# 3 Wood energy in urban areas of developing countries

## 3.1 IMPLICATIONS OF RAPID URBAN GROWTH ON WOOD ENERGY

Urbanization in developing countries, represented mainly by rural households moving to urban and peri-urban areas, brings considerable changes to subsistence energy supply/demand patterns. These changes are the result of diverse factors, including distances from supply sources that limit direct fuelwood collection, increased purchasing power, greater dependence on marketed fuels, high dwelling density limiting open-air cooking, and cultural pressures imposing urban ways and marginalizing rural practices and traditions.

With consequent increases in income, households migrating from rural to urban areas initially change over from fuelwood to charcoal and subsequently to LPG and/or kerosene and electricity. This fuel "ladder" is not upwards only. The decrease in fuelwood use is apparent, as is the slow increase in the use of more modern fuels, but the role of charcoal is stable and dominant. In most poor cities it is the main household fuel, gaining consumers not only from newly urbanized households but also from urban dwellers pushed down the fuel ladder by increasing oil prices, economic recession or sociopolitical unrest.

For example, in the case of Maputo, Mozambique, a comparison between the 1992 and 2000 consumption pattern, shown in Table 1, confirmed a significant shift in the types of fuel used, excluding charcoal, which remained equally important in both 1992 and 2000 (CHAPOSA, 2002).

TABLE 1
**Proportion of fuel types used by households in Maputo, 1992 and 2000**

| **Fuel** | **1992** (%) | **2000** (%) | **Significance** (alfa: 0.05) |
|---|---|---|---|
| Firewood | 78 | 22 | Significant |
| Charcoal | 76 | 75 | Not significant |
| Paraffin | 14 | 44 | Significant |
| Gas | 12 | 21 | Significant |
| Electricity | 12 | 26 | Significant |
| **Total** | **952** | **208** | |

*Source*: Brouwer and Falcão, 2001 (in CHAPOSA, 2002).

Rapid urbanization by the rural poor and an inherent change in the "choice" of household fuels have had considerable effects on the exploitation of woody biomass resources. Table 2 lists some of the main differences between fuelwood use, dominant in rural households, and that of charcoal, dominant in urban households.[4]

The massive and continuing shift from fuelwood to charcoal caused by rapid urbanization presents a serious risk of environmental degradation but also provides significant opportunities for sustainable development in peri-urban and decentralized rural communities, i.e. rural and forest communities located far from the periphery of the urban woodshed. By moving from the informal and ubiquitous gathering of fuelwood towards the structured production of commercial woodfuels, the wood energy issue increases its forestry character. The higher reliance on forests and relatively dense woodlands as sources of woody material boosts the sustainability issue and should receive full attention from the forestry sector and benefit from its tools and best practices such as sustainable forest management and participatory approaches.

[4] There are notable exceptions to this urban/rural characterization such as, for instance, Bangui in the Central African Republic where urban households consume far more fuelwood than charcoal.

TABLE 2
**Urbanization and associated change from fuelwood to charcoal energy systems**

| | **Main features and implications of energy systems** |
|---|---|
| Migration from rural situation dominated by use of fuelwood | • **Fuelwood**<br>• By-product of agricultural crops; gathering of deadwood and green wood from farmlands, woodland and forests; by-product of shifting cultivations and land use changes<br>• Mainly non-commercial procurement; producer and user often the same<br>• Relatively high production efficiency (use of residues and by-products) and low impact in respect of woody biomass resources<br>• Generally low energy conversion efficiency<br>• Relatively high impact on living conditions (gathering time, hardness, indoor health conditions) of women and children in poorest households |
| To: urban situation with wider energy mix dominated by charcoal | • **Charcoal**<br>• Product of exploitation of forests and woodlands through high intensity selective and/or clear felling<br>• Fully commercial supply; producer and user always different<br>• Relatively low production efficiency (due to energy loss in carbonization) and high impact on denser forests and woodland formations<br>• Generally medium-high energy conversion efficiency (offsetting some energy loss in the carbonization process)<br>• Relatively low impact on living conditions<br>• impact on household economy (more than fuelwood) |

From a forestry perspective, sustainable charcoal production represents a major challenge. Arnold *et al.* go so far as to say that "perhaps the single most important issue for forestry is that of continuing to try to put the large and growing charcoal production and trading systems that feed large urban markets, on a more sustainable basis" (Arnold *et al*., 2003).

It is essential for forestry to take up the challenge, in collaboration with rural development and energy actors, and find the tools and means to turn threats into opportunities.

