed relatively stable.[32] Moreover, harvesting is in line with a local right of use, usually regarding farmland or unclassified land, and the income, however low, is essential for balancing the family budget as earnings from cotton growing decline.[33] The relative importance of household consumption and marketing value chains is determined by the scarcity of the resource and the threshold of self-sufficiency. Urban inhabitants, for example, consume 1.5 times more than rural inhabitants. Consumption per inhabitant thus depends on the abundance of the resource and the number of people per household.[34] Woodfuel users can be divided into three categories (the poor, food product processors and industries). Woodfuel consumption (percentage of traditional biomass) is directly proportional to the local inhabitants' level of poverty (incomes below US$2 per day[35]).[36]

The fuelwood, bushmeat and non-wood forest product value chains are the most important economically, coming well ahead of industrial harvesting of natural forests.[37]

The increase in fuelwood and charcoal consumption in towns in many countries can also be attributed to the fact that these fuels cost less than gas or kerosene. In Morocco, on the other hand,[38] 88 percent of woodfuel is used in rural zones, exerting heavy pressure on ecosystems (although this varies depending on the zone). Rural electrification and gas subsidy policies are

[31] Arnold, Köhlin and Persson, 2006.
[32] *Ibid.*
[33] Bazile, 1998.
[34] *Ibid.*
[35] Or €1.47 per day.
[36] Horgan, 2002.
[37] Debroux *et al.*, 2007.
[38] TTOBA, 2007.

slowing the rise in demand and have gone a long way toward stopping woodfuel consumption in towns. Moreover, there is a distinction between domestic needs (cooking, heating), which are met by gas or electricity, and public needs (bakeries, hammams), which still often use wood.

In a summary of reports from 23 countries,[39] there is little consistency in the data because of the lack of a reliable, standardized methodology. There is also a lack of balance between studies on demand (of which there are many) and those on supply (of which there are few), which means a risk of inappropriate policy and management decisions with a view to sustainable management of the production capacity of wood resources. Traditional mechanisms for self-adjustment between resource and demand are increasingly ineffective and there are strong indications of widespread degradation.

Based on the economy of a mainly informal market, the production of charcoal opens up job opportunities, but unfortunately it often entails the search for a quick profit at the expense of sustainability of the resource, leading to wastage in comparison with the traditional gathering of fuelwood, which prefers dead wood and marginal sources. Moreover, charcoal production entails clearing on a wider scale and on vulnerable land (wooded savannah for example), while fuelwood is more commonly a by-product of shifting cultivation. Charcoal production offers an economic commodity, although it may be far from the market, thus opening up the way to intensive exploitation of forests and wooded regions previously protected by distance, but less well supervised. The best-quality wood comes from drier stands, where the regeneration capacity is lower, thereby speeding up desertification processes.

Institutional factors

POLICY, GOVERNANCE, VALUE CHAINS

In many African countries, the juxtaposition of central state power and local traditional power results in a latent conflict between the two. A prior requisite for any development and sustainable management of the woodfuel resource in peri-urban zones is that of security of land tenure.[40] Woodfuel value chains for urban zones are totally or to a large extent informal, except in countries with the means and will to apply the regulations that in most cases already exist.

In some countries, national-level domestic energy strategies (institutional adaptation, decentralization etc.) have allowed the creation of rural markets, but the organization and allocation of receipts (taxes) presents a problem. The value chain is very broken up, with an unequal division of profits.[41] However, the complexity of certain mechanisms established and the vagueness of their objectives lead to a difficulty in informing the informal sector.[42]

On the other hand, land privatization or allocation in certain countries (Ethiopia, Kenya etc.) fosters the development of small private plantations. Although priority is given to personal consumption, part of the production is placed on the market. The woodfuel value chain is mainly informal and is still one of those that best ensure the distribution of income to poor people.[43]

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[39] Drigo, 2001.
[40] Trefon, Cogels and Mutambwe, 2007.
[41] Bazile, 1998.
[42] Arnold, Köhlin and Persson, 2006.
[43] *Ibid.*

Woodfuel is an essential component in development of the forest sector. However, extensive interaction between the forest and energy sectors is necessary in order to make progress.[44]

Woodfuel in peri-urban zones is thus a major issue in land development and management. If the household energy needs of the urban population are not satisfied, this leads to a degradation of all the other goods and services, both monetary and non-monetary, provided by wooded ecosystems.

DEVELOPMENT OF ALTERNATIVE ENERGIES

Most African countries have not developed significant alternative strategies, with the notable exception of such countries as Morocco and South Africa, where woodfuel has been replaced by other fuels in urban zones. However, considerable international funding is being allocated to the issue of energy in Africa, often focusing specifically on technology, capacity-building and the implementation of public policy instruments.[45] The alternative fuels proposed, directly or after processing into electricity, are often of fossil origin (gas, coal, kerosene). Renewable energies (hydraulic, wind and solar) are still very little developed, even if they are now at the heart of the energy development strategies in countries that have mastered the technology and its implementation. The most sensitive points include the management and maintenance of energy installations and transport networks, which pose some difficult problems. The case of the Inga dam on the Congo River in the Democratic Republic of the Congo is an example.

The consequences of such replacements are raised in terms of life-cycle assessment and/or analysis of long-term environmental impacts at a globalized spatial level. Although very little work has been done on this subject, it seems clear that the sustainable management of peri-urban ecosystems dedicated to supplying woodfuel would have a positive overall impact, as compared with many other fuels.

The feasibility of decentralized electricity, using wood as its raw material (cogeneration, biofuels) has yet to be demonstrated, taking into account the infrastructures to be developed and the necessary proximity of a sufficient dedicated resource.

Environmental factors

THE VARIOUS LEVELS OF ASSESSMENT

The environmental impact of the urban woodfuel value chain must be assessed and analysed at various levels.

In terms of space, the two axes of integration are the value chain axis and the supply catchment area axis. For value chains, it stretches from the household, with its plot, to the district, then to the town (markets), from transport to processing and lastly to harvesting. For supply catchment areas, it stretches from the tree to the forest plot, then to the rural community and lastly to its incorporation into the organization of the territory involved and the development of the concentric circles of peri-urban degradation.

[44] FAO, 2007b.
[45] European Commission, 2007.

In terms of time, the short-term impacts must be assessed with regard to their immediate consequences: longer value chains lead to higher costs. In the medium term, consequences concern more such phenomena as erosion, the loading of rivers with fine particles, landslides and soil impoverishment. Lastly, in the long term, the impacts are associated with major global issues such as climate change and its consequences, for example in terms of carbon or human and social development.

THE WOODFUEL VALUE CHAIN AND CLIMATE CHANGE

The woodfuel value chain links the resource in peri-urban zones and its use by urban inhabitants. This whole combination evolves in an international context marked by successive international commitments such as Kyoto (1998) with the Clean Development Mechanism (CDM) and Bali (2008) with Reduced Emissions from Deforestation and Degradation (REDD).

At all stages in the value chain, the use of wood as a source of domestic energy generates flows of carbon and other greenhouse gases. Carbon storage in plants and the soil when forests or plantations are regenerated, the emission of atmospheric carbon from processing or combustion, and the replacement of fossil fuels are parameters to be incorporated into a full analysis of the value chain.

Africa is the least advanced continent with regard to the carbon market, accounting for only 3 percent of the carbon projects submitted for international funding, whereas it offers very many development opportunities. Capacity-building and the improvement of modes of governance should enable Africa to draw greater advantage from the opportunities offered by the carbon market, especially the CDM and REDD mechanisms, which are applicable to planted and natural forests as well as the improvement of value chains.[46] For example, an intensive plantation project in the savannah around Kinshasa is currently being finalized and will be submitted to the BioCarbon Fund. Project Idea Notes for the CDM and Readiness Plan Idea Notes for the REDD have been drafted and the projects are currently being mounted by funding agencies. At present, 60 000 hectares of degraded natural forest are harvested each year in order to provide 4 million tonnes. A programme to establish 112 000 hectares of plantations (industrial and smaller scale) over 30 years is combined with improvement in charcoal processing. Carbon sequestration is estimated at 323 million tonnes of CO_2 over the 30-year period. The cost over the first ten years is estimated at US$24 million and will reach US$260 million over 30 years. Forecast rates of return are based on the cost of a tonne of CO_2 ranging from US$4 (for a temporary certificate) to US$12 (for a long-term certificate).[47]

[46] Mallet and Marien, 2008.
[47] Kasulu and Hamel, 2008.

Fuelwood entering Pointe Noire, Republic of the Congo.

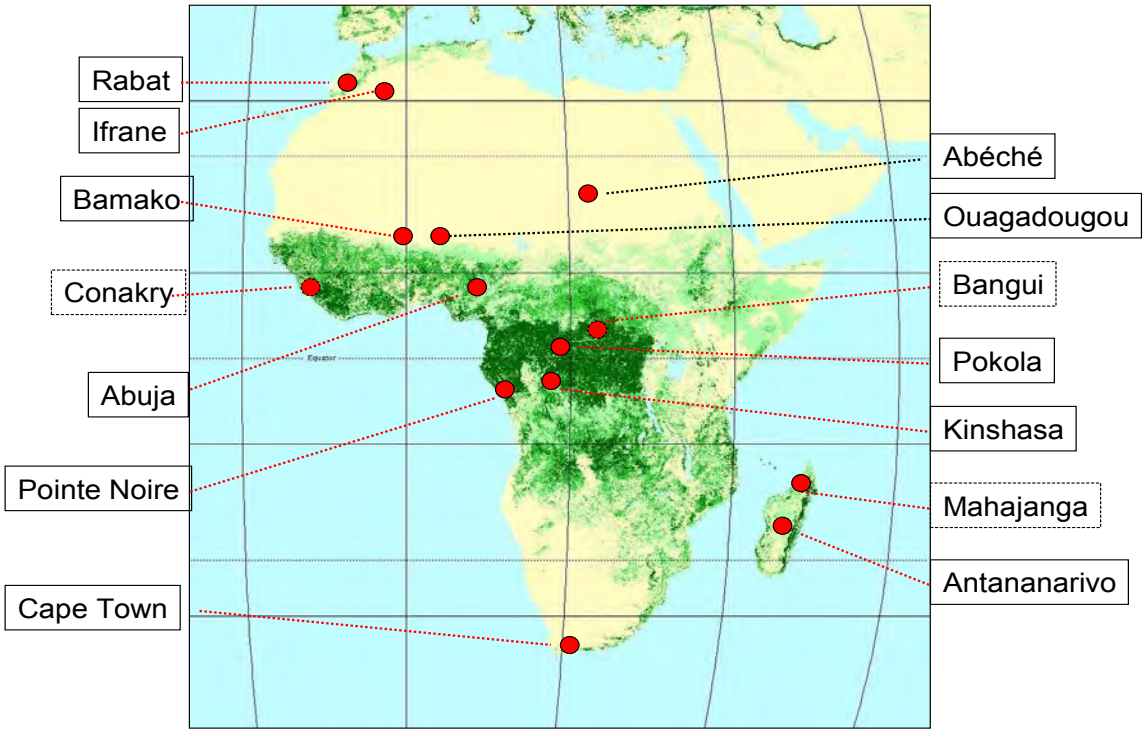
(Photo : B. Marien.)

THE ISSUE OF FUELWOOD TO SUPPLY TOWNS: A COMPLEX PICTURE

A wide range of situations

The large number of studies of fuelwood in Africa provide a broad view of the wide range of situations encountered. Differences are found at every point in value chains and we decided to illustrate this diversity with the help of various examples.[48] Four of these are particularly illuminating and are also given as fuller case studies in the second part of the present work.

Location of the towns studied



■ Abéché, Chad

A study was carried out in Chad, focusing on supplies to refugee camps for people fleeing Darfur. In this area, 200 000 refugees are spread over 12 camps, with 287 000 indigenous inhabitants living within a radius of 40 kilometres around the camps. This concentration of people in a dry zone where the annual productivity is between 0.03 and 0.4 cubic metres per hectare of wooded savannah, combined with the very marked impact of climatic vagaries (dry wood etc.), creates a whole series of problems. Direct competition with pastoral resources and a high risk that the gathering of dead wood will carry over onto green wood, with degradation of traditional production potential, are increasingly complained of by local inhabitants, who place severe restrictions on the refugees. The average consumption of local

[48] The selected examples are given in alphabetical order.

inhabitants is 1 kg/person/day, against a maximum of 0.5 kilograms for refugees. The non-sustainability of the resource is linked to the concentration of extraction in a small portion of the authorized zone, partly because of the lack of security. There are proposals to implement management methods that are compatible with the refugees' security and preservation of the resource and the environment. The possibility of transferring management to local authorities is being suggested.[49]

■ Abuja, Nigeria

Nigeria's new capital has some 3.5 million inhabitants and the population is growing at an annual rate of about 5 percent. In contrast with the situation of the country, which is a major international oil producer, wood represents 80 percent of domestic fuel. This wood is extracted from natural forests, even national parks, forest plantations and any other available source in urban and peri-urban areas in a radius of 80 to more than 100 kilometres. The value chain is informal and the many intermediaries play a major role. Households prefer charcoal to fuelwood because of its ease of use and suitability for local cooking habits. However, fuelwood is used to heat public premises in the cold season or for cooking in the open air (restaurants etc.). The problems involved in management of this sector are critical, for example the lack of political will, the lack of sufficient funding for the creation or management of the resource, the lack of sufficient technical expertise, the fact that regulations are weak and are not applied, and the general population's ignorance of the issues. Unless these problems are solved, it will be impossible to stabilize the situation.

Transporting wood in Abuja, Nigeria.

(Photo : M. Idowu.)

■ Antananarivo, Madagascar

Antananarivo, with 1.5 million inhabitants, is located in a highly deforested upland zone. Its annual consumption of woodfuel is 1 200 000 cubic metres, provided by private peri-urban forests, planted mainly with eucalyptus and covering an expanding area of more than 100 000 hectares. The properties are small, fragmented and managed by simple coppicing (between 1 and 5 hectares), and have a fairly high productivity, bearing in mind the lack of

[49] Besse, Tezenas du Montcel and Garcia, 2005.

technical expertise (5 to 25 cubic metres per hectare per year). There is a major trend toward the establishment of new plantations in peri-urban zones up to as far as 100 kilometres from the city, mainly along major routes. These plantations are the source of an informal but highly organized value chain, now supplying most of Antananarivo's domestic energy.[50] Although the optimal felling age is about eight years, there is a tendency to reduce this period (for example the current average rotation observed is three years, against six in 1980, meaning increased pressure on the resource and the environment).[51] These plantations are replacing other local resources in supplying household fuel.

