8

Fuelwood Problems and Solutions

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Concern over the "fuelwood crisis" facing the world's poor has been widespread since the late 1970s (Eckholm et al. 1984; Soussan 1988; Agarwal 1986). At first the problem was frequently overstated. In the extreme, analysts (foresters, economists, and others) in many countries made erroneous projections of the rapid total destruction of the biomass resource. These projections were usually based on simplistic supply and demand analysis, the so-called gap analysis that was highly influential throughout most of the 1980s (Leach and Mearns 1988). These projections often led to projects that sought to boost fuelwood supplies without regard to local needs, priorities, or resource potentials-or to the economic viability of the plans.

Fuelwood problems are now recognized as rarely generalizable. Fuelwood use and scarcity reflect complex and variable interactions between local production systems and the environmental resources on which they are based. The significance and origins of fuelwood problems in, for example, a semiarid area such as parts of the Sahel are very different from those in a mountainous region such as Nepal or a high-density/high-productivity area such as the Kenyan highlands. A further sharp distinction is evident between rural localities (where fuelwood is usually a free good gathered locally) and urban areas (where fuelwood is a commodity produced elsewhere).

Fuelwood problems have complex causes and take varied forms. In rural areas these problems reflect changes to economic and environmental relationships that affect local supply and demand (Armitage and Schramm 1989). These changes can be gradual, such as erosion of local woodlands as a result of land colonization, increased herd sizes in semiarid regions, increased exports of fuelwood to meet growing urban demands, or lower quantities of residues available as fuel as a result of changing agricultural practices. In some cases the changes can be sudden and catastrophic: for example, large-scale deforestation associated with giant development schemes; mass influxes of refugees; and environmental collapse associated with droughts, floods, or other extreme climatic events. Whether gradual or rapid, these changes lie at the heart of fuelwood problems and set clear limits on the opportunities open to confront the problems effectively.

This chapter first analyzes the nature and origins of fuelwood problems and past policy approaches to solving them. The analysis focuses on the relationship of fuelwood problems to other development issues and on the various forms the problems take under different environmental and economic conditions. Fuelwood problems are viewed primarily as one consequence of the interaction of environmental and economic forces at the local level, which result in a number of resource stresses. We then suggest an approach to formulation and reform of fuelwood policy based on this analysis. The annex to this chapter presents a typology of specific fuelwood situations. Just as there is no one fuelwood problem, there are many potential solutions. The key is to identify what will work where and why.

THE NATURE OF FUELWOOD PROBLEMS

Use of Fuelwood in Rural and Urban Areas

Use of fuelwood in the growing cities of the third world contrasts sharply with the more familiar patterns of rural areas. Despite the growth of energy use in other sectors, rural household consumption still dominates the energy budgets of many developing countries, particularly in the poorer nations of Africa and South Asia. Fuelwood accounts for more than 75 percent of the energy used in countries such as Nepal, Bangladesh, Ethiopia, Burkina Faso, and even oil-rich Nigeria (Soussan 1988). Cooking consumes most of this energy, and most of the energy is supplied by biomass fuels (agricultural residues as well as fuelwood). These fuels are usually gathered freely from the local environment, and their production and use cannot be readily separated from other aspects of land resource management within rural economies. Because rural people rarely fell trees for fuel use and generally depend on trees near their homes, trees outside the forest, within the agricultural landscape, are the main source of fuel for rural people. The reliance on local land resources means that tenurial arrangements are important.

The poor often have few alternatives to fuelwood to meet their basic subsistence need, and problems associated with access to fuelwood can be considered an integral part of the wider rural development crisis. Whatever happens to energy resources and prices at an international level, rural fuelwood use will be important for the foreseeable future. This essential fact must be used as a starting point for the development of policies to deal with rural fuelwood problems.

As urbanization proceeds, the effects of urban fuelwood use and the problems associated with it are growing rapidly (Soussan et al. 1990b; Floor 1987). As in rural areas, most fuelwood in cities is used in the household sector (although the use of fuelwood in small industries such as restaurants, bakeries, and brick kilns can be significant locally). The concept of an energy transition, however, is central to any understanding of household energy in urban areas. As urbanization proceeds and the use of fuel increases, people tend to diversify and switch from wood and charcoal to modern fuels. The stages in this transition are typically not discrete; it is common to find within a household several fuels used for cooking. Recent studies (Leach and Mearns 1988) suggest that even in cities where fuelwood is more expensive than the modern alternatives, people prefer fuelwood because the supply is more secure; the fuelwood is available in small, affordable quantities in local markets; and fuelwood requires no expensive initial investment in cooking stoves. Therefore, to understand urban fuelwood problems, it is essential to understand the structure of urban fuel markets.

The cost of fuelwood to urban consumers (especially the poor) can be significant, and there is some (though patchy) evidence that in many places the cost is increasing. A more general problem is access to fuel (ETC 1987). Markets for many nonwood fuels are typically poorly developed, particularly in peripheral neighborhoods where many poor people live. Governments often restrict imports and the internal distribution of commercial fuels. This situation contrasts markedly with fuelwood markets, which usually reach all corners of the city.

Demand for urban fuelwood and charcoal can have a devastating impact on the rural areas from which supplies are drawn because urban dealers often clear fell woodland areas and make no attempt to conserve the resource base. In effect, they mine the resources and pay only the extraction costs for them.

The problems associated with fuelwood use must be dealt with in the context of the control and management of land resource systems. Some of these complexities are discussed in the next two sections.