## 3.2 URBAN AND PERI-URBAN CONSUMERS OF WOODFUELS

Just as urban and peri-urban areas house a high and diverse concentration of productive sectors, in addition to their obvious residential function, so woodfuel is consumed by an equally varied typology of end users. In developing countries the residential sector is the prime consumer of fuelwood and charcoal, but several other sectors use woodfuels as their sole source of energy or in combination with other fuels and energy sources.

Besides the residential sector, woodfuels are consumed in the agricultural, industrial, trade and services and institutional sectors, as described briefly below (FAO, 2002a). A more extensive listing by productive sector is given in Annex 7.

In the *residential sector*, urban and peri-urban households use fuelwood and charcoal mainly or exclusively for their own needs – cooking, boiling water, heating, laundering and preparing livestock feed. The main distinctions between rural and (peri-)urban households are that the latter purchase the woodfuels they need, rather than directly collecting or producing them, and that in the urban context there is a relatively higher consumption of charcoal.

In the *agricultural sector*, i.e. peri-urban and urban agriculture, charcoal or fuelwood may be used for heating greenhouses and poultry sheds.

In the *industrial sector,* woodfuels are used for processing raw materials. Examples of industrial activities using woodfuels are charcoal plants and brick and tile works; and for coffee drying and roasting, bakeries, sugar mills and fish smoking.

In the *trade and services sector,* woodfuels are used for a variety of commercial activities that are engaged in buying and selling goods or providing services, such as bakeries, hotels, restaurants and laundries.

In the *institutional sector,* users include educational establishments, hospitals and police and military establishments that rely on woodfuels for heating, cooking, laundering, etc.

## 3.3 THE CHARCOAL ISSUE

The many aspects of charcoal production, trade and consumption in Africa have been the subject of detailed field analyses in several recent projects. Of particular interest is the "Charcoal potential in southern Africa" research project (CHAPOSA, 2002), which analysed trends in deforestation and forest depletion in areas supplying three urban centres in sub-Saharan Africa: Lusaka in Zambia, Dar-es-Salaam in the United Republic of Tanzania and Maputo in Mozambique and which contributed to an understanding of the reasons for the "success" of charcoal in African cities.

The following highlights from this research provide an excellent insight into the role of charcoal from a stakeholder perspective, charcoal production systems and the progressive impact of charcoal on forests and woodlands.

### 3.3.1 Stakeholder perspective

These highlights (CHAPOSA, 2002) from the perspective of users, traders and producers help to understand why charcoal is such a successful fuel in the cities of developing countries.

- Retailers have a preference for selling charcoal: "it sells well, it doesn't go rotten and children don't steal it" (Fernandes, 1995, from Maputo market survey in CHAPOSA, 2002).
- People use charcoal in combination with paraffin and, to a lesser extent, electricity and/or gas. When incomes rise, the two latter tend to replace woodfuels but not completely; if the cost of modern fuels rises, the charcoal share in the domestic energy mix increases.
- Fuelwood is typically a fuel of the poor. It is used by extended families in the poorer income strata. Charcoal is also used by relatively large households but can be found among the higher income classes as well.
- The system for producing, transporting and marketing charcoal employs large numbers; it is widely operated as a market system with limited interference from the authorities.
- Charcoal production has become one of the main sources of income for poor people in rural areas; in production areas this income can be more important than that from other sources such as agriculture.
- It is mostly men who are engaged in charcoal production.
- Charcoal production is (or could become) a means to reduce poverty among rural people, on their own and without external support.
- It is also a means of improving the conditions of the urban poor, by providing a reliable, convenient and accessible source of energy for cooking at all times and at a surprisingly stable cost. The study has shown that charcoal prices (in "real" terms) have been stable over at least the last ten years.
- The charcoal trade provides income opportunities for many people in urban areas, through small-scale retail businesses (Figure 9), where women are predominantly employed.
- Electricity infrastructure is insufficient and unreliable, petroleum fuel prices fluctuate widely because of changes on the world market and in domestic policies. The indigenous renewable woodfuels prevail.

FIGURE 9
**Bags of charcoal for sale in Bangui, Central African Republic** (Photo: Salbitano)

### 3.3.2 Charcoal production systems

As regards the main features of charcoal production systems, the CHAPOSA project highlighted the following aspects.