Soil fertility management, security of land tenure, decentralized management and the feasibility of decentralized electricity supplies are all questions affecting the sustainability of this value chain. Questions regarding the sustainability of these plantations are increasingly being raised with regard to the maintenance of soil fertility and the productivity of stands.[52] This situation is a result of the absence of management and the failure to renew aging stands.[53]

Charcoal represents 75 percent of domestic fuel used in Antananarivo and 77 percent of woodfuel (plus fuelwood and sawdust). In a context of paucity of supply, daily consumption is between 257 and 342 grams per person. Pure eucalyptus represents 80 percent of the total, with the remainder coming from acacias and/or pines, which tend to be less favoured.[54] Antananarivo's consumption has increased faster than its population: in 1970, 250 000 cubic metres for 320 000 inhabitants; in 1990, 1 200 000 cubic metres for 1 million inhabitants, including 95 000 tonnes of charcoal.[55] There are various types of supply circuit, depending on how the chain is organized. The distance of the resource has a major impact on the price paid to producers.

Charcoal stores at the entrance to Antananarivo, Madagascar

(Photo : P. Collas.)

[50] Ramamonjisoa, 1991; Ramamonjisoa, 1989; Randrianjafy, 1989; Schmitt and Rasamindisa, 1998.
[51] Randrianjafy, 1989.
[52] Schmitt and Rasamindisa, 1998.
[53] Ramamonjisoa, 1991; Ramamonjisoa, 1989.
[54] *Ibid.*
[55] Schmitt and Rasamindisa, 1998.

■ Bamako, Mali

The fuel situation of the city of Bamako (with a population of 1.3 million, which is forecast to double in the coming 20 years) is similar to that of most of the towns in this Sudano-Sahel region (for example Ouagadougou). Annual demographic growth is 4 percent, while the increase in consumption is 5 percent. The woodfuel consumed (about 1 400 000 cubic metres per year) comes from various sources: dry forests, agroforests and wooded parkland within a radius of 200 kilometres. Unlike the situation in central Africa, village land is normally allocated. Reserved forests may be managed and granted as concessions. Woodfuel extraction is not the sole cause of the degradation of ecosystems, although it is a major factor within a fairly large radius, estimated at 150 kilometres. Peri-urban zones, with an annual demographic growth of almost 5 percent, are particularly affected by deforestation.[56] The issues to be addressed in this type of environment are connected with the sustainable management of woody resources (particularly management of dry forests and the creation of dedicated resources), social impacts and the management of conflict among the various land uses (livestock/agriculture/forestry). Lastly, the place of and relations between formal and informal value chains are delicate points.

For a long time now, the woodfuel value chain has been very clearly seen as one of the factors in desertification in these regions. The authorities have therefore put in place a domestic energy strategy. In the case of Bamako, this strategy has four components: a master plan, a transfer of management to local communities, a differentiated taxation system and the promotion of alternative fuels (natural gas). Together with the strategy, concessions were granted for 135 000 hectares of forest (30 percent of it planted, but not managed). Taxes were increased five-fold, but their management lacks transparency.[57] The value chains have been formalized, from resource management to local markets, transport and urban markets. Points of sale are gradually being concentrated in markets on the outskirts of the city. Organization of the wood and charcoal profession and markets is clearly separated (with a short chain in the case of charcoal). The cost of cooking is less expensive with fuelwood (for one meal: fuelwood, CFAF 24; charcoal, CFAF 69; kerosene, CFAF 80; gas, CFAF 141). The price of charcoal has fallen by 12 percent in the past 15 years (taxes, competition, shortening of the chain). Although the share of woodfuel has remained constant (99 percent of consumption), charcoal is gradually replacing wood, which certainly represents a diversification in the sources of domestic energy. However, it should be noted that the yield of wood/charcoal is 7/1, leading to an excessive consumption of wood.[58] On the outskirts and around the zone irrigated by the River Niger, the annual consumption of fuelwood is 0.55 tonnes per inhabitant. There is a steady shift from the gathering of dry wood to the felling of green wood, with a threshold beyond the renewal capacity in about 2010, and an anticipated degradation from tree savannah to bush or shrub savannah.[59] Inasmuch as it is a remunerative activity, a supply master plan for the zone is being put in place with a view to improving the organization of the woodfuel value chain (motorization,

[56] Bazile, 1998; Gautier, Gazull and Hautdidier, 2006; Gazull *et al.*, 2006; Nouvellet and Sanogo, 2002.
[57] Gazull *et al.*, 2006.
[58] *Ibid.*
[59] Nouvellet and Sanogo, 2002.

quotas, forest plantations, differentiated taxation, inspections, promotion of improved stoves and use of agricultural residue).[60]

Old fallow, an important source of woodfuel around Bamako

(Photo : L. Gazull.)

Bangui, Central African Republic

Bangui, capital of the Central African Republic, has about 800 000 inhabitants and is growing at an annual rate of close on 3 percent. Uncontrolled urbanization (in 2007 the city covered an area ten times that of 1960) is a phenomenon essentially linked to poverty, but also to a feeling of security or insecurity: in times of conflict, people feel more secure in urban areas, which encourages those displaced from rural areas to settle in urban peripheral zones, without any supervision or planned management on the part of the authorities. However, the increase in urban poverty should also be stressed.

The town is spread over a wide area and contains considerable spaces that are not yet built up and are still to some extent rural. Fuelwood represents 92 percent of domestic energy consumption. The sources of fuel depend on the level of poverty, with charcoal and gas playing a greater role among better-off groups. Annual consumption is between 280 000 and 500 000 tonnes of wood, representing a turnover (all of it informal) of CFAF 2 billion to 3 billion (or almost as much as the bushmeat value chain). Lastly, urban mindsets are still fairly unsophisticated and remain permeated by rural habits, including the use of woodfuel. An FAO project has the aim of developing support for decision-making regarding local strategy, in order to make the woodfuel resource and its value chain more sustainable in the Bangui urban area. The tool adopted for this project is the WISDOM participatory approach.[61].

The Cape, South Africa

In South Africa, widespread electrification and economic development have allowed a considerable reduction in the use of biomass fuel (10 percent of the country's total fuel

[60] *Ibid.*
[61] FAO, 2008b.

consumption). Woodfuel is one of the components of biomass fuel (along with sugar-cane waste and paper industry residue) and comes from forest plantations, natural forests and the elimination of invasive plants. The Water Act obliges all those involved (states, industrial companies, communities etc.) to destroy invasive plants (acacias, pines etc.) outside reforestation zones in order to limit their impact on water resources in catchment areas. While woodfuel is no longer of major concern for urban areas, it is still the primary domestic fuel (often complementing or indeed replacing electricity) for rural inhabitants and the very poor (20 percent of the population). Measures have been taken by the government (regulation and markets to organize the value chain and manage it sustainably). The involvement of local communities is taken into account through social forestry. Surveys have shown that rural users have observed that the resource is becoming scarcer. A failure to respect regulations or traditional authorities is stressed. Better management of natural resources and the development of planted forests, together with rural development policies, constitute components of a response to the challenge.[62]

■ Conakry, Guinea

Guinea has major forest potential, even around Conakry, its capital, which has about 1.5 million inhabitants. The city's rapid demographic growth is a result both of the increase in its own population and of the movement of refugees fleeing from conflicts in neighbouring countries.

Urban woodfuel consumption (80 percent of the total) is still made up mainly – 70 percent – of fuelwood (the opposite is true for rural zones) and consumption is roughly 0.8 kilograms of wood and 0.3 kilograms of charcoal per urban inhabitant. There is a gradient in consumption, moving from the urban centre out to peri-urban zones, and then to rural zones. State intervention is minimal, and awareness of the importance of Guinea's woodfuel value chain is only very recent. There has been very little intervention concerning peri-urban forests (apart from a targeted mangrove woodfuel project on the outskirts of Conakry). Coastal forests are suffering degradation, despite the fact that the natural production potential of Guinea's forests is still greater than the country's woodfuel demand. Moreover, the introduction of improved stoves has limited the increase in charcoal needs for the Conakry agglomeration. New policy guidelines are anticipated, which should address both supply and demand. If these are implemented, they should help to stabilize the situation, especially in the peri-urban coastal zones close to Conakry.[63]

■ Ifrane, Morocco

Unlike the situation in sub-Saharan Africa, woodfuel in Morocco is used mainly in rural areas, inasmuch as the towns have long been provided with electricity. In the Moroccan Middle Atlas (Ifrane and Khenifra), where the climate is harsh, the scattered nature of dwellings is unfavourable to rural electrification. Woodfuel consumption, both for private use (heating and cooking) and public purposes (hammams, bakeries etc.) is one of the components of the traditional local silvipastoral system. Pressure on ecosystems (cedar and ilex) is strong, and these ecosystems are shrinking. Part of the woodfuel resource is granted as concessions by

[62] Prasad and Visagie, 2005; Kirkland, Hunter and Twine, 2005.
[63] Camara, 1999; Diawara, 2008.

the authorities in charge of forests, while another part (often the largest) is managed in an informal manner.[64]

There are many questions regarding the sustainability of the woodfuel value chain. Integrated land management is a major point in a local context where the central government plays a large role but where there is also a long-established traditional territorial fabric. The development of alternative fuels and the improvement of fuel yields can curb, but not eliminate, the rise in demand resulting from a high birth rate, the expansion of urban areas and the sedentarization of previously nomadic herders. The development of plantations provides a major complementary resource and opportunities for fuel diversification.

■ Kinshasa, Democratic Republic of the Congo

Kinshasa, with 7 or 8 million inhabitants, is located in the Batéké highlands in a forest-savannah mosaic environment. Annual supplies of woodfuel amount to 5 million cubic metres, coming almost exclusively from informal extraction from degraded gallery forests within a radius of 200 kilometres. It is estimated that local communities harvest more than 60 000 hectares in this way each year, through slash-and-burn cultivation or by felling for woodfuel. Rotation fallows were traditionally fairly long but are being steadily shortened, leading to a progressive degradation of forest ecosystems within a radius of more than 200 kilometres, and indeed to total deforestation in peri-urban zones within a radius of 50 to 100 kilometres. The management and rehabilitation of degraded forest and agroforest ecosystems, increased security of tenure, the revitalization of local communities, issues of gender and human health, the economics of the value chain and issues connected with charcoal are all points still requiring resolution and meanwhile tending to exacerbate the unsustainable situation of this whole sector.

The Mapu acacia plantations (8 000 hectares close to Kinshasa) play an interesting role and provide an example for the development of a sustainable resource.[65] They are currently managed in 25-hectare blocks where food crops are intercropped with woodfuel plantations.[66]

In the Democratic Republic of the Congo, it is estimated that annual extractions of wood from forests amount to 70 million cubic metres of woodfuel, compared with 0.5 million cubic metres of "formal" timber and 5 million cubic metres of timber from the informal sector.[67] In economic terms, the annual figures for the various value chains are as follows: formal timber US$40 million in added value; informal timber US$50 million; fuelwood US$1 billion; and bushmeat US$1 billion.[68] The Government reportedly wishes to carry out the harvesting of 10 million cubic metres per year. The production of woodfuel (85 percent of the country's total fuel consumption) is concentrated around the towns, with total deforestation in an increasingly broad radius. It is the primary product transported by road. Thus Lubumbashi

[64] TTOBA, 2007.
[65] European Commission, 2005.
[66] *Ibid.*; Debroux *et al.*, 2007; Kasulu and Hamel, 2008; Trefon, Cogels and Mutambwe, 2007.
[67] Van de Ven, 2008.
[68] Debroux *et al.*, 2007.

consumes 1 million sacks of charcoal per year. Only 5 percent of the country's population has access to electricity, despite the Inga dam (with only one or two turbines out of its eight in a functioning state). Woodfuel resources are estimated at 70 million petroleum equivalent tonnes. Gallery forests are the most affected by degradation from woodfuel extraction.[69] There is no rational approach to fuelwood production, and its lack of planned organization and the failure to observe any environmental criterion are responsible for some of the deforestation.[70] Poverty also causes indiscriminate extraction for survival purposes. Surveys of some of the country's towns have shown that there are very large numbers of woodcutters (with emigration from the towns to felling zones). The processing of fuelwood into charcoal entails a large loss of energy power.

Since 2008, the European MAKALA Project (*makala* = live embers in the Lingala language), coordinated by CIRAD, has been promoting sustainable management of the woodfuel resource to supply the towns of Kinshasa and Kisangani.

Construction of a charcoal kiln on Mampu acacia plantations

(Photo : J.-N. Marien.)

Sacks of acacia charcoal from Mampu ready for transport to Kinshasa

(Photo : R. Peltier.)

[69] *Ibid.*
[70] Shuku Onemba *et al.*, 2004.

■ Mahajanga, Madagascar

The town of Mahajanga in northwestern Madagascar depends – like the others – on woodfuel, especially charcoal, to meet its domestic energy needs, which are estimated at 20 000 tonnes of charcoal per year. This wood comes from coastal stands of *Ziziphus* savannah, most of which lie within protected zones, and uncontrolled extraction is leading irrevocably to their degradation. Various initiatives have been taken to organize this supply and provide sustainable management of the protected ecosystems. Socio-economic analyses and forest evaluations thus led to the establishment of a Masterplan for Urban Woodfuel Supplies. The second initiative or component entailed the implementation of a policy for the transfer of renewable natural resource management to local communities through "secure local management" contracts. Lastly, training and support initiatives were carried out. Ten years on, the results are encouraging. The satisfactory functioning of the secure local management contracts depends on good control of the whole value chain, especially with regard to monitoring. Proper control of the woodfuel chain entails placing the various types of producer on an equal footing, particularly with regard to taxation.

■ Ouagadougou, Burkina Faso

Development of eight natural forests around Ouagadougou by the Government concerns 667 000 hectares already placed under management and 202 000 hectares in course of rehabilitation. Half of these forests are autonomously owned and are managed by unions of local forest management groups (335 producers). The demand for fuelwood was 1.4 million steres in 2000, 15 percent of which came from managed forests, while the remainder was produced and sold by independent operators outside the managed zones. The supply radius of the non-managed chain is 70 kilometres with very few intermediaries, which tends to keep prices down. The structure of selling prices is as follows: taxes CFAF 1 100 for the managed part; producer CFAF 2 200 (including woodcutter CFAF 1 100); wholesaler CFAF 10 000 (profit CFAF 3 500); retailer CFAF 12 800 (profit CFAF 1 500). However, the internalization of producers' costs makes analysis difficult.[71]

Apart from a situation that is fairly similar to that described for Bamako regarding the woodfuel value chain, the town of Ouagadougou does have one interesting feature. An International Institute for Water and Environmental Engineering has been set up there and now organizes inter-state diploma training courses, thus providing capacity-building – especially regarding woodfuel. Optimization of wood in terms of energy (cogeneration, biofuels) is one of the lynchpins of the technologies developed in this context.[72]

■ Pointe Noire, Republic of the Congo

With a population of 1 million, Pointe Noire is an industrial port, but is also a town located on the edge of savannah forest mosaic zones. Despite the large-scale presence of the oil industry, domestic energy consumption is paradoxically accounted for mainly by woodfuel. Annual consumption (500 000 cubic metres) is divided fairly evenly between by-products of industrial eucalyptus plantations (40 000 hectares), under management by the Eucalyptus

[71] Ouedraogo, 2007.
[72] *Ibid.*

Fibres Congo Company, and informal extraction from gallery forests. The supply radius for the plantations is less than 40 kilometres, but reaches 80 kilometres for natural forests. Although there appears to be no deforestation, the degradation of natural ecosystems is real, albeit limited. This situation is due to the presence of planted stands, which serve as a buffer for gallery forests and also provide substitute wood resources. As elsewhere, the value chain is largely informal.[73]

Sustainable management of industrial plantations (genetics, soil/plant relationships, socio-economic impact), the dynamics of integrated land-use, the comparative economics of the plantation and natural forest value chains, the taking into account of new charcoal markets, the viability of substitute fuels (natural gas etc.) are all points affecting the sustainable supply of domestic energy to the town of Pointe Noire.