Access and Alternative Uses

The existence of fuelwood resources in a locality is not enough to guarantee that no one experiences fuelwood problems; the resources must be available for use by all who need them. A series of factors that limit access to wood resources have been identified as limitations imposed by the location of the resources in relation to demand, by land tenure and ownership of biomass resources, and by the way in which biomass resources are managed (ETC 1987; Johnson and Tomkins 1989).

The locational limitations on access reflect features of the landscape. Most important is the distance between the sources of supply and the point of use. In many localities biomass fuels are gathered freely from the environment, and the main cost of fuelwood use is the time to collect the fuel

(Agarwal 1986). Resources beyond a certain distance will take too long to collect. The time required to collect fuels is also influenced by features of the terrain such as hills, rivers, and gullies. Steep slopes, rugged terrain, and watercourses add significantly to the collection time. Locational constraints on access can be calculated in relation to the benefits accrued for the time and effort taken. Whether people are willing to pay this price depends on the available alternatives to wood, the users' income, and the opportunity cost of the collectors' labor time.

A series of access constraints also derive from the legal status of land in an area. The availability of biomass resources inevitably depends on their ownership, which is a function of the ownership of the land on which they grow. Three broad categories of land tenure can be identified for our purposes:

1. Land that is owned individually by members of the local community-basically, private farmland;

2. Land that is owned by the state, large commercial producers, or other institutions controlled from outside the area-plantations, commercial farms, state forests, and the like; and

3. "Common" land resources that are legally owned by the state or through customary communal forms but having no proprietorial restrictions on access to them-open rangelands and woodlands, hillsides, grazing lands, and so on.

Biomass resources (both residues and trees on farms) from private farmland are the main source of fuel in many rural areas. Households with little or no land may face severe restrictions on access to fuels even if there appears to be a local surplus. In many cases, land-poor and landless families have traditional rights to collect fuels from the land of larger land owners, but such rights may be eroded when biomass resources are under stress or become commercialized. Rural change, which is marked by greater commercialization, new technologies that reduce tree coverage and residue production, and higher population densities in many areas, has aggravated the inequalities of access to private biomass resources.

Access to wood from large-scale commercial farms and plantations is frequently highly restricted or prohibited altogether. Some limited collection rights may be allowed and illegal removal is common, but if the managers of these resources use them for fuel (for example, for crop processing) or sell them (for fuel, timber, pulp, or other uses), access is limited by the policing action the managers take. This category of land may contain a significant proportion of the biomass resources of a locality, and even if limited collection is allowed, these resources may be alienated from the effective control of local people.

Access to biomass resources on communal land is the most complex of all. A range of traditional customs and practices may regulate access to these resources, but these customs tend to break down as local economies change and resource pressures increase (e.g., when outside groups, such as urban wood dealers, exploit the resources). In many areas the amount of communal land is rapidly declining, as woodlands and rangelands are cleared and enclosed for agricultural production. In these areas the lack of limitations on access can result in the unsustainable exploitation of what are often vital but fragile resources.

The final category of access factors consists of those associated with the system of biomass resource management, which reflects the prevailing social structure, resource management and harvesting techniques, nonfuel uses of different categories of biomass resources, and the rights and obligations of different sections of the community. Depending on their gender, class, and age, people typically have very different approaches to the control and use of biomass resources. Fuel provision is frequently the women's responsibility, whereas the men control the resources (especially land and cash) from which the fuel comes. Any attempt to deal with fuelwood problems must take this division of rights and obligations into account.

Women and Fuelwoods

Collecting fuelwood is physically hard and time-consuming work, an arduous burden on women who typically are also responsible for collecting water, caring for children, doing agricultural work, and handling the myriad other tasks that make up the day of third-world women. As pressures on the local resource base develop, the distances traveled, collection times, and other demands on women also increase. In addition, because fuelwoods are smokier and dirtier than modern fuels, women's health may be impaired by fuelwood use. When fuel shortages lead to changes in the number or type of meals cooked, women (who, even in the absence of fuelwood shortage, eat less well then men) often disproportionately suffer negative nutritional consequences. In these and other ways, fuelwood stress hits the health and environment of women harder than those of men in many parts of the third world.

Given their central role in fuelwood provision and use, women will often best understand where and in what form fuelwood problems are found, what interventions are more likely to succeed, and which groups in the community should be involved in designing and implementing interventions. Therefore the sometimes vague notion of community participation must be structured to identify and create situations and institutions within which women can play a central role in building and implementing fuelwood solutions. Giving women such a role implies challenging or circumventing the social and institutional barriers that limit the scope for integrating women in the planning process. Needless to say, this task will be difficult in most communities where men control the resources (especially land and cash) needed to confront fuelwood stress. Furthermore, men typically dominate local institutions that regulate resource management, provide links to the outside world, and perpetuate gender inequalities. This situation creates particularly difficult problems because the local land, finance, and institutions are obviously the resources that need to be harnessed to build local solutions to fuelwood stress.

Responses to Fuelwood Stress

Pressures on the biomass resource base are not simply a matter of fuel demand and scarcity; they relate to the control over and the range of uses made of biomass resources. Biomass fuel stress is often a product of the disruption of traditional systems of resource management-disruption that is in turn generated by a number of forces that vary in importance from locality to locality.