- The charcoal production system manifests several traits of a free market system. This ought to ensure that resources are put to best use.
- Many actors work the system, more or less independently of each other.
- Information on market features is essentially free and the entrance fee to the market is affordable even for the poor. It usually constitutes personal labour.
- The exception to the above is in the transportation sector, especially for long-distance transport, where vehicles, roads and fuel are needed. Yet the profit level in charcoal transportation is not very high, as evidenced by the use of old and dilapidated vehicles.
- The end result is a widespread consumer product.
- Basic resources for the whole production system are trees in forests and woodlands (unlike fuelwood supply sources that include trees outside forests, wood industry residues, etc.).
- Net present value calculations of the basic resource shows that it is perfectly rational to cut trees for charcoal production under existing forest resource regimes, rather than saving them for other future uses or expending money and labour on management for higher-quality wood.
- At present, the whole value of the wood resource is the commercial value it can attain at harvesting. This value is limited in terms of charcoal (a mature tree yields about five bags of charcoal which, at the producer stage, is US$15–20 in monetary terms). Obviously there is no interest rate so low that this value would be positive in a net present value calculation over the 30 to 50 years it takes a tree to mature. This implies that market forces work only towards felling trees, not protecting them.
- There should be other than commercial values ascribed to wood resources, which necessitates an authority to uphold them. The government could be such an authority, especially since in all three countries investigated in Africa (United Republic of Tanzania, Zambia and Mozambique), the state owns substantial parts of (or all) forest resources. However, in all cases, the government is a poor owner of wood resources. Even if policies exist to protect forests for certain reasons, resources assigned to enforcing these policies are woefully inadequate.
- Even the role of management that directly yields income to the treasury is inadequate, and the rules and regulations are complicated and less than transparent. Thus, in the Maputo area it was estimated that only about 1 percent of fees and licences was actually collected for the woodfuel sector. In Zambia the estimate was about 10 percent and in the United Republic of Tanzania 25 percent.
- Forests are almost like an open access resource. Those who cut the forest reap the rewards and care little for future users (or rightful owners). This is in spite of state ownership of the forest resource and instated rules and regulations. The state is usually ill equipped to bear the responsibilities of an owner and to enforce the rules of government.
- However, if the situation has not developed into total resource depletion in favour of investors' profit it is because protection and production policies do have some effect. The risk of policy enforcement, more than actual enforcement, obviously inhibits larger investments for a more rapid and efficient exploitation of the resource.
- The charcoal industry remains dispersed and ill developed; little capital is channelled towards it. Those entering the industry do so with little more than their own labour as input. This attracts poor people in search of a means to make a living.
- The ultimate effect is that a source of income is created for many poor people in rural areas, contributing to the provision of an essential commodity for the poor in urban areas: an affordable, convenient and accessible energy source at relatively stable prices.

## 3.4 IMPACTS OF URBAN WOOD ENERGY

The impacts of urban wood energy practices are effective at multiple levels. The first is the impact at *ecosystem level*, both urban and forest/rural, where wood resources are found. Here, the impacts generated by wood energy supply/consumption depend on i) the size and population of cities; ii) their energy and land policies; iii) the traditional and changing lifestyles; iv) the existing or forecasted price policies; v) the security of energy supply; and vi) the character of the urban, peri-urban and rural/forest landscape. The combination of these factors determines the amplitude, recurrence and timing of impacts at the ecosystem level. A second level concerns the *socio-economic* implications of wood energy production, trade and use as compared with other energy. These include impacts on the economy of rural communities involved in woodfuel production; on urban and peri-urban dwellers involved in transportation and trade; on health problems and air-quality characteristics, both indoor and outdoor, linked to conversion technologies; and other economic and behavioural aspects.

Another way of looking at the potential and/or real impacts of urban wood energy practices is to define aspects directly impacting ecosystems and societies (*directly* linked to the wood energy chain, such as the degradation of forest ecosystems or the pollution effects of charcoal and woodfuel burning in low-efficiency stoves) or *indirectly* affecting, in time and space, urban and rural dimensions, such as the land use changes induced by recurrent exploitation of wood resources and the impact on personal development because of the time spent in gathering fuelwood.

Impacts can also be classified as *positive* and *negative*. The *positive* impacts are income and employment generation for decentralized communities and for poor farmers between crops; the creation of rural markets and induction of sustainable production (and management) systems to guarantee continuation of benefits; and affordable subsistence energy for the urban, peri-urban and rural poor. The *negative* impacts are low and uncertain incomes and resource depletion determined by undefined land tenure and exploitation rights; overexploitation resulting from marked inequality in revenue distribution because of the fragmentation of actors and a lack of clear supply agreements especially affecting the poorest link in the chain; unstable markets and low security in resource exploitation; erosion of tree/forest cover through wood energy crises; energy shortages; and bad or no management applied to tree/forest resources.