The proportions of deliveries to Pointe Noire over 15 days are as follows: fuelwood 1 147 tonnes, charcoal 1 564 tonnes, making a total of 16 800 wood-equivalent tonnes (or 400 000 cubic metres per year) and 1 350 cubic metres of sawnwood (informal), without counting poles. Fuelwood comes from reasonably nearby (20 to 40 kilometres), especially from eucalyptus plantations, while charcoal comes from further afield (40 to 50 kilometres), especially from gallery forests for reasons of cost and the availability of means of transport. The transport of fuelwood involves five times more people than is the case for charcoal, inasmuch as it is mainly carried on foot. Eucalyptus stands account for 53 percent of the total supply of woodfuel, although this figure may not be accurate because the reference period (2006) corresponded to a time of management disturbances, with scattered looting. Production is concentrated around a few villages (with five villages supplying 80 percent of the total).[74]

■ Pokola, Republic of the Congo

The Congolese Wood Industry Company is located at Pokola in northern Congo, in the heart of closed rain forests. It manages a concession of 1 300 000 hectares of closed forest under a management plan and has already received Forest Stewardship Council (FSC) certification for several of its forest management units. The sparseness of inhabitants in the region means that local woodfuel consumption is not a major factor. The Congolese Wood Industry Company harvests 500 000 cubic metres annually, so that it has available a large amount of harvesting residue (left on the ground after felling) or sawmill waste (sawdust, flitches etc.). Sawmill waste is currently placed at the disposal of private charcoal burners, so that a processing chain has grown up. The charcoal produced in this way is used mainly for Pokola (15 000 inhabitants) and nearby towns (Ouesso), but is sometimes sent as far as Brazzaville (1 200 kilometres by barge), where the fuel situation is very tense. A cogeneration unit using sawmill waste will shortly be completed and will mean a major saving by replacing almost all the fuel (gasoil) currently purchased and transported to Pokola at a high cost. The woodfuel value chain is thus finding a new place in the economy of central African countries, although without disturbing the dynamics of the natural forests concerned. The production potential (logging residue and waste from primary and secondary processing) and the economics of the value chains (charcoal, cogeneration) are points that still need further investigation.

[73] Marien, 2008; Nkoua, 2008.
[74] *Ibid.*

■ Rabat (Maroc)

Rabat is the capital of Morocco. Situated on the coast, it now has a population of 1.7 million, a number that rises to 3 million if the twin city of Salé is included. The whole agglomeration is linked to the electricity grid and subsidized gas is available in bottles at an affordable price. Ninety-five percent of fuel is of fossil origin, but there is a trend toward the development of renewable energies (solar, wind etc.). Woodfuel is still, however, popular for heating bakeries and hammams. The Rabat-Salé agglomeration is surrounded by a natural forest of cork oak (*Quercus suber*), the Maamora forest, covering an area of 130 000 hectares. Eucalyptus plantations (50 000 hectares, both public and private) are also under management in the Gharb plain, often on what was traditional farmland or on common grazing land. Land tenure is for the most part secure, although conflicts over usage may exist between forest managers and transhumant herders who are reluctant to respect regulations.

Woodfuel comes from zones near the city (harvesting residue from the Gharb eucalyptus plantations), but also from further afield and as far as 300 kilometres (felling of dead trees in cedar groves in the Middle Atlas zone).

The country is undergoing rapid urbanization and is in demographic transition, which means that greater priority is set on jobs and growth than on the preservation of ecosystems. Even so, outlook studies on energy rule out the development of biomass from natural forests as a source of fuel for reasons of environmental preservation.[75]

The Maamora forest, which has traditionally been managed for the supply of cork, is one of the few examples in Africa of a peri-urban forest where recreational purposes, explicitly taken into account in its management, are compatible with its production functions. The ecological and social importance of this forest is sufficient to justify major research work on its assisted regeneration and rehabilitation.[76]

Thinning of coppiced eucalyptus for fuel (Sidi Yahia, Gharb plain, Morocco

(Photo : J.-N. Marien.)

[75] Blanc, 2007.
[76] Mtarji, 2008.

Towards a typology of peri-urban forests versus woodfuel

The examples given above show, if proof were needed, the extreme variety in local situations and the difficulty of grasping the full diversity of relations and interactions between towns and peri-urban forests in Africa.

However, the issue of woodfuel in peri-urban zones concerns almost the whole African continent to a greater or lesser degree. With the exception of a few countries, the situation is deteriorating and there is a risk that it will very soon become uncontrollable, leading to incalculable consequences for the environment and the development of African societies, especially in the megalopolises whose numbers are increasing fast, while urban management models are not being updated to keep pace with this growth.

Until now, the solutions proposed have been drawn up and applied at the local level. The recent growth in awareness of the global nature of the problem raises the question of the global solutions that could be provided.

The exercise is not simple. So long as an international strategy is not established on a regional scale, similar to the strategies concerning, for example, sustainable management of central Africa's closed forests, the present risk will certainly develop into a catastrophe.

To start with, it therefore seems important to identify clearly and prioritize the main criteria and indicators involved in interactions among towns, peri-urban forests and woodfuel. A global typology of local situations should thus be fairly quickly reached. This typology and the segmentation to which it would lead would then point the way to a definition of priority intervention strategies.

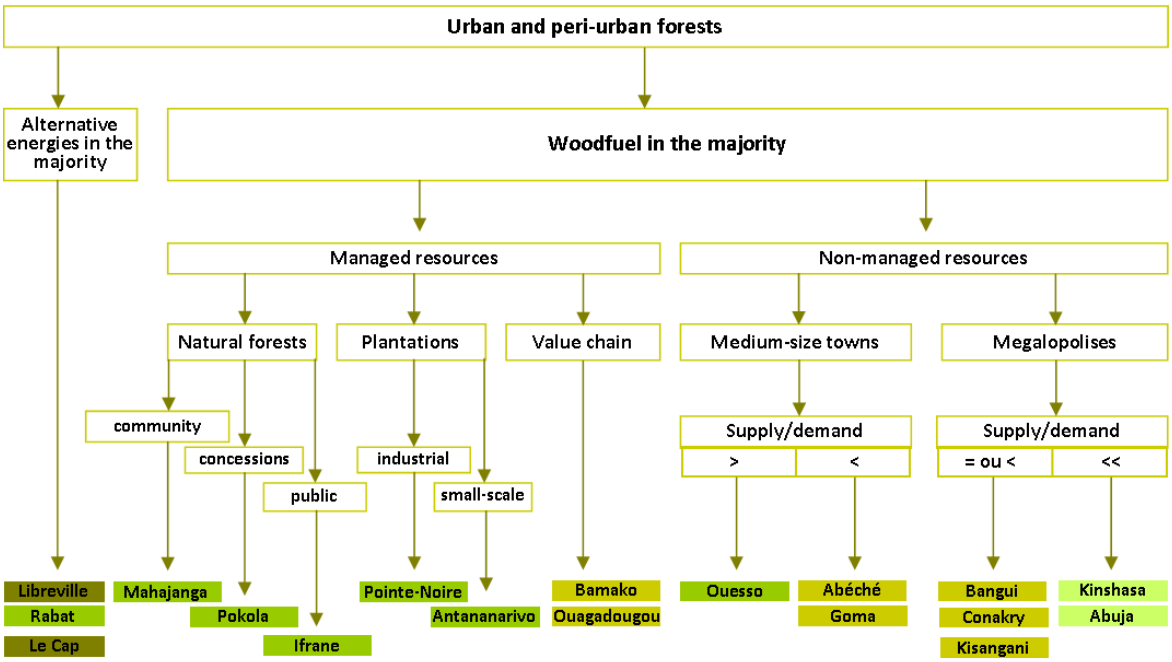
A first provisional list of criteria and indicators is given below. The recent launching of targeted studies (Bangui, N'Djamena etc.) will provide complementary information that will make these elements more precise.

Provisional criteria and indicators concerning urban woodfuel supply systems

	Criteria	**Indicators**
1	Size of town and consumption	Number of inhabitants Consumption of wood, charcoal, other woodfuels Proportion of wood in the town's fuel consumption
2	Uses and distribution of consumption	Consumption according to type of use (heating, electricity, cooking, craft work, industry etc.)
3	Present trends	Evolution of consumption Evolution of types of fuel
4	Types of resource	Dedicated or non-dedicated use (plantations/natural forests) Average productivity Rules of access and use
5	Spatial distribution of the resource	Distribution (uniformity, fragmentation) Accessibility (distance, costs)
6	Organization of production	Actors in felling (farmers, professionals) Level of professionalization Level of organization (cooperatives) Technical skills (chainsaws, charcoal-making techniques etc.)
7	Organization of collection, transport and distribution	Level of concentration level Rules of access to the profession
8	Monitoring of extraction and marketing	Taxes Organization of monitoring, fines

Once these criteria and indicators have been validated, a comparative typology can be drawn up of the various situations of peri-urban forests in relation to the dynamics of woodfuel supplies. The diagram below allows an initial provisional and qualitative typology to be drawn up on the basis of the towns taken as examples in the present report.

Typology of towns in terms of woodfuel supplies



	Little pressure, low risk		Significant degradation, but in a limited area
	Significant pressure, but contained		Accelerated generalized degradation of the resource

The search for solutions suited to each individual case is then easier to carry out in a rational manner. It can in particular take a lead from initiatives that have already borne fruit in other towns in Africa. This typology example shows clearly that it is possible to maintain, or indeed create, an urban and peri-urban forestry on condition that certain basic rules are respected.

Sustainable management of peri-urban forests

Peri-urban forests in Africa are still too often the residual space left when all the other more remunerative (in the short term) forms of land-use have been satisfied (allotment, agriculture, livestock production, infrastructure etc.). The precarious situation of the most disadvantaged urban inhabitants, together with their low level of education, is unfavourable to long-term projections and promises.

A number of towns in Africa are finding that a dynamics of development and sustainable management of urban and peri-urban forests and wooded spaces is not only possible, but is in fact compatible with urban development, even a fairly unsystematic development.

This raises a first question as to governance and management of the areas concerned. In our view, the technical component is not the determining criterion and experience over the past decades has provided a solid basis of knowledge and know-how for the creation of dedicated resources, especially in the form of forest plantations. However, the move has to be made from

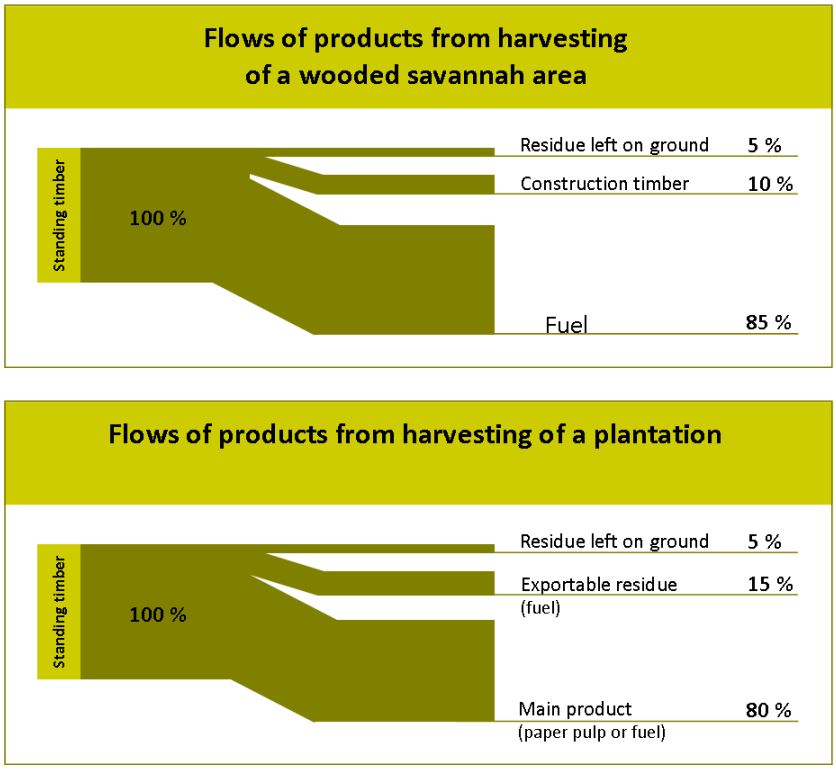
the stage of creation to the infinitely more complex stage of sustainable management; and all projects and initiatives should be analysed in this perspective.

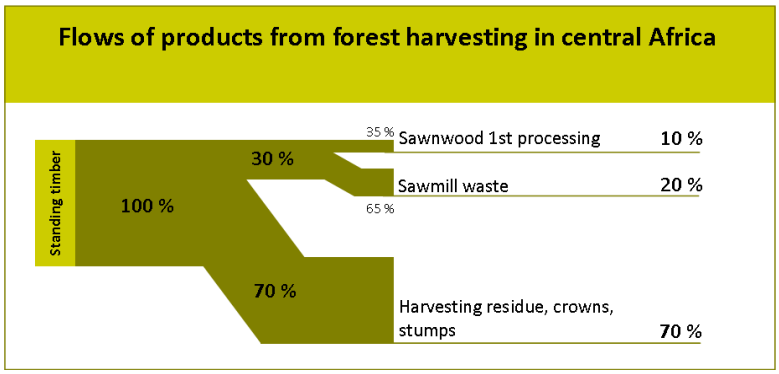
A BETTER UNDERSTANDING OF PRODUCT FLOWS

The proportion of the volume extracted that can be used as fuel depends on the type of peri-urban forest stand. There are various possible situations and the following three are not exhaustive:

- Harvesting of wooded savannah (miombo woodland in some countries) extracts 80 to 100 percent of the woody biomass for woodfuel, either directly in the form of fuelwood or after processing into charcoal.
- Harvesting of a plantation dedicated to a main product (paper pulp, posts, fuel etc.) makes use of 80 percent of the wood extracted, 5 percent of the total being eliminated during primary processing. Waste and residue may then be used to produce energy.
- The large-scale harvesting of natural forests for timber (central Africa) entails a considerable loss of woody matter all along the chain, with an over-all yield of approximately 10 percent. Harvesting residue is usually left in the forest, but sawmill waste is often burned, sometimes with the recovery of energy or carbonization.