One of the first responses to fuelwood stress is more careful fire management, which can result in dramatic fuel savings. This one-time gain, however, is inevitably limited by the laws of thermodynamics. Conservation consciousness takes extra time, but results in desirable and sustainable efficiency gains. Fuel scarcity may also produce changes in cooking practices that are less clearly beneficial. People may turn to enclosed stoves, losing other functions of the fire such as light, heat, and a social focus. They may reduce the number of meals cooked per day or adopt quicker-cooking foods. The dietary implications of these developments are hard to quantify but may be serious.

As biomass resources become scarce, the other, nonfuel uses can be cut back. This may impair other aspects of the production system. For example, increased use of dung as a fuel may reduce soil fertility, and overexploitation of common woodland resources may jeopardize the availability of fodder or construction materials. When resources are abundant, the alternative uses of biomass materials produce no problems, but when resources are scarce, conflicts between alternative needs may emerge. How these conflicts are resolved depends in large part on who controls the resources and who benefits from the alternative uses.

The sorts of resource conflicts outlined here are at their most acute in regions where residues have replaced wood as the main household fuel. When wood is unavailable, people may switch "downward" to crop or animal residues (Barnard and Kristofersen 1985). In many areas, such as Bangladesh, northern India, and Lesotho, residues have long been the dominant household fuel, because wood is far too valuable to burn. Alternatively, people may switch "upward" to nonbiomass fuels such as kerosene and liquefied petroleum gas (LPG). If this switch occurs through choice, it is a good indicator of development, but the switch may occur through necessity, when people have no choice but to spend scarce cash on a basic need.

When pressures on biomass fuels become acute, rights and responsibilities connected to needs provision and resource management may change to reflect emerging scarcities. Often, men begin to assist in fuel provision, either by helping to gather fuel or by providing alternative resources. Landless or land-poor families may find that traditional rights to collect fuel on the land of others are eroded (a particular problem when resources acquire commodity value). Traditional, sustainable management practices of communal land may break down, depleting the resource base and eventually resulting in the loss of the indigenous knowledge on which these practices are based. These and other changes are symptomatic of the erosion of the social fabric of local communities as systems break down under the traumas of resource scarcity.

Finally comes the actual or potential erosion of the land resource base, as conflicts between the different uses and needs of different groups are resolved temporarily by the extraction of biomass materials (not just wood, but fodder, manure, and so on) at a rate greater than the capacity of the local environment to produce these materials. The conflict between the immediate needs for survival and the long-term maintenance of the resource base often produces environmental degradation.

Fuelwood, Deforestation, and Land Degradation

Much of the international concern over tropical forests has centered on the loss of large tracts of natural forest areas. The causes of this deforestation are associated mainly with the drive to open up and exploit what is seen as one of the last great land frontiers. Commercial logging, clearance for large-scale ranching, in-migration as a result of road construction or through government-sponsored transmigration schemes, flooding from giant hydroelectric power schemes, and other development pressures are all widely cited as contributing to large-scale deforestation (Fearnside 1986; Monbiot 1989; Tyler 1990). The exploitation of forests for fuelwood use contributes little to this process. This is especially true for fuelwood gathered to serve the needs of local rural communities, because where there are large tracts of forest, there are usually few people.

Commercial exploitation for urban fuelwood and charcoal markets does have an impact in many regions. Fearnside (1989) cites charcoal production for iron smelting in the Carajas region of Brazil as a threat to the forests of eastern Amazonia; a major study by the Overseas Development Administration (Bird and Shepherd 1988) has shown that the acacia woodlands of the Bay region of Somalia are being devastated by charcoal production for Mogadishu's markets; Bowonder et al. (1987) detail the impact of urban fuelwood use around a number of Indian cities, and Soussan et al. (1990) provide further evidence from a number of sources. Rural fuelwood use is often cited as a factor in large-scale deforestation, but these assertions are rarely substantiated. Indeed, the evidence points the other way: where the forests are opened up, land clearance leads to massive fuelwood surpluses, and substantial quantities of wood resources are either burnt or left to rot. In such circumstances, talk of stress associated with the overexploitation of forest resources for fuel use obscures the real causes of large-scale deforestation.

Fuelwood use, both for local needs and external markets, does have other environmental implications. There is considerable evidence to suggest that land resources in agricultural areas can experience degradation if overexploited for fuel use. This problem is particularly associated with the small areas of woodland scattered within agricultural landscapes. Most farming areas have woods on steeper hillsides, along river courses, on marshy ground or areas of poorer soils, and in other areas not used for farming. These woodlands, which are often communally owned and managed (although the state may have nominal proprietorial rights), provide a range of products and are an integral part of the rural economy. Peasant farming systems are based on the use of both private and communal land resources to produce goods for markets and for subsistence consumption.

Growing populations, increasing commercialization of rural economies, and other incentives to clear more land have often led to the incremental colonization of these resources for cultivation. Cultivation leaves a smaller area to serve growing needs for fuel and other products (especially fodder); the result is overexploitation of biomass resources. The remaining communal areas usually have scant regenerative capacity and declining stocks and become more vulnerable to environmental hazards such as drought or soil erosion. The loss of communal resources may lead to an increasing reliance on externally produced commercial goods, which, in turn, depend on greater cash income. Communal goods are further eroded as they are exploited for private commercial gain.