### 3.4.1 Impacts on urban and peri-urban ecosystems

The term *ecosystem* applied in the urban context generated a fairly heated debate over the last decades in relation to the fact that a city cannot be considered a real ecosystem, according to ecological theories and practice; the population of the biocoenosis of a city or metropolitan region has very little chance of being self-sufficient in terms of food and energy. This consideration leads to the assumption that, even if the concept of ecosystem in the urban dimension is accepted, it has to be looked at as a fragile and relatively unstable system in space and time. Energy, particularly wood energy, is together with food the best example of this fragility.

The direct impacts of woodfuel production on urban/peri-urban ecosystems are constrained by the obvious fact that tree and forest resources are often scarce in and around cities. Nonetheless, the chopping of branches and even entire trees for fuelwood is a common sight along city roads in many poor countries (Figure 10A, B). This direct exploitation of urban trees and forests may increase considerably whenever the shortage of energy supply becomes dramatic (Box 6).

BOX 6
**Case study: Sarajevo urban forest**

"Global ReLeaf Sarajevo" is the first project of the "Plant It Green" programme in partnership with American Forests. Global ReLeaf Sarajevo is a tree-planting initiative to help restore the war-devastated urban forests of the host city of the 1984 Winter Olympics. During the four-year siege of Sarajevo, residents cut trees for heating and cooking fuel, and consequently deforested the hillsides. The devastation of the urban forests created a major risk of landslides. Debbie Armstrong, gold medallist at the 1984 Winter Olympics, has joined the effort to help Sarajevo to restore its urban forests.

FIGURE 10
**Fuelwood production from urban trees**
A. Heavy tree pruning for fuelwood in Bangui, Central African Republic (*Photo*: Salbitano) B. Fuelwood bundle from city trees (*Photo*: Salbitano)

### 3.4.2 Impacts on rural and forest ecosystems

Charcoal and fuelwood are frequently secondary products of various land uses and forestry regimes, rather than their primary objectives. Similarly, they tend to be the by-products of deforestation and land use changes rather than the direct cause, although charcoal production, for example, may sometimes be a direct cause of degradation (Pancel, 1993). Fuelwood, in particular, is a secondary product of timber harvesting, shifting cultivation processes, orchard and farm tree management, etc.

In many cases, among a multiplicity of factors with an established result, such as a permanent loss of forest cover, it is difficult to point out with precision a single cause or quantify the contribution of a single factor. Logging roads (or simply new access to forest areas), new settlements, the demand for new farmland and woodfuel needs are often concomitant causes in the process of forest depletion.

It is now generally accepted that woodfuel extraction is less destructive than had been assumed in the 1980s and early 1990s (Arnold *et al*., 2003) and far less responsible for forest depletion than agricultural expansion. It is also true, however, that unsustainable charcoal production for urban markets, which is fairly frequent, has a much greater impact on forests and woodlands than fuelwood collection (Arnold *et al*., 2003).

Under normal conditions, forest clearings for charcoal production revert to secondary forest as a result of coppice growth and regeneration but intense production may lead to forest degradation and, where there is high population pressure, indirectly to permanent deforestation. As stated in the final report of the “Charcoal potential in southern Africa” project (CHAPOSA, 2002), charcoal production in forests and woodland has several ecological implications, depending on the intensity and intervals of the exploitation but permanent impacts, such as loss of tree and shrub cover, are usually a result of agricultural expansion following charcoal production. Research carried out in the United Republic of Tanzania, Zambia and Mozambique highlighted the following progressive impacts and phases.

- Initially, there is a depletion of mature trees favoured for charcoal production. As these species become scarce, less favoured trees are used.
- When no mature trees remain, charcoal production can no longer be sustained. The fate of the area will depend on external factors.

- If the population has increased in the area, some of the previous woodland will be used for cultivation; if this is shifting cultivation, the land will eventually be abandoned and left to regenerate as shrubland or woodland; if the cultivation is permanent, stumps will be cleared and the land will remain cleared indefinitely. The same will occur if the land is used for heavy grazing.

- In areas where the land cleared for charcoal production is abandoned, regeneration takes place, initially mostly from coppice, since charcoal producers generally leave the stumps of trees felled. Hence the species composition will remain essentially similar to composition before charcoal production.
  - However, under heavy pressure for charcoal production, regrowth is again cut before the trees reach maturity.
  - Under a sustainable management regime, regeneration can be improved by fire control (early burning), selective cutting of non-viable coppice and protection from grazing.