Main flows of woody products in three different forest management systems.





SUSTAINABLE MANAGEMENT OF DEGRADED PERI-URBAN WOODLAND AND NATURAL FORESTS

Wood and biomass fuel supplies for towns are directly linked to the presence of a resource at a distance congruent with the economics, even informal, of the value chain. With the exception of planted forests and wooded parkland (see the following subsection), almost all supplies come from forest stands of natural origin, whatever their tenure, administrative or land-use status. Human pressure and the lack of management of peri-urban woodland and natural forests have significant negative effects – economic (rural income, costs to urban inhabitants), social (employment and rural exodus, poverty, ethnic and gender-related tensions, post-conflict situations) and ecological (environmental goods and services, competition for the use of land).

The concept of the sustainable management of forests (with or without certification) is mainly applied to private forests (often industrial plantations), forest concessions (especially in central Africa) or protected areas, parkland and special-status zones (throughout the continent). Unfortunately, most of the woody biomass for fuel comes from peri-urban forests and wooded bushland that are situated in the supply catchment areas of the targeted towns and for which no rational management is applied. There are numerous, often interlinked, reasons for this lack of management.

The generalized degradation of these peri-urban stands all over Africa raises many more fundamental questions, which should be addressed before proposals are made for viable, appropriate management systems. While there is considerable knowledge of the ecology and dynamics of these ecosystems in dry Africa, little is known about the dynamics of degraded forests in humid tropical Africa.

The specific issues to be addressed in order to ensure sustainable management of peri-urban natural forests include the need for solid knowledge on the following points:

- typology of degraded natural forests and ecosystems;
- dynamics and resilience of degraded ecosystems;
- mechanisms and tools for the rehabilitation of forests;
- community and traditional management approaches;
- assumption of responsibility and conflicts over use;
- territorial and social dynamics;
- land use and changes of use (slash-and-burn cultivation, fallows etc.);
- value of forests and non-wood forest products;

- means of communication and other types of infrastructure;
- institutional and fiscal environment.

Once these basic aspects have been clearly defined, appropriate management principles can then be drawn up; these could be called "simple management plans" and have the purpose of ensuring sustainable management of the various types of forest – gallery, strip, riparian etc. – with progressive assumption of responsibility by local communities, who are the sole guarantors and beneficiaries of the sound application of these principles.

The process will be long, if only for the lack of basic knowledge. However, it is certainly the greatest challenge facing peri-urban forestry in Africa, in both dry and humid regions.

PERI-URBAN PLANTED FORESTS AT THE SERVICE OF WOODFUEL

Although forest plantations have found favour with international investors and institutions for some decades now, the results appear contradictory, especially in Africa.

- ***Industrial plantations*** of rapid-growth species (eucalyptus, acacias, pines) have been concentrated in a few countries where the conditions are favourable. They are most often backed by large-scale companies or groups, and have allowed the development of largely internationalized industrial value chains, especially for paper pulp. South Africa, the Republic of the Congo and Morocco are examples here. Such plantations benefit from the contribution of new technologies (genetics, silviculture etc.) and are considered crops. In this case, only harvesting residue may possibly be available to local inhabitants, when it is not left on the ground to maintain soil fertility and the sustainability of the plantations. The rise in energy costs also leads to the development of internal optimization, for example in the form of cogeneration. All this means that there are unlikely to be significant volumes available at the end for the inhabitants of towns close to the plantations. On the contrary, these industrial plantations, or rather the conditions under which they are established, sometimes give rise to conflicts over social management and relations with the local population, who draw very little benefit from them.

Canopy of a plantation of cloned eucalyptus near Pointe Noire, Congo

(Photo : Y. Nouvellon.)

- ***Private peri-urban plantations*** of rapid-growth species do not expand without security of land tenure, a local growth market and a favourable institutional environment. In Madagascar (Antananarivo), the dynamics are completely private and are developed

without any outside intervention. In the Democratic Republic of the Congo (Kinshasa-Mampu), the private sector has partially taken over from an international grant, and the success of the initiative has started to encourage local inhabitants to develop their own plantations, following the example of the original plantations (but now with an agricultural component). The rate of return on this type of plantation is often high or extremely high, inasmuch as rotations are short, productivity is high and prices are attractive. The plantations seldom have the benefit of modern technologies and are most often established in an informal context. Nevertheless, they constitute one of the best ways of meeting the woodfuel (and construction timber) needs of towns.

Private eucalyptus plantations around Antananarivo, Madagascar

(Photo : P. Collas.)

- ***Agroforest plantations and wooded parkland*** are often developed in peri-urban zones and are also the fruit of private or community initiatives. They are found in very many countries, especially in dry Africa. Conflicts between herders and farmers result in the growing scarcity of available, unallocated rural areas, increasingly strong pressure and the accelerated degradation of resources and ecosystems.[77] These fallows, wooded parkland and agroforest systems are producing an increasing proportion of the woodfuel consumed in agglomerations.

[77] Harmand and Bale, 2007; Peltier *et al.*, 2007.

Harvesting of land cleared for agriculture, a major source of fuelwood for Kisangani, Democratic Republic of the Congo

(Photo : J.-N. Marien.)

- The traditional ***forest development projects*** launched in many countries since the 1960s and 1970s have unfortunately often proved only partially successful, or have indeed failed, leading for a long time to a negative view of the very principle of forest plantations. These large-scale plantation projects were implemented under the auspices of the forestry services of the various countries, using international cofinance in the form of grants or loans. Although the diagnosis has usually been sound (soil rehabilitation, demand for wood and wood products, peri-urban afforestation etc.), actual initiatives have sometimes been unrealistic. With hindsight, certain critical factors can now be identified:
    - *technical factors*, with techniques that are poorly understood or inappropriate;
    - *ecological factors*, with the introduction of species that are inappropriate for the plantation zones;
    - *economic factors*, with short-term planning, costs that are not in line with projections, or considerably overestimated returns;
    - *institutional factors*, with fairly ineffective, or indeed absent, state management;
    - but, above all, *social factors*, with poor control of land tenure (public or collective), leading to claims, counterclaims and conflict with local inhabitants or herders.

Nevertheless, these stands continue to supply woodfuel in the peri-urban zones of certain African towns. It is therefore important to learn lessons from these partial successes and relaunch these production chains on more modern and sounder bases. Although the public sector does not have responsibility for developing this type of plantation, it should – through support not only regarding technological aspects (operational research, quality seedlings, extension etc.) but also territorial aspects (security of tenure) and fiscal aspects (transparent taxation) – promote the development of private peri-urban plantations, the profitability of which is ensured by the constantly growing demand and the rising cost of fuels of every type.

New challenges, new opportunities

CARBON ECONOMICS

■ Woodfuel: the primary component of the carbon assessment in Africa

The woodfuel value chain is the primary element in the overall carbon assessment (*Bilan Carbone*) and the degradation of forests in Africa. While much effort has been devoted to the management of forests under concession, very little has been done concerning this sector and its impacts. We have analysed more particularly the situation in central Africa. Adopting the carbon/wood ratio traditionally used by FAO (0.50), the following overall assessment is obtained for central Africa:

Distribution of the quantity of carbon exported according to type of wood product in central Africa

× 1000 tonnes carbon/year	Total harvested	Remainder left on site (humus)	Exported from the plot: ± long carbon life-cycle	% total C exported from forests through harvesting
Energy	57 563	5 756	51 807	82
Industry	8 110	1 216	6 894	11
Sawnwood	6 250	1 785	4 465	7
Total	**65 923**	**8 757**	**63 166**	**100**

The fuelwood value chain is responsible for more than 80 percent of carbon exports linked to the harvesting of forests in central Africa.

The extraction of fuelwood is often associated with a system of fallows and/or slash-and-burn cultivation – both unsustainable systems. Although the agricultural fallow system entails localized deforestation, in central Africa the natural dynamics mean that forest stands have a resilience where the rotation is long enough. Fires particularly affect fallow areas and areas of slash-and-burn cultivation, which are the main woodfuel production zones. Their effects are added to this total, increasing the contribution of the woodfuel value chain to the African carbon assessment.

Woodfuel extraction, which is in many cases an indissoluble part of slash-and-burn cultivation, is a major factor in degradation and even in deforestation. In central Africa, the zones placed under management (concessions, protected areas etc.) by the Conference of Ministers in Charge of Central African Forests (COMIFAC) represent only 37 percent of the total area of forests.[78] Traditional management methods, whether individual or community, cannot stand up to any significant increase in human pressure. This is particularly the case for all urban and peri-urban forests, which are seldom under any management plan and bear the brunt of pressure for the supply of woodfuel to urban inhabitants.

[78] CBFP, 2006.

Distribution of forest uses in central Africa[79]

	Million hectares	%
Total forest area	180	100
Forests under concession	49	27
Protected areas and parkland	18	10
Other forests	113	63

What are the opportunities for the carbon market?

Despite many advantages, Africa currently represents a mere 3 percent of the global carbon market. There is therefore huge room for progress. The steady establishment of basic skills and project identification proposals through actions now under way[80] should make it possible to meet this challenge within a reasonable timeframe. Only 15 percent of the 288 CDM projects recorded in 2007 deal with biomass and 16 percent with fuel efficiency.[81] These projects, for a total cost of US$7 billion,[82] are distributed among public capital (22 percent), semi-public capital (17 percent) and private capital (the remainder).

Is there then a real carbon market for woodfuel in Africa? The woodfuel forest value chain (plantations or natural forests) is considered neutral in terms of carbon assessments, which are applied exclusively to a renewal of forests identical with the amount harvested.[83] The use of inputs (fertilizer, mechanized ploughing etc.) could entail carbon costs, but also, conversely, increased storage through the improvement in yields all along the value chain.[84] The international situation is evolving fast. The Bali Conference in 2007 endorsed the concept of avoided deforestation and degradation – or reduced emissions from deforestation and degradation (REDD). It is a process complementary to that put in place in Kyoto in 1997 for plantations, but the aim this time is to use the market to promote actions to avoid the degradation of natural forests. However, past events regarding the CDM indicate that the process will taker a long time to set up and will be restrictive. Lastly, the opportunity costs of the REDD process must still be clearly defined.

It should thus be fairly easy to incorporate the woodfuel value chain into one of the following finance mechanisms:

Opportunities for implementation of carbon markets according to various forest management systems

Nature of mechanism	CDM, Kyoto	REDD, Bali	"Free" market
Plantation management	Yes, but	No, but	Yes
Management of natural forests	No	Potentially	Potentially
Energy optimization	Yes, but	No, but	Yes

[79] FAO, 2007b.
[80] Kasulu and Hamel, 2008.
[81] Caisse des dépôts et consignations, 2007.
[82] Or €5 139 011 596.
[83] Carbon storage = wood production = export of wood = carbon emission through combustion.
[84] O. Hamel, personal communication, 2008.

AVAILABILITY AND PRICE OF ALTERNATIVE FUELS

■ Fuel costs

People often say that the cost of fossil fuels has very quickly become one of the main factors in the development of world economies.[85]

The demand for energy will continue to grow, with projects for 2030 of +3 percent per year in Asia and +2.5 percent in Africa and Central and South America, compared with +0.8 percent in developed countries.

While woodfuel is considered neutral in terms of carbon, the risk of worsening atmospheric pollution is, on the contrary, very real, unless combustion is made more efficient. The use of forest residue is not optimal (about 2 billion cubic metres per year). Moreover, the growth in demand and the recovery of all residue would have a negative impact on soil, diversity etc.

■ Biofuels and the woodfuel resource

Biofuels are targeted: heat and electricity for biomass energy, while cellulose-based liquid biofuels are easier to transport than cereal-based fuels.

In global terms, the trend is towards competition between energy optimization and industrial optimization of roundwood (paper pulp) and an increase in the price of the resource.

Oil-palm plantations (for biodiesel) in Indonesia are contributing to deforestation (an estimated 5 million hectares to date, with an annual increase of 16 percent, or 1.8 million hectares per year, equivalent to 2 percent of forest cover). There are projects to establish large-scale oil-palm plantations, for example in the Democratic Republic of the Congo.

The choice between food and fuel crops is bound up more with economics than food security. Woodfuel helps to ease pressure on farmland and the predictable rise in prices (from single to double between woodfuel strategy and cereal-fuel strategy). The combination of woodfuel and crops (agroforestry, intercropping, forest plantations) should be encouraged.

Large-scale cultivation of biofuels also leads to competition over access to land (farmland conversion, deforestation, forest management). In Cameroon, for example, the use of sawmill waste could improve the country's electricity consumption. In the end, political decisions are what will define future energy strategies.[86]

In developing countries, especially in Africa, priority must be given to improving management of the wood resource, leaving fuel crops in second place (risks over access to land and food security, especially in developing countries).[87]

[85] Mtarji, 2008.
[86] FAO, 2008a.
[87] FAO, 2007a.

The possible development of biofuel crops should thus not have any major direct impact on urban and peri-urban forestry, inasmuch as the areas needed for their establishment tend to be far away from large urban centres.

FOOD AND DOMESTIC ENERGY

Urbanization is in a transitional phase in Africa. The new urban inhabitants, who most often previously lived in the countryside, still retain some of their rural habits, cultivating a plot on the outskirts of the town or owning a small flock.

Urbanization is accompanied by a growing demand for staple foods. Food crop cultivation and market gardening are thus boosted by demand and often expand onto peri-urban wooded areas. It is thus reasonable to wonder whether we can speak of competition between the fuel and food crop uses of urban and peri-urban forests.

The areas involved are not comparable. Supplying a town of 1 million inhabitants with woodfuel represents the annual harvesting of 10 000 hectares of productive plantation, and may entail as much as 100 000 hectares of forest, depending on the natural productivity of the stands and on how the land is used. For the same number of inhabitants, only a few thousand soundly managed hectares of horticultural crops will be needed to meet fruit and vegetable needs.

On the other hand, shifting cultivation or extensive livestock production constitute traditions and cropping systems that are widespread in a large part of Africa. They represent major risks of competition over peri-urban wooded areas. Slash-and-burn cultivation is a hybrid case. Areas are given over to agriculture, then to a wooded fallow, which may vary in length, but is the source of a considerable proportion of urban woodfuel supplies. The length of the fallow is therefore the critical element in this type of land management.

PAYMENT FOR ENVIRONMENTAL SERVICES

Peri-urban forests supply a whole range of products and services at both local and global levels. Sustainable development of a peri-urban forestry dedicated to the priority supply of woodfuel allows the maintenance, or indeed the boosting or creation, of many secondary services, especially those of an environmental nature. Such environmental products and services, which are often non-monetary, most usually represent common goods essential to the closest communities, both rural and urban.

Certain forest products (non-wood forest products, for example – leaves, fruit, lichen, game, resin, fodder etc.) have a clear monetary value, which can be calculated and integrated with varying degrees of ease into a calculation of the global value of the forest in question.