Fuelwood use certainly contributes to the degradation of land resources in agricultural regions where more general resource pressures are felt. This form of degradation, however, is far from universal; indeed in most rural areas, fuelwood gathering for local use has only a marginal, if any, impact on land resource quality. It is a problem precisely where the rural economy and environment is most vulnerable: in localities where the resource base is already under threat and where the community has the fewest resources to counter this threat. Many case studies illustrate this form of environmental stress. Saxena (1987), Moench (1989), and Singh et al. (1984) give examples from the foothills of the Himalayas, Christianson (1988) provides evidence from Tanzania, and Johnson and Tompkins (1989) illustrate the pressures on Swazi Nation lands in Swaziland. In more comprehensive studies, Smil (1983) cites local fuelwood use as a contributory factor to land degradation in China, and Ryan (1990b) presents a preliminary analysis linking the degradation of woodland resources in many parts of India to the pressures of growing fuel demand.

When local fuelwood use does contribute to land resource degradation, it is not the sole, or even the main, cause of this stress. Fuelwood use contributes to this degradation because it is an integral part of the rural economy/environment relationship, and it is the general pattern of rural development in poor, environmentally vulnerable areas that creates stress, not fuelwood use alone.

FUELWOOD POLICY ANALYSIS

Since the mid-1970s most governments and donor agencies have approached the fuelwood crisis as an energy demand and supply problem. Both the diagnoses of problems and the designs for solutions have been based in large part on simple models of supply and demand (Foley 1988; Leach 1988; Leach and Mearns 1988; McGranahan 1986; Teplitz-Sembitzky and Schramm 1989). Viewed from this perspective the solutions were self-evident; if projected fuelwood demands exceeded supplies, the solution was to plant more trees and shift the supply curve outward, or to devise policies to reduce demand and shift the demand curve inward.

Most of these efforts have failed to have lasting effects on fuelwood scarcity or forest depletion. These failures, however, have led to a rethinking of the fuelwood crisis (Teplitz-Sembitzky and Schramm 1989). Although the specific details vary widely between and within regions, fuelwood problems are now more clearly seen as manifestations of more fundamental failures in rural land, labor, and capital markets, urban energy markets, and failures of governments (local and national) to establish the conditions that would allow efficient and sustainable allocation of land and resources between forest and cropland and wood and food production (Dewees 1989; Cline-Cole et al. 1990; Leach 1988; Teplitz-Sembitzky and Schramm 1989).

The complex interactions among demand, supply, and market forces and the lack of success of fuelwood interventions indicate that considerable care is required for designing appropriate interventions.[1] For example, some policy interventions may have paradoxical effects. Improving the efficiency of charcoal production may actually increase rather than decrease deforestation rates by expanding the areas accessible to urban markets (World Bank 1987). Likewise, if consumer disposable income is effectively increased through the subsidization of improved stoves, the quantity of fuel demanded and consumed might increase (Clarke and Shrestha 1989a; Foley 1988). In this section, the common supply- and demand-side policy approaches for solving fuelwood problems are examined.

Supply-Side Policies

Most supply-side fuelwood policies and programs have concentrated on planting trees or manipulating fuelwood prices. Subsidized tree-planting programs have been frequently proposed and implemented as solutions to fuelwood shortages with few successes. Recent criticisms of these programs

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[1] More complete models of the interactions of fuelwood demand and supply are presented in Hyde and Mercer (1990) and Mercer (1991).

have centered on the analysis (e.g., fuelwood gap theory) used to justify the expenditures and on the extent to which tree planting for fuelwood production is economically justifiable or feasible given local fuelwood prices, land tenure and property rights regimes, and the local causes of deforestation. The supply-side pricing policies attempt to influence supply through fuelwood royalties, stumpage fees, and fuelwood taxes or subsidies.

Tree-Planting Approaches

The most common approach by governments and donor agencies to ameliorate perceived fuelwood problems has been to plant trees. Programs have ranged from establishment of large-scale fuelwood plantations near cities to establishment of village woodlots, subsidies for small-scale private fuelwood enterprises, and private initiatives and incentives for tree planting by small farmers. With planning that takes into account the opportunity costs of the land, land tenure problems, availability and accessibility of markets, and so on, tree planting can be an appropriate response to fuelwood shortages. Unfortunately, too often the decision to spend scarce revenue planting trees has been almost a knee-jerk reaction, taken without consideration of other options and the consequences of existing market and policy failures (Ryan 1990a). Three general approaches have been used: large-scale block plantations, rural or social forestry (agroforestry), and natural forest management.

Large-scale plantations. The majority of large-scale plantations have used exotic, fast-growing species in state-owned and managed block plantations. Block fuelwood plantations were encouraged for a variety of reasons. Plantation forestry was considered a tested technology, understood and successfully applied by foresters in a variety of locations.[2] Plantations were viewed as discrete, highly visible activities for which inputs and yields were easily quantified; as a result plantations lent themselves readily to standard economic analysis. Indirect benefits were thought to include employment generation, environmental protection, reduction of pressures on other forest lands, and demonstrations that governments were actively solving an important problem (Catterson 1984, cited in Freeman and Resch 1986).