Results of the land cover change analysis carried out by the CHAPOSA project around Dar-es-Salaam provided evidence of considerable degradation in the region as a result of charcoal production. For a significant fraction of closed and open woodlands around the city the change observed between 1991 and 1998 was so intense that it qualified as “deforestation” (change to bushland or grassland) even in the absence of agricultural activities. The report itself, however, considered that in the majority of cases the permanent impact of deforestation was primarily a result of increasing demand for cropland while the most frequent impact of charcoal production was degradation with loss of tree density and of charcoal-suitable species, particularly along roads.

### 3.4.3 Impacts on urban and peri-urban dwellers

The rapid growth of urban populations and the concentration of woodfuel use in the urban context cause a series of impacts, both negative and positive, on the health, well-being and economic and social aspects of urban dwellers.

#### *Negative impacts*

Dense agglomeration and intensive housing imply a significant increase in emissions for energy needs. The use of woodfuels determines changes in the urban environment with potential effects on human health. Especially in the poverty context, where the technologies applied to woodfuel use are low, the increase in emissions is massive, together with derived smoke and high particulate matter. This can give rise to a range of human pathologies, from respiratory diseases to cancer.

Overexploitation for wood energy production alters the quality of *urbanscapes*. Reducing or exhausting the urban and peri-urban tree cover modifies the microclimate, particularly solar radiation, relative humidity and particulate absorption. Such changes can indirectly cause health and well-being problems. The reduction (or absence) of tree cover also means a decrease in the potential for outdoor activities, both leisure (sport, recreation, etc.) and economic (trade, open-air markets) and is therefore an indirect cause of deterioration in living conditions.

Whenever the sources of wood biomass are depleted, a negative effect will be an uncertain or insufficient subsistence energy supply.

The prevailing use of wood energy requires more room for storage at retailer and domestic levels as compared with other energy sources such as gas and electricity.

#### *Positive impacts*

The use of wood energy is intimately linked to popular tradition and culture. Wood and charcoal are visible and tangible materials, part of the daily life and landscape of many places in the world (Figure 11).

Woodfuels impact on cultural identity by being part of the traditional way of cooking in most developing countries; they are always on the market even when other energy sources are available. Their familiarity gives urban dwellers a sense of belonging, with no dependency on external forces.

Woodfuels are an essential commodity for poor people in urban areas since they represent convenient and accessible sources of energy at affordable and relatively stable prices.

The woodfuel chain supports a wide range of income-generating activities with a low initial investment. Wood energy systems have a positive impact on diffused employment in and around cities. Of all energy sources, woodfuels have the highest employment rate per released unit of energy.

Woodfuels are safe energy options in comparison with insufficient and unreliable electricity or fluctuations of oil prices on the world market.

FIGURE 11
**Fuelwood and schoolchildren in Bangui, Central African Republic, where wood energy systems are an integral part of daily life and culture** (Photo: Salbitano)

### 3.4.4 Impacts on rural and forest communities

There are a considerable number of people involved in one way or another in the chain of activities that constitutes urban wood energy systems. Together with the traders, retailers and transporters in urban and peri-urban areas, there are even more rural and forest dwellers involved, albeit sometimes temporarily, in fuelwood collection and charcoal production. For "decentralized" people living on the periphery of the urban woodshed, woodfuel production is the main source of income or, as in the case of many poor farmers, it is an important addition to their primary agricultural revenue.

#### *Negative impacts*

Among the serious negative social and economic impacts of unregulated fuelwood extraction and charcoal production are the degradation and loss of communal resources through overexploitation of forests and woodlands traditionally under customary laws. This is the effect of uncertain land tenure and ambiguous rights of exploitation of forests and woodlands by rural and forest communities. The situation not only prevents the development of long-term benefits and sustainable production for villagers but also facilitates the dealings of unscrupulous traders who are interested only in fast profits and can impose low wages. Under these conditions unregulated fuelwood and charcoal production may lead to:

- degradation of the village environment and the loss of woodfuel resources for villagers' own use;
- a massive transfer of wealth from rural communities to a few urban-based traders;
- inequitable revenue distribution among producers and traders;
- traders operating in quasi-monopolistic conditions and unilaterally deciding upon exploitation sites on a short-term profit basis;
- increased levels of corruption;
- impoverishment of rural areas;
- an acceleration of the rural exodus.

#### *Positive impacts and opportunities*

As discussed above, it is evident that urban woodfuel demand must be taken extremely seriously by city planners as well as by forestry, agriculture, rural development and energy agencies in view of its many social, economic and environmental implications. There are solutions whereby negative impacts can be mitigated and opportunities exploited in support of sustainable development. Key factors are clear land

tenure and exploitation rights, participatory approaches and sustainable resource management.