Although other products and services, most often those of major environmental value, are equally important, their monetary value is much harder to assess. Soil protection, erosion and siltation control, spatial organization, recreation, water quality, treatment of used water and bioremediation, biodiversity and ecosystem conservation are all examples of such non-monetary environmental goods and services. Unlike the previous products and services, these have a high, albeit not quantified, long-term global value for urban inhabitants. The latter, unlike many rural communities who know and manage their area sustainably, are not in a position to influence its evolution sufficiently to modify the trends observed.

Many studies are currently focusing on the idea of payment for environmental services, considering such key issues as:

- quantification of environmental benefits;
- fixing of opportunity costs;
- public policies;
- public-private partnership;
- international relations and treaties;
- a fair division of income.

These points are obviously not easy to grasp in countries lacking stability or currently undergoing stabilization or in areas where a wide range of urban and rural dynamics is found, some of them at odds with others.

In this environment, woodfuel represents a major advantage in the monetarization and validation of a sustainable management of peri-urban forests. It is possible to quantify the value of forests and all the various stages in the value chain supplying woodfuel to towns. Various countries have shown that the development of a resource dedicated to supplying woodfuel is certainly competitive with other land uses. However, the benefits of such action still need to be allocated to those involved in carrying it out, and this is not possible unless the limits, prerogatives and actions of the public and private spheres are clearly established. Most African countries now have appropriate legislation, but real application of this legislation, fiscal transparency and security of tenure are essential links in a virtuous dynamics.

TOWARD A SUSTAINABLE TERRITORIAL MANAGEMENT OF PERI-URBAN ZONES

Sustainable management of peri-urban wooded areas, the source of woodfuel, is a major challenge for the inhabitants of the great African megalopolises, especially the poorest groups and women, who are those most concerned by problems of access to the resource. The aim of any intervention should be set within the context of efforts to reduce the poverty and precarious situation of the most disadvantaged urban inhabitants. Providing peri-urban rural inhabitants with diversified income and employment is a major challenge for the authorities with a view to maintaining a rural fabric, limiting uncontrolled migration to the towns and their peripheral neighbourhoods, and helping in the reintegration of people into local contexts.

Forests are one of the constituent elements of peri-urban zones. Any initiative to ensure sustainable management of these zones, including forests and wooded areas, cannot be carried out without an appropriate, specifically designed strategy – although certain components of this strategy can be defined as follows.

■ Outlook analysis of the woodfuel resource and value chain

This type of analysis provides objective elements to help understand and anticipate the possible evolution in urban zones and woodfuel value chains in forthcoming decades, thus allowing more informed decision-making. Efforts are thus made, using an appropriate method (scenarios, for example) to:

- identify the main variables that could disturb and/or modify the past and present dynamics of the woodfuel resource and value chain;

- provide political and institutional decision-makers with elements for reflection with a view to drawing up national and regional policies.

■ Incorporation of the woodfuel issue into urban and peri-urban development

The fuelwood resource is mobilized in the framework of a given zone in which the various spaces and types of vegetation have a range of functions (agricultural production, water and soil protection, fallows to reconstitute fertility, forest areas, land reserved for allotments or infrastructure etc.) and are appropriated in various even contradictory manners. It is important that a development strategy for forest plantations and sustainable management of degraded peri-urban forests should take account of these different functions and that this development should not clash with other important functions of the zone. The initial objective is not to draw up a management and development plan for peri-urban zones as such, but rather to define appropriate criteria and indicators to assess the relevance of the places and conditions for sustainable development of the woodfuel resource.

An overall spatialized framework for intervention, both at a global level and in the context of a "landscape" approach, makes it possible to draft a masterplan for sustainable management of the peri-urban zones in which a fuelwood resource is found.

■ Conceptualization and scaling up of the strategy

If there is no intervention, the inexorable increase in the consumption of wood products (for construction and fuel), in the absence of substitute sources that are accessible to the general population, results in an equivalent increase in the volumes extracted from forests. Woodfuel consumption, which is concentrated around urban areas, accounts for almost 90 percent of the total volume extracted in Africa and is thus the primary factor impacting on natural forests.

The expansion of plantations and the placing of natural forests under simple management plans should help to stabilize extractions from closed forests, if only for the cost of such operations. This trend will eventually lead to a recovery of the area by secondary forest. Lastly, planted areas will become stabilized by the shrinking availability of land in an economically viable radius, while volumes will increase thanks to improved productivity and the professionalization of the whole value chain.

CONCLUSIONS

This regional report on urban and peri-urban forestry in Africa intentionally targeted the woodfuel value chain, inasmuch as this chain encompasses a large part of the issues, both urban and rural, associated with the search for sustainable management of peri-urban forest ecosystems.

The woodfuel value chain dominates all other forest value chains in Africa. The exploitation of forest stands for woodfuel, basically in peri-urban zones, accounts for 80 percent of all wood extracted and is one of the main causes of forest degradation.

Observations made in various towns show that clearly understood national and local policies, or even well organized profitable private initiatives, can act as a catalyst for the development of active peri-urban forestry. Conversely, poor governance, especially, sad to say, in countries with sizable alternative fuel resources to wood (kerosene, gas, water power etc.), exacerbates the level of poverty and the precarious situation of urban inhabitants, who have no choice but to use existing resources at the risk of causing their disappearance. This increasing scarcity of resources has significant consequences for urban ways of life, and indeed for people's diets and health. A typology of African towns can be drawn up, based on objective, verifiable criteria and indicators, on the basis of which the conditions for the success of a sustainable urban and peri-urban forestry can be specified.

Dedicated forest plantations, whatever their practical details, are among the most effective means of establishing a peri-urban forestry that is close to consumption areas and is both productive and sustainable. They also play an important role in providing environmental goods and services for urban and rural communities (whose interests do not always converge), while helping to stabilize pressure on residual natural ecosystems. The dynamics of degraded peri-urban natural forests, which are often the only source of domestic energy in many African towns, are still poorly understood and will need to be clearly defined before deciding on sustainable management measures.

Urban and peri-urban forests cannot remain separate from an increasingly monetarized environment. Urban and peri-urban forests have a very high value, although this value is often not expressed in monetary terms and is therefore hard to quantify. Through the financial flows it generates, the woodfuel value chain can contribute to the preservation and management of these natural and planted forests, to the extent that land tenure, espcially in the case of private land, is secure and the value chain is placed on a more formal footing. Among other possibilities of profiting from these forests, carbon markets could generate considerable income, but their implementation and the equitable division of their benefits are still major problems. The anticipated development of biofuels, whether first- or second-generation, poses more problems than solutions for peri-urban forestry.

Lastly, we can offer some generic recommendations that have emerged from the analysis of African towns and are applicable to all the various situations:

- definition of appropriate criteria and indicators to analyse the evolution of urban and peri-urban forestry with regard to the main causes of the degradation of wooded ecosystems (urbanization, energy, agriculture, livestock, infrastructure etc.);
- practical, transparent application of national laws and regulations, if need be helping to boost existing arrangements and make them more appropriate to the current situation;
- improvement in the knowledge of forest dynamics, particularly in the case of natural stands suffering urban pressure, and promotion of appropriate management plans;
- involvement of all stakeholders and users in reflections and in the implementation of policies concerning the management of the woodfuel resource throughout urban and peri-urban zones;
- promotion of private plantations dedicated to supplying woodfuel on the outskirts of towns, by securing land tenure, clarifying the taxation system and strengthening infrastructures;
- boosting of and support for local strategies for sustainable management of the resource, formalization of value chains and improvement in the energy performance of local equipment and techniques;
- carrying out of life-cycle assessments of the various urban energy value chains in order to compare the impacts of the various energy sources, especially the position of wood *vis-à-vis* alternative fossil fuels;
- highlighting of successful strategies and actions concerning the management of urban and peri-urban forests;
- development of systems of payment for the environmental services of urban and peri-urban forests, especially global services (carbon, biodiversity etc.), ensuring that local people are involved in this dynamic.

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Part 2. Case studies

PART 2 – CASE STUDIES

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TABLES DES MATIÈRES

FIGURES, TABLES AND PHOTOGRAPHS

NIGERIA

MANAGEMENT OF URBAN AND PERI-URBAN FORESTS TO SUPPLY ABUJA WITH DOMESTIC ENERGY

(M. Idowu)

Introduction

Domestic energy is vitally important for the existence and well-being of the inhabitants of both rural and urban zones. The woodfuels traditionally used are fuelwood and charcoal, which account for more than 80 percent of Nigeria's domestic energy consumption. Although Lagos and Kano are ancient, densely populated centres, Abuja – the country's new capital and the lynchpin of the Federal Capital Territory, with a population of about 3.5 million and covering nearly 8 000 square kilometres – was selected to illustrate the issue of woodfuel in Nigeria in the present study. The effects of urban and peri-urban forest management aimed at satisfying the demand for woodfuel (both fuelwood and charcoal) are at their most critical there. The rapid development of infrastructure involves further exploitation of land combined with population growth (about 5 percent a year), and hence an increased demand for woodfuel, which in turn leads to deforestation and increasing environmental degradation.

Origin and management of wood resources

ORIGIN OF WOOD RESOURCES

Woodfuel comes from various sources:

- natural forests in and around Abuja, in other parts of the Federal Capital Territory and in some neighbouring areas such as Kaduna, Kogi, Nassarawa and Niger States;
- plantations in forest reserves in Abuja and the same neighbouring states: there are about 6 900 hectares of forest reserves spread over 14 zones in the country; the reserves in the Federal Capital Territory include those of Idu, Karamajiji, Kusoru and Shaba;
- trees scattered on farms, of such species as *Parkia biglobosa*, *Vitelleria paradoxum* and *Adansonia digitata*, which community farmers deliberately retain on their own land when preparing fields for food crops, because of their value as sources of food, medicine etc.;
- line trees and ornamental plantings in the parks and gardens of green zones and other open spaces, including Muslim Eid prayer places along the highway to the airport: green zones are among areas where the law forbids the building of

permanent structures, because they lie over such public infrastructure elements as drains, electrical installations, water supply pipes and telecommunication cables;

- woody residue from clearing carried out to make space for the building of roads and houses or to allow the establishment of other priority infrastructure in the city.

Charcoal comes from Gwagwalada and Abaji, which lie within the Federal Capital Territory, respectively 55 and 80 kilometres from Abuja, and also from the neighbouring states listed above.

Road to Abuja Airport

(Photo: M. Idowu.)

MANAGEMENT OF WOOD RESOURCES

Wood taken from "free zones" (i.e. outside forest reserves) of natural forests (Sudanian savannah-type vegetation) is collected in the form of residue or debris left in community forests when land is being prepared for cultivation.

Indigenous communities living in forest reserves are authorized to gather restricted amounts of forest products, including fuelwood, but solely for their own use and not for sale.

The Federal Capital Territory and adjacent states contain several plantations of *Gmelina arborea, Tectona grandis, Cassia siberiana, Eucalyptus deglupta* and *E. terreticornis* intended for the production of construction timber and poles (for electricity and telephone lines). The thinning required by management of these plantations allows an interim collection of fuelwood, which is sold.

Lines of trees and windbreaks are planted along the streets and highways of Abuja. Ornamental trees (*Terminalia catapa, T. menthalli, T. ivorensis, Delonix regia, Gmelina arborea* etc.) have also been established in many parks and gardens in the city's green zones for ornamental purposes and to provide shade. The trees are periodically pruned to remove dead or broken branches or those stretching dangerously over the roofs of buildings, and also to enhance the beauty of the environment. Management of the vegetation also produces fuelwood.

Wood supply chain and market organization

Wood extracted from urban and peri-urban forests is piled up beside the road and carried to market for sale, either on people's heads or by donkey, barrow, cart, van or truck. Intermediaries (wood merchants) travel to forest or rural areas and purchase fuelwood or charcoal, which is transported by hired vehicle to designated centres, where it is sold to retailers with whom agreements have previously been made. There is no single wood market, inasmuch as sales points are scattered throughout the city and suburbs. Fuelwood is sold in billets about 1 metre long, which are then split lengthwise into smaller pieces. A stere of fuelwood (equal to 1 cubic metre of stacked wood) is sold for 2 500 Naira (US$21[88]) and a van-load for 10 000 Naira (US$85). Charcoal is produced in traditional earthen kilns, packed into 50-kilogram sacks and transported by charcoal merchants' intermediaries to their customers, who split them up into smaller bags. A 50-kilogram sack of charcoal is sold for 1 000 Naira (US$8.50), while a van-load (50 sacks) costs 50 000 Naira (US$424). As with fuelwood, charcoal sales points are scattered throughout the city and such suburbs as Gwagwa, Karmo, Kubwa, Karu, Mpape and Nyanya. Six units of fuelwood are needed to produce one unit of charcoal.

The linear structure and organization of the market are also significant factors. Motorists buy small quantities of fuelwood and charcoal beside highways for their own use or as extra loads (in the case of tanker or truck drivers) that can be delivered directly to urban customers.

An interesting aspect of how the market is organized in the wood trade – as is the case for quite a number of agricultural products – is the dominant role of intermediaries, who finance purchase of the product and then sell it on to retailers. This practice, entailing a succession of profit margins, explains why the price of wood when delivered to the end customer is much higher than the farmgate price.

Sale of wood beside the road (Abuja)

(Photo: M. Idowu.)

[88] US dollar equivalents according to the exchange rate on 4 July 2008.

Description of use

Woodfuels are used widely for a variety of purposes and in a broad range of contexts and places.

FUELWOOD

Fuelwood is used for cooking in private homes, restaurants, hotels and institutions (secondary schools, higher education establishments, Abuja University, Kuje prisons etc.), and also for heating homes during the cold *harmattan* season. It is used in the open to fry such snacks as *dodo* (ripe plantain) and *akara* (bean dumplings), to roast groundnuts, *bole* (plantain) and maize for sale, and to make picnic fires. It is also used to fry *gari* (a local cassava flour).

Fuelwood is used to smoke fish and meat (bushmeat) and to cook *suyas* (kebabs of beef, goat meat, mutton, chicken etc.). Many people prefer smoked fish and meat, because the burning of certain woods lends food a pleasant taste. Fuelwood is also used to dry tobacco before it is made into cigarettes and to dry sheets of rubber prior to further processing. It is used to cook sorghum in the preparation of certain local alcoholic drinks (*burukutu* and *pito*).

Stacks of fuelwood for sale by the roadside (Abuja)

(Photo: M. Idowu.)

CHARCOAL

Charcoal is used for cooking in homes and public institutions. It is generally preferred to coal because it burns cleanly, whereas coal produces a great deal of soot and pollutes the atmosphere. It has a higher calorific value than wood. Charcoal is used in all types of cooking for which fuelwood is suitable, for example to dry or roast meat and fish, or for barbecuing. Crackling braziers of charcoal, on which meat, fish, plantains, maize etc. are grilled, are a pleasant sight and can be found in most of the many gardens that dot the Abuja landscape. Charcoal is also used in bakeries and in laundries to heat flatirons.

Sacks of charcoal for sale (Kubwa)

(Photo: M. Idowu.)