Unfortunately, the actual cost-benefit ratios usually fell far short of preproject expectations (Floor 1988; Leach and Mearns 1988). Frequently, the predicted benefits were overestimated and the costs underestimated. Because of the shortage of available land and competition with agriculture, fuelwood plantations were usually relegated to marginal lands where biomass productivity rarely produced revenues greater than the costs of the planting. French (1986) provides an excellent case study of the financial

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[2] Experience in Africa and Asia with plantation forestry was particularly significant (Freeman and Resch 1986).

constraints to using state-run plantations to solve deforestation and fuelwood problems in Malawi.[3]

There have also been some successes. Two examples in Ethiopia are the 20,000 hectares of eucalypti around Addis Ababa and the 50,000 hectares around other cities where fuelwood has become so scarce that demand has driven the price well above replacement costs (World Bank 1986). Also, in the state of Minas Gerais, Brazil, private commercial wood energy plantations occupying over 200,000 hectares produce the bulk of the energy for the iron and steel industries, and in Rondoneia, Brazil, a private company supplies the city of Ariquemas with electricity produced with plantation-grown fuelwood. Similarly, in the Philippines a successful dendrothermal program was established in 1980 to produce electricity from fuelwood grown in small plantations by farmers (Gregersen et al. 1989). Failures, however, outnumber the success stories.[4]

Social *forestry.* The failure of large-scale plantations led to the popularity of social, or rural, forestry projects emphasizing tree growing for fuelwood by small farmers in woodlots or in agroforestry systems. Because most fuelwood demand is associated with rural households, some observers (e.g., Gregersen et al. 1989) believe the key to solving the fuelwood problem can be found in encouraging farm families to grow enough trees to meet their own requirements and to generate surpluses for sale. The results with social forestry for fuelwood production, however, have generally not been encouraging (Floor 1988).

Although there have been some spectacular successes in promoting tree planting by private farmers, particularly in India, the end products are usually higher-valued building poles or pulpwood rather than fuelwood (e.g., see World Bank 1985; Arnold et al. 1987). This situation has led to reevaluation of some basic assumptions concerning tree planting and the fuelwood crisis. For example, the highly acclaimed and successful social forestry projects in the Gujarat state of India were based in large part on the assumption that any increase in tree planting would diminish the pressure on the natural forest and thereby ameliorate the fuelwood crisis (World Bank 1990).

The experience in India, however, indicates that this assumption was misleading and often incorrect. Indeed, small farmers planted many trees but few were for producing fuelwood; the stumpage price of fuelwood was too low to compete with products such as poles, pulpwood, or lumber. In some areas, the Indian social forestry projects actually reduced the availability of biomass fuel to landless farm workers who had previously been allowed to collect the agricultural residues following harvests. When farms

3 Also see Freeman and Resch (1986) for an excellent analysis of a case study in the Bandia, Senegal.

4 This statement may apply only to donor- or government-related fuelwood plantations, because the successes and failures of private plantations are not well documented. (K. Openshaw, World Bank, personal communication, 1990).

were converted to pulp and timber production, not only were these wage-earning opportunities eliminated, but the fuel derived from agricultural residues also was eliminated, creating potentially greater pressures on open-access woodlands.[5]

A survey of farmers involved with social forestry projects in eight sites around the world-Bangladesh, Haiti, India (3), Indonesia, Philippines, and Thailand-by Energy/Development International (1986) for the U.S. Agency for International Development (USAID) reported the following findings:

- Farmers base tree-planting and management decisions mainly on their expected profits from cash sales of wood. (This is true even of farmers who consume more of their tree products than they sell.)
- Independent small farmers frequently fail to receive the high prices for trees that they had been led to expect.
- In areas where tree growing is a mature, stable enterprise, farmers usually grow several species and produce a variety of products.

These findings suggest that although the potential for social and agroforestry is very large, rarely will social forestry schemes based primarily on fuelwood production be successful so long as open-access forest resources are available and prices remain low. Where fuelwood-oriented programs have been successful, planners have actively sought advice and help from local communities and have taken into account different uses of trees in farming systems (Gregersen et al. 1989).

It should be emphasized, however, that agroforestry and other social forestry initiatives have in general been quite successful (see Spears 1988). Many trees are being grown on farms, and agroforestry, if promoted correctly, provides a means for farmers to stabilize agricultural output without using much artificial fertilizer. In addition, tree planting by small farmers provides considerable economic and environmental returns, such as soil conservation, shade, shelterbelt, and cattle forage.

Nafural forest management. Natural forest management systems have typically been neglected in favor of ambitious reforestation schemes. The current dissatisfaction with the results of fuelwood plantations has led to increased interest in managing the natural forest for fuelwood and other products. Furthermore, because a large proportion of the fuelwood supply for urban areas comes from woodlands, the proper management and regulation of natural woodlands will likely be essential to establishing a sustainable supply of fuelwood. Advantages to natural forest management include lower investment costs (e.g., no land-clearing, seeding, or planting costs) and the greater adaptation to local conditions. As has been noted, the problem with fuelwood plantations is that they generally supply only relatively low value fuelwood. The goal of natural forest management is to produce a sustained yield of forest products while maintaining ecosystem

[5] A. Molnar, World Bank, Washington, D.C., personal communication, 1990.

balance. Thus natural forests provide food, fodder, and other products as well as fuelwood. The natural forest approach recognizes that the fundamental resources (e.g., soil, water, vegetation, wildlife) must be managed as a whole rather than separately. Other benefits are the protection of biodiversity, watershed protection, and reduced soil erosion.

USAID has refocused most of its fuelwood activities in Africa on natural forest management, with notable success in Niger and other arid and semiarid Sahelian countries.[6] Studies around Niamey, Niger, for example, have demonstrated that appropriate harvest and management practices can substantially increase fuelwood production from natural forests in the Sahel. Heermans (1986 cited in Heermans and Minnick 1987) demonstrated that it may be possible to achieve growth rates for major fuelwood species almost twice current consumption rates. Although natural forest management for fuelwood production appears promising, considerable research is needed to evaluate its biological, economic, and social potential.