Senegal's Sustainable and Participatory Energy Management (PROGEDE) project (1997–2004), supported by the World Bank and the Government of the Netherlands, is one such positive case. On the supply side, the project focused on the implementation and monitoring of 300 000 ha of environmentally sustainable community-managed forest resource systems in the Tambacounda and Kolda regions of Senegal. It also dealt with important practical issues regarding woodfuel demand, capacity building and institutional strengthening of institutions.

Box 7 gives a summary of important lessons learned from the PROGEDE project and its achievements that are also relevant and promising for other countries facing similar problems.

BOX 7
**PROGEDE project**

**Lessons learned**

- Production and marketing of biomass fuels can not only be stabilized and made sustainable, while arresting deforestation and contributing to ecological conservation, but can become a highly effective social and economic rural development strategy.
- While demand management is important and needs to be pursued – especially through dissemination of improved end-use technologies and practices – this alone cannot resolve existing problems. It is an element of particular relevance, in view of the considerable distance between urban demand and production sites.
- The establishment of environmentally and socially sustainable woodfuel supply systems can only be achieved through the introduction of integrated community-based forestry and natural resources management schemes. Governments generally lack the financial and human resources and the incentive to do this, while the private sector is not interested because of the long payback period, inherent risks and low profit margins.
- A minimum policy platform is therefore required, which should include i) clear and legally enforceable forest resource and land tenure rights and responsibilities; ii) a transparent decentralized fiscal and taxation system; iii) a clear and fair pricing system; and iv) guaranteed access for woodfuel producers to final consumer markets.
- Investments in women's activities (rural vegetable gardens, microcredit, etc.) result in the most significant and tangible poverty alleviation, especially in terms of health, nutrition and education of the beneficiary population, particularly children.

**Achievements of particular relevance**

- ✓ Sustainable community-managed forest systems were established over an area of 378 161 ha.
- ✓ Rural communities and NGOs in project regions implemented participatory management modules and produced and marketed woodfuels and other potential wood and multiple non-wood products.
- ✓ Community-based microenterprises were established, including beneficiary-operated improved carbonization units, apiculture cooperatives, collective (women) and individual agricultural/livestock diversification units/systems.
- ✓ A sustainable income-generating base (wood and non-wood products) was established.
- ✓ Some 20 percent of Senegal's current energy supplies are now derived effectively from renewable resources.
- ✓ The urban charcoal trade was reorganized and modernized to establish long-term supply agreements (contracts) between rural communities and urban traders.
- ✓ Existing charcoal traders were helped to diversify their economic activities.
- ✓ Interfuel (kerosene and LPG) substitutions were supported as was the distribution of improved stoves by the private sector and the NGO community.
- ✓ A permanent energy sector digital database and information system were established.
- ✓ Urban and peri-urban "energy boutiques" were designed and established.
- ✓ The Forest Service was transformed into a technical assistance and capacity development agency with a participatory vocation and significantly improved governance.
- ✓ Traditional social institutions and their natural management resource roles and responsibilities were revitalized and strengthened, as were women's groups and associations.
- ✓ Charcoal traders within the project zone went from being "enemies" of the rural communities to becoming actual commercial partners – legal contracts helped make this change.

*Source*: World Bank, 2006 (based on World Bank, 2005).

## 3.5 URBAN DEMAND AND RURAL SUPPLY: EVOLVING SPATIAL AND SOCIO-ECONOMIC INTERACTION

### 3.5.1 Expanding supply zones

From the geographic angle, it is evident that the area of woodfuel demand by cities in developing countries is growing rapidly. Urban woodsheds tend to include vast portions of the national territory, as a result of increasing demand arising from the combination of urbanization and poverty and reduced resources because of land use changes and overexploitation. Woodfuel supply areas may be far from cities, especially in the case of charcoal, which may be produced several hundred kilometres away from consumption sites (such as in Dakar, whose charcoal supply sources are at the opposite side of Senegal, in Casamance).

Furthermore, it is important to remember that woodfuel supply areas are often degraded, especially woodlands and forests exploited for charcoal production. These processes of degradation are the result of overexploitation and short rotation periods that do not allow enough time to recreate the original stocking level, together with changes in land use resulting primarily from the growing need for farmland and pastures. Consequently, actual supply areas are often insufficient and "nominal" supply areas in sustainable regimes need to be larger than current ones.

When analysing urban woodshed areas and their spatial evolution over time following urban demand projections, it is vital to consider *actual* supply zones and the impact upon them, as well as to delineate the *nominal* or *potential* sustainable supply zones. In turn, knowledge about the availability, or otherwise, of potential sustainable supply areas should influence development policies and priorities in urban forestry and energy.