Challenges to be met by sustainable natural resource management

There are many obstacles to achieving the sustainable management of Nigeria's forests and natural resources:

- a lack of political will to allocate adequate resources to sustainable forest management;
- insufficient finance granted for management and research activities;
- overgrazing by livestock;
- uncontrolled forest fires;
- illegal felling and extraction;
- pressure on forest reserves from efforts to allocate additional land to the development of infrastructure (urbanization, roads etc.);
- deforestation in favour of agriculture;
- undervaluation and low prices of forest products and services;
- a lack of an effective forest policy;
- an absence of deterrent forest laws;
- a failure to implement work and management plans;
- wasteful practices in the use of wood;
- exclusion of local and indigenous communities from forest management;
- insufficient resources devoted to sustainable forest management (financing, vehicles, computers and other equipment);
- weak databases and poor record-keeping at all levels;
- state governments' view of forests as sources of immediate funds/income;
- a failure to determine the annual allowable cut – or a failure to apply it;
- an absence of a forest trust fund in many states;

- a shortage or complete lack of a well-trained, competent workforce;
- a lack of forest guards to protect publicly owned forest areas and reserves against illegal extraction, poaching, encroachment by farmers or herders, forest fires, pests, disease etc.;
- a shortage of equipment and other supplies for forest protection (uniforms, communications equipment, vehicles, lookout posts etc.);
- irregularity of forest inventories;
- population pressure;
- farm subsidies;
- the roles of the Federal Department of Forests and of states in forest management;
- the length of concessions;
- insufficient awareness-raising among the general public as to the importance of sustainable forest management.

Alternatives to wood as a source of domestic energy

Although a number of substitutes for wood do exist, their effectiveness as sources of energy is limited by their low availability, their cost and their level of development. This is the case with kerosene, coal, gas (liquefied natural gas or liquid petroleum gas), biogas, electricity, and solar and wind energy.

KEROSENE

This is the most widely used alternative source of energy, but it is expensive and subject to periodic shortages.

COAL

Although the country has large deposits of coal, this fuel is barely used at all, being considered "dirty", and most people prefer charcoal, which is cleaner. When coal is burned in confined spaces, it also causes health problems because of the toxic gases it releases.

GAS (LIQUEFIED NATURAL GAS AND LIQUID PETROLEUM GAS)

Although gas for household use is available, it is expensive and subject to periodic shortages. The high cost of the equipment needed for its use (cylinder, stove, cooker etc.) put it beyond the reach of most of the population. It is also felt that if used carelessly, it can lead to potentially fatal accidents (explosions and fires).

BIOGAS

Some research institutions and universities have demonstrated the potential of biogas, but it has never been effectively marketed or widely adopted. More public information is needed in order to make its use more popular in such institutions as schools, universities and prisons. The possible use of biomass residue or organic waste (human faecal matter, animal excreta and vegetable matter) as raw materials (in digesters) would also help to keep the environment clean.

ELECTRICITY

Electricity does exist, and the national grid is fed by various sources: hydroelectrical (the Kainji Jebba and Shiroro dams), thermal/gas (Afam, Sapele and Egbin) and coal (Oji River and Ijora). However, its high price and the irregularity of supplies discourage people from using it as a reliable substitute for woodfuel.

SOLAR ENERGY

Abuja is located in the tropics (at about latitude 4° north) and has more than 300 days of sunshine a year. There are therefore considerable possibilities for the use of solar energy. Some energy research institutes have shown how it may be used for interior lighting, cooking, driers etc., and some people have been adopting this technology. However, the high initial cost of equipment (solar panels, photovoltaic cells, converters, batteries etc.) and insufficient awareness-raising among the general public have limited the widescale use of this energy source.

WIND ENERGY

Abuja receives enough wind with a speed and direction favourable to the production of wind power, which could viably replace other sources of energy (woodfuel, for example). Research institutes and universities have demonstrated that windmills can be used, for example, to pump water into small irrigated areas (home gardens) and to draw water from wells for household needs. The adoption of this technology has been hampered by the high cost of the necessary infrastructure (wells, pumps, masts) and the lack of sufficient awareness-raising among the general public.

Conclusion

The woodfuel consumed in Abuja comes from forest reserves (natural forests, plantations and farms), urban and peri-urban forests in Abuja and neighbouring states, and line trees, ornamental plantings and windbreaks in the town. The construction of urban infrastructure also swells the supply of wood. Woodfuel management depends on source and location. Natural forests supply dead wood, while debris from clearing is collected on plantations. Farms provide biomass coming from the preparation of land to grow food crops, and the thinning of line trees and plants in parks and gardens adds to supplies.

Wood from various sources is carried on the head or by barrow, donkey or motor vehicle to sales points by fuel merchants (intermediaries) whose operations have a major influence on the price paid by the end user. Indoors, woodfuel is used to cook food in homes and public institutions, and outdoors to cook meals ranging from snacks to feasts.

There are many challenges facing sustainable natural resource management: the lack of political will, the meagre resources allocated to forest programmes, the absence of operational capacity in the forest sector, the weakness of policies and of the legal framework, and the lack of awareness-raising among the general public as to the importance of this kind of management, to name but a few.

Substitutes for woodfuel as sources of domestic energy include kerosene, coal, gas (liquefied natural gas and liquid petroleum gas), biogas, electricity, and solar and wind energy. However,

their effectiveness as alternatives depends on their availability, the level of their development, their adoption by the general public and their cost.

The viability of woodfuel as the main source of domestic energy in Abuja depends on sustainable management of the natural resource – i.e. forests. The problems facing sustainable management of Abuja's urban and peri-urban forests are the same as those facing the rest of Nigeria's forest sector.

In conclusion, it should be noted that forests are a crucial element in humankind's well-being. In addition to wood, forests provide a wide range of essential goods and services, such as food, bushmeat, fodder and medicines, while also offering opportunities for leisure, education, research, spiritual renewal and employment. Moreover, forests are the basis of life on earth thanks to their ecological functions: climate stabilization (carbon capture), soil and water conservation (hydrological cycle), and the provision of habitats for plant and animal wildlife. The pivotal environmental role of forests means that sustainable forest management must look beyond the mere supply of wood. If such management is to be developed in Nigeria, an overall strategy must be formulated and implemented to stimulate the political will, provide sufficient resources as and when needed, boost existing forest institutions, build the skills of forest staff, encourage local communities to participate in decision-making and the implementation of forest projects, set up an enabling decision-making and legal framework, and promote the development and implementation of a vigorous public awareness-raising campaign. The full commitment and responsible participation of all the stakeholders is crucial if sustainable forest management is to be achieved, thus guaranteeing the ongoing availability of forest goods and services for all Nigerians.

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MALI

THE ISSUE OF WOODFUEL IN MALI: BAMAKO

(A. Kassambara, D. Gautier, L. Gazull)

Introduction

In Mali, wood is by far the main source of energy in both urban and rural areas, and will probably remain so for a long time to come. It currently provides about 85 percent of the energy consumed by households.

The amount of wood extracted to meet the nation's energy needs was estimated at 7 million tonnes in 2006 (woodfuel supply master plans for the country's various towns). Supplying the city of Bamako (1 500 000 inhabitants in 2007), with an annual consumption estimated at the equivalent of 568 960 tonnes of wood in 2006, is (along with clearing for cultivation) a cause of the impoverishment of the savannah ecosystems located around the city.

The Domestic Energy Strategy, a coordinated, global approach linking action on energy and action on forests, neither of which can solve existing problems on its own, has been in operation since 1996. It led to a reform of forest regulations, forest monitoring and surveillance, and the woodfuel taxation system.

The regulations on the harvesting of woodfuel represent a major advance over their predecessors. They consider forest resources as economic resources from which the people must derive greater benefit. They promote professionalization of fuelwood harvesting, transport and trade activities. And they give individuals, communities and the State a chance to generate income in the context of participatory sustainable management of forest resources.

Structure of woodfuel consumption

- *Consumers*:
  - rural households;
  - urban households;
  - the informal sector and industry.

- *Consumption:*
  - In rural areas.
    Wood consumption surveys carried out in 2006 during preparation of the woodfuel supply master plans give estimates ranging from 0.7 to 2.4 kg/person/day,

depending on zone (mostly used for cooking). Surveys carried out by the Woodfuel Unit in 1999 estimate wood consumption at 0.77 kg/person/day with improved stoves and 1.15 kg/person/day with traditional three-stone stoves.

- In urban areas.
  Wood consumption in towns ranges from 0.6 to 0.9 kg/person/day. The average consumption in Bamako is 0.7 kg/person/day with improved stoves and 1.5 kg/person/day with traditional stoves. Charcoal consumption in Bamako is estimated at 0.33 kg/person/day as the main fuel and 0.995 kg/person/day as a secondary fuel. When charcoal is used as the main fuel, households use energy-saving equipment (improved stoves and cookers, saving up to 40 percent on charcoal). This covers the cooking of three meals. However, when charcoal is used as a secondary fuel, no energy-saving efforts are made; this applies, for example, to the making of tea and snacks or the heating of water, which are usually done on an individual basis. When wood and charcoal are taken together, the current average daily consumption of a Bamako resident is the equivalent of 2 to 2.5 kilograms of wood. Gas consumption is estimated at 0.005 kg/person/day and kerosene consumption ranges from 0.011 to 0.015 kg/person/day.
- In the informal sector and bakeries.
  Although nearly all informal-sector trades are small consumers, bakeries consume large amounts of wood. Nationally, consumption ranges from 10 kilograms of charcoal per day for blacksmiths to 25 kilograms of wood per day for dyers. In Bamako, consumption ranges from 27 kilograms of wood per day for small restaurants to 103 kilograms of wood per day for dyers and 137 kilograms of wood per day for bakeries.

State and management of woodfuel resources

Mali's biological diversity is seen in its wide variety of forest types, ranging from bushy savannah in the north, with less than 10 cubic metres of wood per hectare, to striped bush, covering 25 percent of the south of the country, with standing volumes that often reach 20 to 40 cubic metres of wood per hectare, and forests in the Sudano-Guinean zone with 50 to 80 cubic metres of wood per hectare – and sometimes more than 100 cubic metres in gallery forests and closed forests in the west of the country.

The 1982 FAO study on the current situation and the outlook for woodfuel availability in the Sahel region of West Africa drew attention to the risk of woodfuel shortages facing a large part of the country, but in 1991 the work of the Woody Resources Inventory Project (PIRL) provided a clearer picture of the potential of Mali's forests, revealing a less disastrous situation, especially in the country's southern regions.

Women returning from collecting wood in Korokoro

(Photo : A. Bonnérat.)

Woodcutters in Fiena carrying wood to a charcoal kiln by cart

(Photo : A. Bonnérat.)

Preparation of the woodfuel supply master plans for the country's main towns confirmed that some areas of Mali had already eaten into their forest capital since 1998: extraction of woodfuel for local household consumption and for use in towns now exceeded – sometimes to a considerable degree – the natural regeneration capacity of forest stands. For example, nearly 47 communes out of 61 (more than two-thirds of communes) in Bamako's supply area, within a radius of 200 kilometres around the city, are showing a shortfall.

A shift in extraction activities towards the parts of the country that are richest in forest resources (in the south and west) is therefore now under way, with the establishment of new supply chains based on more appropriate means of transport, such as trucks, replacing the covered wagons or vans currently used on the outskirts of Bamako.

In general, the work of the Malian Agency for the Development of Household Energy and Rural Electrification (AMADER) reveals an overall positive situation for the country as a whole in 2006, although this does not deny the existence of localized overexploitation, especially around large towns.

However, if nothing is done to alter the present trend, the situation will very quickly deteriorate, especially inasmuch as the demand for charcoal, which has been growing rapidly in towns, will increase still further with the country's ongoing urbanization: 25 years from now, 50 percent of Malians will be living in urban centres. The extraction of wood will therefore continue to increase at a rapid rate, and it will be hard for the amounts projected for 2025 to be sustainable.

A partial solution can be provided by the rural woodfuel markets set up by the State in 1995 and the master plans enabling them to be localized. When rural markets are understood as a factor for development, they can be used rationally as a tool in sustainable management.

Transporting wood in a Peugeot 404 covered van

(Photo : Laurent Gazull.)

Rural markets and woodfuel sales points

With regard to the new legislative and administrative provisions put in place in 1995, not all wood sales points are rural markets. Rural markets follow the management and extraction rules for a village forest, such as the rural management structure, the extraction quota, the development plan, the simplified management plan, the place of sale, and accounting and management documents. These new legislative and regulatory measures state that the following are authorized to extract and sell wood:

- rural management structures for rural wood markets (local organizations);
- duly registered owners of private forests;
- individuals with extraction rights for zones that are not delimited and not under management.

Owners of private forests and individuals holding extraction permits are not subject to any form of organization for the marketing of the wood they produce. Once these producers have a permit, they have the choice and freedom to set themselves up wherever they see fit – beside highways or in any other place where there would be a ready market for wood and charcoal.

In other words, anyone holding a permit has the right to extract wood in the specified zones and sell it wherever he or she chooses. If equipped with a permit, the owner of a product placed at a sales point cannot be considered in breach of the law.

Wholesale charcoal selling in a Bamako market

(Photo : Laurent Gazull.)

Conclusion

The trade in forest products, especially woodfuel, is a vital issue for the country, inasmuch as the cumulative reduction in agricultural production, linked partly to rainfall deficits, has led some rural inhabitants to fall back on selling wood in order to survive. The political and administrative management of this sector is hence a very sensitive matter, concerning, as it does, a vulnerable sector of Malian society. Forests are in fact the only resource within the reach of the poorest inhabitants.

The State's role is therefore not that of preventing or banning forest extraction, but rather that of organizing it in a more appropriate legal, technical and social framework. In other words, the State must devote itself more to research on substitutes for woodfuel in order to reduce pressure on forest resources. In the context of a process of coordination and cooperation, the State should also pilot all woodfuel producers toward the controlled type of extraction that is a sure path to sustainable forest management, provided that all the stakeholders in the supply chain are sufficiently committed to it.

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REPUBLIC OF THE CONGO

PERI-URBAN FORESTRY: WOODFUEL RESOURCE AND SUPPLIES TO POINTE-NOIRE

(M. Nkoua)

General context

The city of Pointe-Noire, economic capital of the Republic of the Congo, is the country's second largest urban agglomeration after Brazzaville, the political capital. Located on the coast of the Atlantic Ocean with a deep-water port and the railhead of the Congo Ocean line, Pointe-Noire is surrounded by planted eucalyptus forests and natural forest mosaics, gallery forests and closed forests.[89] It is home to several petroleum, industrial and commercial infrastructures, making it a city undergoing full urbanization. Its population has doubled in the past ten years and is currently estimated at 1 million, 20 percent of the country's total population.

In order to meet their domestic fuel needs, especially for cooking, most households in Pointe-Noire use woodfuel from eucalyptus plantations and natural forests, a practice justified by low household incomes, difficult access to electricity, kerosene and gas, and the proximity of forest resources.