Policy constraints to growing frees for fuelwood. Even when countries overcome the technical problems for growing sufficient amounts of fuelwood in large-scale plantations, in agroforestry systems, or under natural forest management systems, as long as enough "free" open-access forest resources remain to dominate market prices, tree-growing approaches are likely to be ineffective. Problems with land ownership and tenure, therefore, are the central issues for developing sustainable fuelwood resources under all three technical schemes.

Three direct fuelwood supply effects can be attributed to the availability of open-access forests (Clarke and Shrestha 1989a):

1. People have no incentive to invest in restocking the biomass in open-access resources, because other people may expropriate the benefits from the investment. Even if property rights are enforced for privately owned tree stocks, the existence of nearby open-access forests tends to make commercial plantations or tree growing on small farms uncompetitive, because commercial tree growing must take into account not only the costs of harvesting but also the land, planting, and maintenance costs.[7]

2. Open-access promotes underinvestment in the provision and acquisition of information concerning such things as efficient and sustainable harvesting practices and techniques or the environmental impacts of deforestation. There is no incentive to discover the maximum levels of harvest to ensure sustainable fuelwood supplies or the critical minimum extent of tree cover to prevent environmental degradation.

[6] Tim Resch, USAID and U.S. Forest Service, personal communication, 7990.
[7] See French (1986) for a case study of these effects in Malawi.

3. The lack of the ability to enforce property rights over forest resources contributes to the general misallocation of lands between forest and farmland. Because individuals can usually reap all the benefits of land converted to annual agricultural crops but must share the benefits of open-access forest with the rest of the community, forests will be converted to private farmland even when its social value is greater as common property forest.

Even if the problem of property rights is solved, approaches to increasing fuelwood supplies which involve encouraging small farmers to grow trees for fuelwood either in small woodlots or in agroforestry systems face serious constraints because of policies that distort prices in a variety of markets. For example, the existence of distorted prices in labor and nonlabor agricultural input, capital, commodity, and foreign currency markets provides significant disincentives to tree growing for fuelwood by small farmers in many developing countries (Mercer 1990; Repetto 1988; Southgate 1988).

Fuelwood Pricing Policies

One of the major constraints to implementing effective tree-growing programs to increase the supply of fuelwood has been the low value of wood used as fuelwood. In niany countries "free" open-access wood resources, the bulk of which are government owned, still account for 80 to 90 percent of the supply both for charcoaling and for direct fuelwood use (World Bank 1987). As long as this is the case, the stumpage price at those sites is zero, and market prices for fuelwood and charcoal will not reflect the full scarcity values (i.e., the full social value) of the wood (Hyde and Mercer 1990). Undervalued fuelwood resources may cause waste and inefficiency in production and consumption and disincentives for tree growing.

In acknowledgment of this situation many observers (e.g., Openshaw and Feinstein 1989) argue that stumpage fees for harvesting fuelwood on government land should be raised at least to its replacement cost. Setting a stumpage fee at the same royalty rate typically applied to crude oil (about US$12 per barrel), for example, could produce revenue of about $2.5 million a year from a city of 250,000 that consumes a million bags of charcoal each year (Leach and Mearns 1988).[8] Currently most countries charge some kind of stumpage fee for fuelwood.[9] Most stumpage fees, however, are nowhere near the social value of the in *situ* resource or the replacement cost, and the fees are rarely imposed on subsistence users.

[8] These rates are about the same as for fuelwood produced from government-run plantations in Kenya and Tanzania (World Bank 1987 and World Bank/UNDP 1988).

[9] Botswana is an example of a country that imposes no stumpage fee at all on fuelwood except in the Kweneng District (K. Openshaw, World Bank, personal communication, 1990).

One of the main difficulties with stumpage-fee programs is determining the correct amount to charge. There are three principal methods: residual stumpage, alternative fuel substitute, and replacement cost. Implementing these procedures can be quite complicated and costly. (See Openshaw and Feinstein [1989] for a detailed discussion.)

Even if the correct stumpage fee could be determined, however, implementing effective stumpage fees in places where most fuelwood is obtained from open-access wood resources poses several other administrative, institutional, logistical, and political problems. There are practical problems and large administrative costs in countries where institutional capacity is already weak. For example, in areas where fuelwood comes primarily from operations to clear agricultural land, it may be relatively easy to collect fees from large, commercial farming operations. Collecting stumpage fees from the myriad subsistence farmers who are responsible for the bulk of land clearing, however, would be extremely difficult and costly.

Even assuming that the administrative and logistic problems could be overcome and that the government succeeded in raising the price of fuelwood enough to make growing trees for fuelwood a viable option, the distributional effect on low-income urban households could create severe political problems. For example, in Kenya, the World Bank (1987) estimated that a stumpage fee based on replacement values would increase retail prices by as much as 30 percent. Given the fact that any benefits associated with a stumpage fee might not materialize until well into the next century, it is highly unlikely that the political will could be mustered to pass and enact such significant increases in stumpage fees.

Furthermore, it is uncertain whether stumpage fees would actually increase private tree growing or enhance the viability of government plantations. The situation would depend on such factors as land tenure, the opportunity returns of other land uses, and transportation costs (Hyde and Mercer 1990). Simply setting stumpage fees at the replacement cost in no way guarantees that growing trees for fuelwood would be profitable.