### 3.5.2 The socio-economic chain

In socio-economic terms, the urban woodshed includes several categories of consumers, extended chains of producers, traders and retailers who represent a fundamental dimension of wood energy systems. Fuelwood and charcoal production, trading and commercialization provide employment, both temporary and permanent, and income for a large number of people often located outside urban areas.

Among other conventional and renewable energy options, bioenergy is the most labour-intensive technology and has the highest employment-creation potential in both developing and industrialized countries (IEA Bioenergy, 2005). This is particularly true for wood energy systems in developing countries and their high employment rates, as compared with other energy systems, as shown in Table 3, which gives an estimation of local employment potential of different household fuels per standard unit of consumed energy (FAO, 2003c). The values in Table 3 resulted from estimates of local employment from the production and distribution of different fuels, taken from studies undertaken in developing countries (UNDP/WB-ESMAP, 1992). Of the various household fuels, fuelwood and charcoal production and trade provide the greatest employment per standard unit of energy consumed, and petroleum fuels have the least effect on employment.

Applying standard fuelwood and charcoal conversion factors (Annex 1) to the employment rates of Table 3, employment rates per tonne of woody biomass (oven dry) for fuelwood and for charcoal have comparable values, with average values of 2.7 and 2.3 workdays, respectively. These values are indicative only and subject to major local variations but they are useful in defining the order of magnitude of the employment potential of wood energy systems.

Given the concentrated and increasing demand for woodfuels, particularly charcoal, by large cities in developing countries, it is easy to imagine the growing amount of people outside the cities dependent on this resource for their livelihood.

Town administrators, planners and policy-makers need to be aware of this dependence and its environmental and socio-economic interactions. Growing cities have responsibilities for the management of resources exploited for their needs and for those communities that depend upon them. Urban forestry can play an essential bridging role in this respect by assisting in the definition and mapping of urban woodsheds and the associated geography of stakeholders.

In order to act in response to this expanded responsibility town planners and policy-makers must be informed about these environmental and socio-economic interactions and urban forestry can play an

essential bridging role in this respect by assisting in the definition and mapping of urban woodsheds and the associated geography of stakeholders.

TABLE 3
**Estimated local employment potential of different household fuels per standard unit of energy consumed** (UNDP/WB-ESMAP, 1992)

| Fuel type | Amount of fuel per TJ | Employment per TJ energy in workdays[1] |
|---|---|---|
| Kerosene[2] | 29 kl | 10 |
| LPG | 22 $m^3$ | 10–20 |
| Coal[3] | 43 tonnes | 20–40 |
| Electricity[4] | 228 MWh | 80–110 |
| Fuelwood[5] | 62 tonnes | 100–170 |
| Charcoal | 33 tonnes | 200–350 |

1 Employment covers growing, extraction, production, transmission, maintenance, distribution and sales, including reading of meters. It excludes employment generated outside the country for fuels that are imported in a semi-finished state.
2 This assumes that crude oil (for refining), kerosene and LPG are imported.
3 This varies according to the capital intensity of the mine, seam thickness, energy value of the coal and distance from demand centres.
4 This varies according to production methods, ranging from hydro to traditional oil/coal-fired units and the efficiency of electricity generation, transmission and distribution.
5 This depends on the productivity of the site, efficiency of producers and distance from markets.

## 3.6 SWOT ANALYSIS OF URBAN WOOD ENERGY

It is evident that urban wood energy is at the crossroads of different sectors (forestry, agriculture, energy, urban and rural development), with an important influence on the environment and the economies of urban and rural areas and communities, and at scales ranging from individual households to national or even international contexts.

In order to see the many aspects that characterize urban wood energy and its environmental and socio-economic influence in urban and rural contexts, an analysis of strengths, weaknesses, opportunities and threats (SWOT) is given in Table 4.