It is in this context that a woodfuel supply chain has been organized around Pointe-Noire, representing a major economic activity for the region and a source of income for a large number of both urban and rural inhabitants.

The present article provides a description of the resource, its management, marketing and types of use, the challenges to be faced if it is to be sustainably managed, and the alternatives to wood as a domestic fuel in Pointe-Noire.

The resource

The two main sources of woodfuel for Pointe-Noire are natural forest stands and industrial eucalyptus plantations.

The natural stands are the gallery forests and forest mosaics that intersect the coastal savannah on the outskirts of Pointe-Noire, and the large closed Mayombe forest over 100 kilometres away. These various natural forest stands have been overexploited since the 1950s and are now degraded, a condition increasingly aggravated by the effects of the monetarization of slash-and-

[89] Marien, 2006.

burn cultivation and of woodfuel. In these natural forest stands, *Alstonia boonei* of the Euphorbiaceae family and *Xylopia aethiopica* of the Annonaceae family are the species most sought after for woodfuel, especially in the Youbi forest zone, 80 kilometres northwest of Pointe-Noire.[90]

Apart from these natural stands that are threatened with disappearance from the peri-urban zone, 42 000 hectares of industrial eucalyptus plantations have been established around Pointe-Noire to produce roundwood for export to the paper industry.

Residues from this activity are then made available to local inhabitants for woodfuel, thus helping to meet Pointe-Noire's demand for domestic energy.

EFC industrial plantation in Pointe-Noire (3 years)

(Photo : J.-N. Marien.)

[90] Yembé-Yembé, 2007.

Gallery forest with clearing for slash-and-burn cultivation and charcoal-making

(Photo : J.-N. Marien.)

In 1995, eucalyptus plantations supplied about 43 percent of the charcoal and 75 percent of the fuelwood consumed in Pointe-Noire, so that total supplies were drawn roughly half and half from natural forests and plantations.[91] However, more than ten years later the population has doubled, extraction rhythms have changed and these proportions need to be revised.

Management of the resource

Two management models are found in connection with woodfuel supplies to Pointe-Noire.

The first management model is found in ***natural forest stands***, which are directly managed by the landowners, who hold the right of management over the land. Although these natural forests are of course accessible to everybody for their own domestic fuel needs, their use for the production of woodfuel for commercial purposes is subject to the condition that the operator must be an outsider and not a member of the landowner's family. In the Youbi and surrounding zone, a demijohn of red wine, a one-litre carton of wine and a sum ranging from CFAF 10 000 to more than CFAF 60 000 is enough to gain access to a stretch of forest reaching as far as the eye can see.[92] This stretch is used for the collection of dead wood, selective extraction of timber or clear felling as a preliminary to cultivation after burning. The wood selected is processed into charcoal in traditional earthen kilns, and the remainder is made up into steres (1 stere = 1 cubic metre) and bundles of fuelwood. When extraction has been completed, the area is abandoned by the operator and usually reverts to the landowner.

The second management model is specific to the ***industrial eucalyptus plantations*** currently managed by the Eucalyptus Fibre Congo (EFC) limited company. Plots harvested for the production of roundwood for the paper industry or accidentally burned are then made available to urban and rural operators to extract woodfuel. Operators wishing to produce woodfuel make applications to EFC's management. The company makes its selection and publishes an official list of the operators selected, taking into account requests for intervention from the heads of its local units, who specify the plot, the area involved, the

[91] Pierre, J.-M. 1996.
[92] Yembé-Yembé, 2007.

type of intervention and the timeframe. Letters of agreement are then signed by EFC and the selected operators. Crowns and branches with a diameter of less than 6 centimetres are packed into bundles of fuelwood and/or processed into charcoal (still using traditional earthen kilns). This employment-creating, income-generating activity follows an administrative procedure that benefits urban inhabitants more than local people, a situation that encourages illicit extraction from the eucalyptus stand by clandestine local and urban operators. The Forest Economy Department taxes woodfuel coming into Pointe-Noire, levying CFAF 150 per stere of fuelwood and CFAF 100 per sack of charcoal. EFC's guards carry out systematic monitoring of woodfuel from eucalyptus plantations.

Marketing

The woodfuel consumed by households in Pointe-Noire is basically fuelwood and charcoal. The table below gives details of the amounts of these products entering the city.

Characteristics of fuelwood and charcoal entering Pointe-Noire (average values)

Form of woodfuel	Units (packaging)	Dimensions		Volume (steres)	Weight (kg)
		Length (m)	Diameter (m)		
Fuelwood	Stere	1,00	1,00	1,00	650,00
	Adult's bundle	2,03	0,35	0,20	38,00
	Child's bundle	1,65	0,27	0,09	11,70
	EFC bundle	0,69	0,24	0,03	13,10
	CFAF 100 bundle	0,65	0,01	0,00	1,36
Charcoal	Bag with cap	1,24	0,37	0,14	32,00
	CFAF 500 packet	0,40	0,30	0,03	1,36
	CFAF 100 packet	0,13	0,21	0,00	0,68
	CFAF 50 packet	0,27	0,13	0,00	0,35

Charcoal is the most widely used form of woodfuel in Pointe-Noire, with 96 percent of households using it, while 31.5 percent use fuelwood for cooking.[93]

There are three types of woodfuel market serving Pointe-Noire: village markets (sale of woodfuel by the producer in the village or directly at the production site), eucalyptus plantation markets (sale of woodfuel by the operator beside the eucalyptus plot made available to him or her for woodfuel extraction) and urban markets (sale of woodfuel in the city by the producer, the operator and/or the wholesaler or retailer for urban consumption). The first two are solely wholesale markets, while the third is both wholesale and retail.

Motor vehicles are the most widely used means of transporting woodfuel to Pointe-Noire. Wholesale prices range from CFAF 1 000 to CFAF 1 500 per sack of charcoal and from CFAF 300 to CFAF 400 per EFC bundle of fuelwood, while the retail price ranges from CFAF 2 500 to CFAF 3 500 per sack of charcoal and from CFAF 450 to CFAF 500 per EFC bundle of fuelwood. The variations in price are the result of seasonal differences and fluctuations in petroleum prices.

[93] Marien, 2006.

Types of use

The various uses of woodfuel in Pointe-Noire are summarized in the table below.

Uses of woodfuel in Pointe-Noire

Form of woodfuel	Type of use	Users
Charcoal	Cooking meals	Households
	Heating water	Households
	Heating irons for ironing	Households and tailors
	Heating chicken incubators	Poultry farmers
	Heating various objects	Craftworkers
	Manufacture of substratum for eucalyptus seedlings in nurseries	EFC company
Fuelwood	Cooking meals	Households, food stalls and restaurants
	Heating water	Households and restaurants
	Baking cassava loaves	Households
	Cooking fritters	"Fritter Mums"
	Smoking fish	Fishermen
	Preparing maize	Brewers of traditional maize beer
	Recasting aluminium	Making aluminium saucepans and other cooking utensils
	Making art objects	Metal-casters and jewellers
	Heating various objects	Craftworkers

Charcoal is the fuel most widely used by Pointe-Noire households for cooking, because it can be purchased for very little and is easy to use. A household uses an average of 1.23 kilograms of charcoal per day – the equivalent of 14 138 tonnes per year.[94] Fuelwood is used much more by fishermen (to smoke their catch), food stalls, fritter makers and aluminium casters. If each household consumes on average a total of 6 kilograms of wood per day – the equivalent of 125 428 tonnes of fuelwood per year – the consumption of other users of fuelwood is as yet unknown. In 2006, the total annual consumption of Pointe-Noire households was estimated at the equivalent of 647 845 tonnes of fuelwood, with an estimated yield of charcoal/wood of 15 percent, or 893 587 cubic metres, and an estimated density of 725 kilograms per cubic metre.[95]

Challenges to be met with a view to sustainable management of the resource

Sustainable management of the woodfuel resource means first and foremost ensuring that every management act by every stakeholder contributes to the sustainability and quality of forest stands for generations to come. One of the main principles of most woodfuel management policies is that of ensuring protection of the ecological, economic and social balance.

In the Congo, especially in Pointe-Noire, apart from household consumption, there are still various unknown elements to be determined, analysed, understood, improved, monitored and

[94] *Ibid.*
[95] *Ibid.*

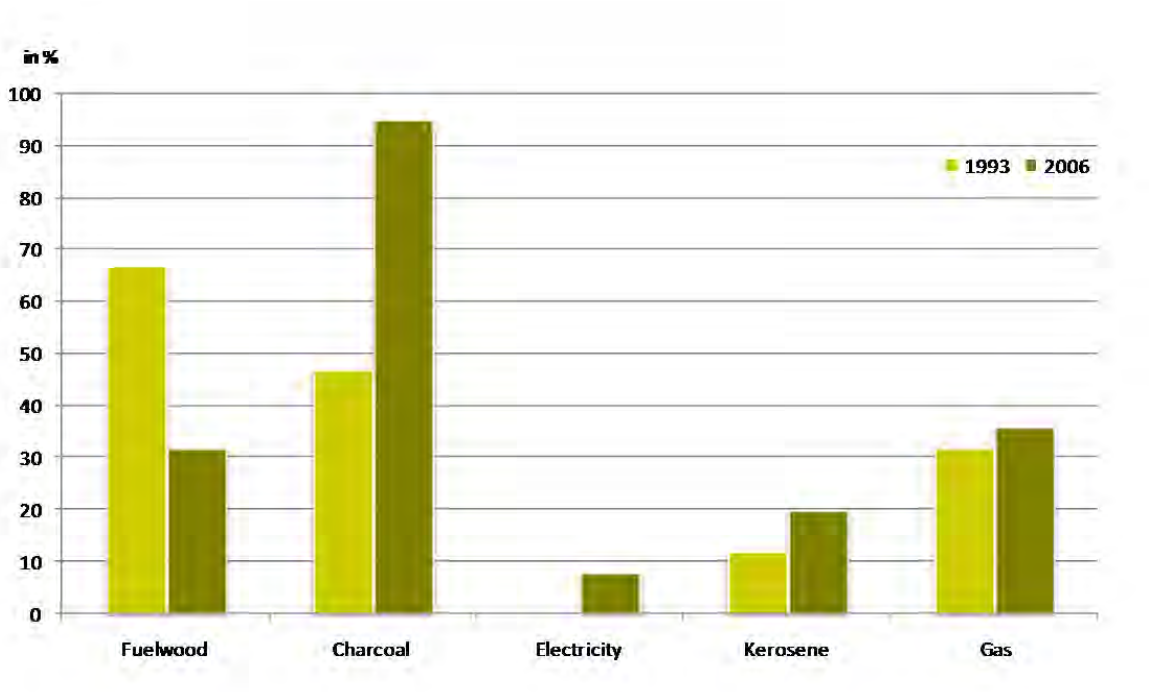
incorporated into the management plans for forest concessions with a view to certification (for example in the case of the EFC stand). This regards particularly the balance between overall supply and demand, and between rural and urban people in the vertical division of income, but also the spatial balance of woodfuel resources within the Pointe-Noire supply area. In this connection, the main issue in regulating supplies to Pointe-Noire is the balance between woodfuel supplies from plantations and those from natural forests, which requires a clear spatial overview of the various activities involved in the production, transport and marketing of wood around the city.[96]

When all these factors are determined, sustainable consumption and supply mechanisms can be put in place, which would also take account of opportunities offered by new energy-saving technologies (improved stoves and ovens).

Alternatives to wood as an urban domestic energy

The overall shift in domestic fuel consumption in Pointe-Noire between 1993 and 2006 is shown in the figure below [97].

Changes in the use of various fuels by Pointe-Noire households over 13 years[98]



While the population of Pointe-Noire doubled in the 13 years, fuelwood consumption by households decreased by nearly half and that of charcoal doubled. The creation of a woodfuel supply chain by the managers of the eucalyptus plantations and the establishment of charcoal production using eucalyptus residue in 1994[99] contributed to an increase in charcoal

[96] GECKO, 2006.
[97] B. Marien, 2006.
[98] Marien, 2006.
[99] Pierre, J.-M. 1996.

consumption in Pointe-Noire. Use of other more "modern" sources of energy is increasing more slowly.

Use of kerosene doubled in the 13 years, an increase perhaps explained by the liberalization of the management of fossil fuel sales points since 2000. Gas consumption grew by only 4 percent, a meagre increase explained by the frequent supply problems and also by the reputation of gas as a dangerous fuel. Electricity is little used by Pointe-Noire households because not all homes are connected to the grid and repeated outages discourage its use.

In terms of the outlook for the future, the establishment of two gas-fired power stations by two local petroleum companies, planned for 2010, with a combined production of 340 megawatts, against an overall fuel consumption currently estimated at 140 megawatts for Pointe-Noire (60 megawatts during the day and 80 megawatts at night), could make electricity the main alternative to the charcoal and wood currently used by households..

Conclusion

Point-Noire's peri-urban forest is disappearing. Together with overexploitation of natural forest stands by loggers since the 1950s, woodfuel extraction and slash-and-burn cultivation are causal factors in forest degradation.

In this context, the main issue in regulating supplies to Pointe-Noire is that of striking a balance between woodfuel from plantations, in which the residue from forest harvesting is used for this purpose, and from natural forests.

This whole issue, which requires a clear spatial overview of the various activities involved in producing, transporting and marketing wood in the Pointe-Noire area, is the subject of a doctoral thesis in the framework of collaboration between Marien Ngouabi University, the Research Unit on the Productivity of Industrial Plantations (UR2PI, which in 2009 became the Research Centre on the Sustainability and Productivity of Industrial Plantations [CRDPI]) and CIRAD. The results of this study will help in designing sustainable woodfuel consumption and supply mechanisms for Pointe-Noire.

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SOUTH AFRICA

OF WOOD FROM INVASIVE EXOTIC TREES TO COVER URBAN WOODFUEL CONSUMPTION: CAPE PROVINCE

(Ben Du Toit, Jan Swart et T. J. de Waal)

Introduction

Cape Town is located on the Cape Peninsula in the southwest of South Africa, about 100 kilometres west of Africa's southern tip. The city and its surrounding towns have a population of more than 6 million. The region enjoys a Mediterranean climate with winter rains and contains the Cape Floral Kingdom (also known as the Fynbos Biome), unique of its kind. The vegetation of this biome is rich in shrubs and flowering plants, but contains very few indigenous arborescent species, since fire plays an important role in this type of vegetation.[100] The region therefore depends heavily on forest plantations and invasive exotic species for its supplies of wood.

The rarity or absence of trees that could provide woodfuel has given rise to a very particular situation around Cape Town, inasmuch as wood taken from invasive and unwanted exotic plants in peri-urban zones has become a major source of woodfuel to cook food and to heat homes belonging mostly to the poorest sections of the population.

Thanks to current clearing operations and biological control (using harmful insects that attack the trees and prevent seeds from forming), the invasive exotic species are now under control, but it will take several decades for their numbers to be appreciably reduced. However, the combination of clearing and biological control methods is not in itself a solution. The challenge is to coordinate ongoing clearing programmes with the supply of wood for domestic use and the anticipated future demand for sustainable sources of energy, parallel with conservation of the biodiversity of the Cape Floral Kingdom and improvements in water security.