Finally, obtaining information to estimate costs and benefits of stumpage fees would be difficult and costly and any potential welfare gains would probably be offset by the costs. In many cases implementing effective stumpage fees might well be more expensive than directly enforcing property rights (Clarke and Shrestha 1989b). However, implementation of stumpage fees has proved successful when enforcement and collection are ceded to local communities that share in the benefits. For example, Leach and Mearns (1988) describe the successful program in Rwanda.

Demand-Side Policies

Demand-side policies can be separated into two main groups: (1) policies designed to reduce demand by promoting efficient use of wood through improved cook stoves and charcoal kilns; and (2) policies to reduce fuelwood demand by subsidizing the substitution of modern fuels such as kerosene and liquefied petroleum gas. Unfortunately, the experience to date with demand-side policies has been discouraging. Scant evidence exists to suggest that the programs have changed demand patterns substantially; some programs (e.g., subsidizing modern fuels) have been expensive failures, the main effect of which has been to provide inexpensive energy to people who least needed it.

Increasing Efficiency of Use

Fuel-efficient stoves. Programs to design and propagate improved stoves were viewed with great enthusiasm in the 1970s and 1980s. It was believed that if improved stoves became widely used, firewood consumption and hence deforestation would fall and opportunities for higher incomes would increase because people would spend less time cooking and collecting fuel. In addition, improved stoves were expected to generate dramatic health benefits by reducing indoor air pollution. Rural households were targeted for the new stoves because they typically consumed the bulk of fuelwood and were perceived to need the most help in saving the surrounding forests (Foley 1988).

During the mid-1980s, however, improved-stove programs fell into general disfavor among the donor community as a result of critical reviews by Foley and Moss (1983) and Gill (1987), which questioned whether improved stoves actually performed any better than the traditional stoves they were replacing.[10] Kirk Smith (1983) added fuel to the fire with his studies indicating that the new stoves also failed to alleviate significantly the ill-health effects associated with indoor air pollution. More recent studies of performance under normal operating conditions, however, suggest that the new stoves are capable of achieving fuel-use efficiency 30 to 50 percent better than that of traditional stoves (Joseph 1987; Floor 1988; World Bank 1987). The disappointing results of most of the early stove programs can be more accurately attributed to putting "the wrong thing (heavy-mass mud stoves), in the wrong place (rural areas), in the wrong way (self-built stoves), and with the wrong people" (Floor 1988, p. 128).

In contrast, the recent successful programs in Kenya, Niger, Burundi, Rwanda, and Harare have used commercial, charcoal, metal stoves in urban areas. Indeed, in Nairobi it is reported that 80 percent of the traditional stove makers are now producing the new stove with no government or other donor assistance (Foley 1988). In Colombo, Sri Lanka, a ceramic wood-burning stove has been successfully introduced. In all these cases, improved

[10] Generalizations about improved-stove programs have ranged from "the majority . were more or less a complete flop" (Foley 1988) to "results . have been disappointing" (Floor 1988) to "failed to displace traditional modes of cooking to any significant extent" (Gill 1987).

stoves have saved wood resources and cash for the urban poor, and have produced a healthier household environment. They show that improved stoves may be successful when fuelwood is a commercial good produced and sold through the private sector, and when fuel savings mean cash savings.

Stove programs are more likely to be successful in urban than rural areas for a number of reasons. First, there are many substitutes for fuelwood in rural areas, and biomass fuels are rarely perceived as scarce (Dewees 1989), at least by men. Women may have very different perceptions. Second, because cash is scarcer in rural areas, the people there have a much lower ability to buy the improved stoves. In many rural communities, labor is in surplus except during planting and harvesting times, so the market value of an individual's time may be close to zero. Therefore it may well make sense for households to use fuelwood inefficiently rather than to spend their scarce cash on improved stoves.

Furthermore, the relationship between improved stoves and reduced pressures on forest stocks may be tenuous at best. Clarke and Shrestha (1989a) showed that only when the demand for fuelwood is very price inelastic will improvements in conversion efficiencies reduce the pressures on forest stocks. However, if demand for fuelwood is elastic (as is probably the case in rural areas where there are many substitutes), efficiency improvements in wood consumption which result in lower prices per unit of energy may provide incentives to harvest existing forest stocks more intensively. When energy demand is highly income elastic, if improved fuel-use efficiency frees household members to pursue wage labor or other income-producing activity, use of fuelwood may actually increase. Foley (1988) suggests that improved stoves may even delay the shift to modern fuels and hence make fuelwood consumption higher than it would otherwise have been.

At this time it is difficult to generalize about the benefits to be obtained from improved stoves. Improved stoves apparently can contribute to solving fuelwood problems, but the stove programs probably should be limited to urban areas. As Foley (1988, p. 72) stated, "As far as demand management is concerned, improved stove programs are a venture into the unknown."

Improved charcoal kilns. Efforts to improve charcoaling methods have been under way for a long time. Improved mound kilns were introduced in India in 1884 and portable steel kilns in 1891 (Cleghorn 1884 and Fernandez 1891, cited in Foley 1988). The Mark V portable steel kiln was introduced in Uganda in the 1960s, the Tropical Products Institute kiln was introduced in a variety of countries in the 1970s, and the Casamance kiln was developed in Senegal in the 1980s (Foley 1988).