TABLE 4
**SWOT analysis of urban wood energy systems**

| | URBAN- PERI-URBAN context | | | | RURAL context | | | |
|---|---|---|---|---|---|---|---|---|
| | **Strengths** | **Weaknesses** | **Opportunities** | **Threats** | **Strengths** | **Weaknesses** | **Opportunities** | **Threats** |
| **General** | Expertise and methodologies in (urban) forestry, energy and agriculture sectors are adequate to cope with wood energy system | Information on the entire chain from production to final users is weak | Integration of (urban) forestry, energy, agriculture and political will can improve urban and rural environments and quality of life through sound intersectoral policies and actions | The lack or absence of information may be an impediment to the understanding and formulation of sound policies | Expertise and methodologies in (urban) forestry, energy and agriculture sectors are adequate to cope with wood energy system | Information on the entire chain from production to final users is weak | Integration of (urban) forestry, energy, agriculture and political will can improve urban and rural environments and quality of life through sound intersectoral policies and actions | The lack or absence of information may be an impediment to the understanding and formulation of sound policies |
| **Environ-mental** | Biomass is a renewable resource<br>Integration with other benefits and services (multipurpose land management)<br>Landscape restoration/ improvement<br>Quality of air, water and soil<br>Substitution of non-renewable fuels<br>Improve urban ecosystem<br>Increased biodiversity in urban environment | Emissions with low technologies<br>Smoke and high particulate matter<br>Storage space at domestic and retailer level | Lower emissions with more efficient technologies<br>Evolution to bioenergy<br>Substitution of non-renewable fuels<br>Improvement, in the long term, of urban environment<br>Increase in urban forestry activities can encourage a comprehensive and participatory management of urban environment | Degradation and depletion of urban/peri-urban trees because of increasing energy needs by urban poor<br>Land degradation through inappropriate techniques<br>Inadequate institutional capacity and political recognition may cause unsustainable management and environmental degradation<br>Floods/landslides caused by deforestation, degradation of watersheds, etc. | Valorization of marginal forests and forest residues<br>Maintenance of forest cover (through sustainable forestry techniques)<br>Maintenance of water resources | Forest and land degradation through inappropriate techniques<br>Rapid increase in charcoal demand and derived profit opportunity encourages unsustainable “mining” of forest/woodlands | Promotion of a sustainable forest management<br>Enhanced profitability of sustainable forestry<br>Community forestry and participation enhance sustainability<br>Increase in charcoal demand requires and encourages a stronger approach to comprehensive and participatory forest management | Irreversible forest/land degradation, desertification,<br>Increase in charcoal demand (compared with fuelwood) puts higher pressure on forest resources<br>Inadequate institutional capacity and political recognition may cause unsustainable management and forest depletion<br>Floods/landslides caused by deforestation, degradation of watersheds, etc. |

(*continued*)

| | URBAN – PERI-URBAN context | | | | RURAL context | | | |
|---|---|---|---|---|---|---|---|---|
| | **Strengths** | **Weaknesses** | **Opportunities** | **Threats** | **Strengths** | **Weaknesses** | **Opportunities** | **Threats** |
| Socio-economic | Lower dependency on external fuel market<br>Energy security<br>Reduction of external bills<br>Local and regional employment chain<br>High employment rate<br>Commodity appreciated by retailers and users (charcoal)<br>Integration with alternative energy sources<br>Stable economic value (charcoal)<br>Women retailers<br>Affordable entrance to woodfuel business chain<br>Widespread demand<br>Adequate planning and decision-making guarantee suitability for creation of community-based microenterprises<br>Urban (community) forestry and participation enhance sustainability | Use of fuelwood considered an indicator of poverty in terms of social status<br>Limited use (cooking and heating) as energy resource with traditional technologies<br>Price of land for activities of small urban forest producers<br>Lack of knowledge and scarce silvicultural techniques<br>Urban forest and wood energy are neglected sectors at the political level and not part of the agenda of national/international energy/environment agencies | Expanded uses as energy resource with improved technologies<br>Involvement of small urban forestry producers and stakeholders enhances the sense of belonging<br>Increased energy security because of lower dependence from imported fuels<br>Reduction of foreign bills and debt | Inadequate institutional capacity and political recognition may generate social inequality, illegality and corruption<br>Rapid increase in land value in peri-urban areas may threaten urban forestry projects that need medium-/long-term investment | Option for combating poverty in rural areas<br>High employment rate<br>Refuge source of revenue in agricultural crisis period<br>Suitable for creating community-based microenterprises<br>Community forestry and participation enhance sustainability | Transport dependent<br>Inequality of added income among those involved, from producers to retailers, in the absence of pricing policies and with an uncontrolled market<br>Market forces work only towards felling trees and not protecting them, because of low product output<br>Rapid increase in charcoal demand and derived profit opportunities lead to depletion of communal resources benefiting urban operators but impoverishing rural communities | Creation of small producers' cooperatives<br>Establishment of long-term supply agreements between rural communities and urban traders | Disproportionate transfer of wealth from rural communities to few urban traders<br>Impoverishment of rural communities in the absence of policies, regulations, participation<br>Acceleration of rural exodus<br>Increasing urbanization caused by the impoverishment of rural/forest communities whose communal resources have been depleted<br>Inadequate institutional capacity and political recognition may engender social inequality, illegality and corruption |