Vegetation and tree resources

The Cape Floral Kingdom, the smallest of the six such kingdoms on the planet, lies wholly within the southwestern region of South Africa. It has a great wealth of species, with 68 percent endemicity, therefore exceeding many tropical forest regions in floral diversity. It occupies only 6 percent of South Africa's land area, but contains 36 percent of its plant species.[101] Several species are under threat of extinction as a result of urban expansion, fragmentation and

[100] Cowling and Richardson, 1995.
[101] *Ibid.*

destruction of habitat, invasive plants and the frequency of fires. Fire is a natural element for Fynbos vegetation, but the excessive numbers of fires that break out in other seasons disturb natural seed production and modes of dissemination, and could thus cause the disappearance of species.

The Fynbos Biome is rich in shrubby species belonging to the Proteaceae, Ericaceae and Restionaceae families, but contains only a few indigenous arborescent species. Tiny isolated pockets of natural forest are found scattered on humid, southeast-facing slopes, but they are extremely rare and are well protected. Several exotic arborescent species (mainly Australian *Acacia* species) were introduced into the Fynbos zone for various reasons, such as the stabilization of sand dunes, but have since become invasive. Tree resources found in the zone include about 20 000 hectares of *Pinus radiata* and some plantations of *P. pinaster* for the production of sawnwood, plus small stands of eucalyptus on farms. The main threat to the Fynbos Biome and its plant diversity comes from the invasive exotic species. These invasive species also compete strongly with human activities and the Fynbos vegetation for the region's scant water resources.

Energy supplies in urban and peri-urban zones

Electricity, Cape Town's main source of energy, is provided by Eskom through the national grid. Eskom is a public company producing electricity in 26 power stations fired basically by coal, one nuclear power station located in the Fynbod Biome, gas turbines, small conventional hydroelectric installations and pump-operated hydroelectric reservoirs. Although electricity is normally available in sufficient quantities, during peak periods the city's demand sometimes exceeds availability, causing serious difficulties for industry, commerce and the general population.

Inhabitants of Cape Province and woodfuel (statistics)

Number of inhabitants in Western Cape Province (2008) (2001 statistics with a 3% annual growth rate)	6 millions
Number of urban inhabitants (Cape Town) (2001 statistics with a 3% annual growth rate)	3,89 millions
Number of urban inhabitants (Cape Town) using woodfuel (estimate based on data provided by C. Marais[102])	1,94 million (estimate)
Number of rural inhabitants using woodfuel (estimate based on data provided by C. Marais[103])	1,42 million (estimate)
Woodfuel used: more than 91% taken from invasive exotic *Acacia* species (estimate based on data provided by C. Marais[104])	150 000 tonnes per year

Two important aspects of the energy supply situation call for constant attention and consideration:

- the dependence of the poorest sectors of the city's population (some of whom live in makeshift accommodation) on woodfuel as the cheapest source of energy for

[102] Personal communication from C. Marais, Acting Head, Operations Support, Working for Water Programme, July 2008.
[103] *Ibid*.
[104] *Ibid.*

cooking and heating: in peri-urban zones, this wood comes from forests – or more precisely from thickets composed of invasive exotic species of *Acacia*, mainly Australian[105]; the amount of woodfuel used in urban and peri-urban zones is not known, because the wood is sold on the informal market and consumed locally;

- the threat of increased consumption of this source of fuel by local inhabitants in order to produce electricity using renewable resources (biomass), of which invasive exotic species clearly form a part.

If this scenario becomes a reality, there is a danger that the current source of fuelwood will be compromised, at the expense of current users.

Combating invasive exotic trees through the water promotion programme

The Working for Water (WfW) Programme is a multidepartmental programme of the South African Government run by the Department of Water Affairs and Forestry. It was launched in 1995 to reduce water consumption by the invasive exotic thickets found along water courses, and also to create employment. More than US$125 billion has been invested in this programme since its creation, and it provides employment opportunities for 300 000 people in approximately 300 clearing projects throughout the country. It can be said that it has slowed down the growth and propagation of invasive exotic species.

The water promotion programme seeks to optimize its socio-economic and environmental investment by removing and using the biomass resulting from the clearing of exotic invaders. In addition, these operations increase both the environmental advantages and the sustainable economic advantages of the programme, which respects international rational environmental standards.

There are many reasons for eliminating the cleared biomass, especially in the west of Cape Province, including the following benefits:

- preservation of biological diversity;
- improvement in water security by boosting the flow in water courses and underground sources of water (inasmuch as river-bank thickets use a huge amount of water);
- improvement in ecosystemic processes to counter the impact of fires and floods;
- rehabilitation of the land's productive potential;
- promotion of the sustainable use of natural resources.

The main factors in the success of the programme are the availability of a viable source of supply and a reliable, economic supply chain. To attain some of its objectives, the programme undertook an inventory of the biomass in three zones in the coastal plains of South Africa, two of which could be defined as peri-urban zones of Cape Town.[106]

[105] FAO, 2008.

[106] Marais, 2008; and personal communication from C. Marais, March 2008, on "Techniques used to determine approximately 30% of the biomass in South Africa, mainly on the coastal plains".

INVENTORY AND INFORMATION ABOUT THE RESOURCE

The programme thus carried out an inventory between 2001 and 2003 of the various components of the biomass and the quantities of invasive plants. The material used to estimate the quantity of biomass came from two coastal plains that can be briefly described as follows:

- west coast plains: the total area within a line running from Somerset West in the east, along highway N2 to Stellenbosch, Kuilsrivier and Belleville, then along the R302 from Belleville via Durbanville to Malmesbury, then along the N7 to Berg River and along the north bank of the river as far as the sea, then south along the Atlantic coast to Strand, and inland again from Strand to Somerset West;
- Agulhas plains: the total area within a line running from the east bank of the Bot River estuary north along the Bot River to highway N2, east along the N2 to Caledon, then east along the R316 to Bredasdorp, east along the R319 to the De Hoop Wydgelee road to Malgas, along the Breede River to the west bank of its estuary, and west along the Indian Ocean coast to the Bot River estuary.

The inventory focused only on the dominant species, namely *Acacia cyclops* (Rooikrans) et *A. saligna* (Port Jackson). Other invasive species found in the zones and marked for clearing, but not included in the inventory, include *Eucalyptus* spp. (gums), *Pinus* spp. (pines) and *Leptospermum laevigatum* (Australian myrtle).

The west coast and Agulhas plains fall within the category of peri-urban zones of Cape Town and currently supply woodfuel from invasive exotic trees and shrubs to the urban and peri-urban zones of the city.

AREAS AND BIOMASS

The tables below[107] give a summary of the amounts of biomass available in the west coast and Agulhas plains between 2001 and 2003. The total available amount of woody biomass was estimated as the total infested area (hectares) multiplied by the average standing biomass per unit of area. The area infested was determined by satellite imaging[108] and the yield calculated with the use of an allometric coefficient.[109]

Areas infested by invasive species with a cover of more than 50 percent of the total.

Species	Area (ha) *		
	West coast plain	Agulhas plain	Total
A. cyclops	2 840	11 794	14 634
A. saligna	8 417	3 492	11 909
TOTAL	11 257	15 286	26 543

** 30% reduction to compensate for possible imprecision in satellite imaging*

[107] Van Laar and Theron, 2006a and 2006b.
[108] Theron *et al*., 2004.
[109] Van Laar and Theron, 2006a and 2006b.

Exotic plants (*Acacia* spp.) near Hermon, Cape Town

(Photo B. Du Toit.)

Estimated standing woody biomass in infested areas with a >25 mm stem diameter, according to species and regional density

Species	Element	Biomass (tonnes)*		
		West coast plain	Agulhas plain	Total
A. cyclops	> 25 mm	67 425	1 213 598	1 281 023
A. saligna	> 25 mm	291 794	249 290	541 084
TOTAL		359 219	1 462 888	1 822 107

** 30% reduction for area and 10% reduction for yield, to compensate respectively for possible imprecision in satellite imaging and sampling errors*

Weighted average of usable standing woody biomass present in infested areas, according to species density

Species	Element	Usable biomass (tonne/ha)*		
		West coast plain	Agulhas plain	Total
A. cyclops	> 25 mm	23,74	102,90	87,54
A. saligna	> 25 mm	34,67	71,40	45,43
Weighted average of all elements		31,91	95,70	68,65

** sult calculated by dividing the data from Table 3 by those from Table 2 and assuming a conversion factor of volume to mass of 0.84*

Estimated total quantity of biomass according to component and regional density

Component	Total biomass according to element and region (tonnes)*		
	West coast plain	Agulhas plain	Total
Trunks >25 mm	359 219	1 462 888	1 822 107
Branches <25 mm	268 691	889 842	1 158 533
Foliage	191 856	499 546	691 402
Total biomass	819 766	2 852 276	3 672 042

** 30% reduction for area and 10% reduction for yield, to compensate respectively for possible imprecision in satellite imaging and sampling errors*

GROWTH RATE AND PREDICTIONS FOR EXOTIC THICKETS

The average growth rate of the thickets is not known. However, the inventory described the situation of biomass at a moment in time that may now be used as the baseline when evaluating the success of operations to reduce existing invasive exotic species. Although the biomass may be eliminated through the water promotion programme and the use of woodfuel, a huge reserve of seeds that will keep plant populations going for many decades is found in all the infested areas. Biological control, using insect pests that prevent seed formation and cause galls (*Melanterius* spp. and *Trichilogaster* spp.), was introduced to eliminate the main invasive species of *Acacia*. Seed formation practically stopped as the introduced insects became established.[110] It is anticipated that the exotic thickets will decrease noticeably and then disappear over coming decades, if the agents of biological control continue to carry out their task and the programme continues with the eradication of existing stands and the control of germinating seedlings from existing seed reserves.

MARKETING AND USE

One of the main objectives of the programme at present is to add sufficient value to products to make them marketable, in order to cover, or partially cover, the costs of clearing and eradication operations. Technical evaluations will be needed in order to support these efforts and allow identification of new possibilities for optimization. Such evaluations will include determination of the distribution of fibre lengths and wood density, and assessment of the quality of charcoal, wood chips, pulp and paper.

Available wood in the two areas studied consisted of woody stems with a diameter of more than 25 millimetres and branches with a diameter of less than 25 millimetres, and was assessed at 2.98 million tonnes. The total amount of available wood in all the peri-urban zones around Cape Town was thus estimated at 8.9 million tonnes, a sum obtained by multiplying the sum of the two areas under study by three.[111]

Data from the inventory allows proper planning and sound management of the problem of invasive exotic species in the southwestern Cape and regular contracts can be drawn up on the basis of the real situation, allowing the greatest possible benefit to be drawn.

[110] Donnelly and Hoffmann, 2004; Dennill *et al.*, 1999.
[111] C. Marais, personal communication, March 2008.

Exotic plants near Vernmershoek, Cape Town

(Photo B. Du Toit.)

Challenges to be met in order to ensure a sustainable or increasing resource base for energy production

Throughout the world, there is a trend away from fossil fuel-based energy production systems and toward renewable sources and/or nuclear energy. South Africa's sole nuclear power station (Keoberg) is located near Cape Town and supplies a portion of the region's energy. However, economic and demographic growth will necessitate a rapid increase in the country's energy-production capacity. Insofar as the establishment of new power stations has not yet been planned, it will probably take more than ten years to get any such stations up and running. South Africa is therefore trying increasingly to use energy from renewable sources,[112] because coal-based energy production – a polluting practice – would be the only other realistic option.

Efforts to control and eliminate invasive exotic thickets in the peri-urban zones around Cape Town bring many environmental benefits and improve water usage, and should therefore be encouraged. However, woody biomass has become an important source of energy, and the complete eradication of these thickets will leave a large gap in the energy market, thus threatening indigenous vegetation (through illicit extraction by impoverished inhabitants) and making the more developed sectors more dependent on coal-based electricity production. However, a substitution strategy does exist and should be pursued: the planting of rapid-growth non-invasive species for use as woodfuel or as a source of biomass for the production of electricity. A new source would thus be created that would gradually replace the current source as it dwindles with the ongoing eradication strategies. The criteria that such an afforestation programme should observe are as follows:

- rapid-growth non-invasive species or hybrids should be used and the plantations should be properly managed;
- plantations should not replace productive agricultural crops;
- plantations should not be established in places where they could absorb considerably more water than the existing vegetation, such as areas along river banks;
- integrated fuel and fire management strategies should be adopted.

[112] Centre for Renewable and Sustainable Energy Studies, 2008.

Preliminary work in this direction has been undertaken in the form of tests of the compatibility of species with sites and trials of rapid-growth but non-invasive eucalyptus hybrids that are well adapted to the climate of the region.

Conclusion

At present, the only available source of cheap woodfuel for some of the inhabitants of Cape Town is the thickets of invasive trees and shrubs found in the coastal plains near the city. The natural vegetation contains very few indigenous trees and no large forests.

Long-term strategies have been adopted to eradicate invasive exotic species from the region, thus boosting both conservation of the biodiversity of the Cape Floral Kingdom and also water security – for water is a scarce commodity in the region.

However, the invasive exotic species cannot be eradicated at present without establishing plantations created expressly with the help of rapid-growth non-invasive species and hybrids well adapted to the climate of the region, and without good management. The current and future demand for a reliable source of wood cannot be ignored.

The energy needs of the inhabitants of Cape Town and the supply of wood from peri-urban zones must be coordinated with conservation and water supply requirements, and with the sustainable production of a major source of renewable energy.

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The ever-increasing urbanization of African countries represents a fundamental change in society and way of life for people who have traditionally been rural. In this context, the sustainable supply of energy for domestic use by urban inhabitants is a major issue in development. In Africa, unlike other continents, woodfuel still accounts for a major proportion of the domestic fuel consumed, and the quantities involved are likely to continue rising in coming decades. This increase in consumption leads to increasing pressure on peri-urban forest ecosystems, which are already being used to provide such other services as infrastructure, urbanization and agriculture. The resulting competition over land use and the ever-growing needs of urban inhabitants govern the evolution, and often the degradation, of this land on the interface between towns and the rural world.

Management of these peri-urban forest areas, which are often degraded and tend to be ignored because of a failure to grasp their full complexity, therefore becomes a vital element in ensuring a sustainable supply of wood and preserving the main ecological and social functions they have traditionally fulfilled.

FAO's awareness of the importance of this issue and the specific nature of relations between towns and peri-urban forests in Africa led it to call on the International Cooperation Centre on Agrarian Research for Development (CIRAD) to carry out a study of the question during the international conference on "Trees connecting people: in action together" held in Bogotà, 29 July–1 August 2008. This resulting report is intended as a basis for reflection.

Urban and peri-urban forestry in Africa: the outlook for woodfuel

http://km.fao.org/urbanforestry