The usual objective of these efforts is to reduce pressures on forest resources by reducing the amount of wood required to produce a given quantity of charcoal. As long as open-access forest resources exist and charcoalers obtain "free" wood, however, efforts to reduce wood consumption by introducing improved kilns are unlikely to succeed. Under open-access situations, there are virtually no incentives for charcoalers to economize on wood use if the cost of the kiln is more than the increased fuelwood harvest costs using inefficient kilns. If collection costs are very small or close to zero, as in open-access situations, there would be little incentive to switch to the improved kilns.

Clarke and Shrestha (1989a) found the results for the effect of kilns similar to those for cook stoves. If demand for charcoal is inelastic, improved kilns increase revenue from a unit of fuelwood and reduce the aggregate costs of wood collection per unit of charcoal, thereby increasing the availability of forest stocks. If demand is elastic, however, improved kilns are likely to reduce forest stocks by increasing the areas that are economically accessible. Where forests are underused and the main problem is access, this outcome may be desirable because it achieves increased harvest levels with reduced effort. But if the intent is to reduce pressures on overused open-access forests, charcoal kilns may be counterproductive unless they are accompanied by land tenure reform or other programs to reduce access.

In Brazil, the introduction of improved kilns has been very successful in -areas where a large portion of the wood for charcoaling is grown and owned by individuals, corporations, or the state, but the efforts have been unsuccessful in open-access areas. The successful implementation of improved kilns in Uganda in the 1960s was due to its combination with an effective program to reduce access and to control harvest levels (Foley 1988).

Substitution of Modern *Fuels*

Increased reliance on modern fossil fuels and electricity rather than on fuelwood usually accompanies economic development. As national income rises, more and more people are able to pay for the increased cleanliness, convenience, and efficiency associated with modern fuels. For example, fuelwood typically makes up 60 to 95 percent of total energy use in poor developing countries, 25 to 60 percent in middle-income countries, and less than 5 percent in high-income countries (Leach 1988; Leach and Mearns 1988).

This energy transition is also central to any understanding of urban fuelwood use. As urbanization proceeds, households tend to use more energy and to switch from wood and charcoal to modern fuels. The Energy Sector Management Assistance Program (ESMAP) (1990a) has discovered this pattern in Indonesia, and Soussan et al. (1990a) discuss a number of other examples.

Some countries have initiated policies to encourage a more rapid transition. In most cases these policies have consisted of price subsidies for modern fuels. To encourage consumers to switch to modern fuels, Indonesia instituted kerosene subsidies as high as 80 percent of the international market value. In hopes of reducing charcoal consumption in Dakar, Senegal initiated a massive campaign to subsidize butane. Sri Lanka provided poor families with stamps that could be traded for kerosene (Foley 1988). Thailand and India have provided subsidies for biogas plants (Clarke and Shresthra 1989b).

Unfortunately, most of these policies have been expensive failures. For example, Indonesia's kerosene subsidy reduced the retail price of kerosene to 18 percent of its international price-at a cost of $3.7 billion (roughly 5.4 percent of the GDP) in 1980–81 (Pitt 1985). Household surveys indicate that the main beneficiaries were middle-income households, which would have used kerosene at its nonsubsidized price, and the transportation industry, which substituted kerosene for diesel fuel. There is no evidence to indicate that the subsidies promoted decreased fuelwood consumption or deforestation. In Senegal, subsidization did result in increased consumption of butane, but no evidence exists that charcoal use was significantly affected. Furthermore, a substantial fraction of the subsidized butane was exported to Mauritania. This program also appears to have primarily benefited the middle class, which would have been able to afford the nonsubsidized price (Foley 1988).

It is clear that designing effective policies to encourage substitution of modern fuels for fuelwood requires clearly articulating the goals of the policy and understanding the driving forces behind the transition. Goals of interfuel substitution policies typically include reducing high fuel costs for the poor, increasing consumer welfare, saving fuelwood, and protecting the environment. If the goal is to reduce the environmental damage associated with deforestation, success will depend on the source of fuelwood. For example, if the bulk of fuelwood comes from clearing land for agriculture, subsidizing modern fuels will have little impact. If a large proportion of demand is made up of charcoal produced in open-access forests, substitution policies may well produce environmental benefits, but only if fuelwood use is the chief activity associated with forest exploitation.

A variety of household surveys have shown that the two main forces driving the transition from fuelwood to modern fuels are access to dependable supplies of the modern fuels and income. The positive relationship between fuel choice and income is well established (Alam et al. 1985; Dowd 1989; Fitzgerald et al. 1990; Dunkerley et al. 1990; Leach 1987; Leach and Gowen 1987; Leach and Mearns 1988). The higher the income, the greater the likelihood to choose modern fuels over biofuels. As urban incomes rise, people typically progress from low-grade biofuels (e.g., crop residues, scrap timber, tires) to firewood, charcoal, kerosene, LPG, and electricity or natural gas (Leach and Mearns 1988).

In an analysis of fuelwood and modern fuel prices in 19 developing countries, Barnes (1986) reported trends suggesting that rising incomes rather than prices are the predominant factor for fuel substitution and that reducing the prices of substitute fuel (e.g., kerosene) does not reduce fuelwood prices (or demand) unless incomes simultaneously increase or are redistributed toward lower-income groups. This study suggests that subsidies for modern fuels are likely to encourage increased consumption among the high- and middle-income households while having negligible effect on the fuelwood consumption of the poor.

Access to dependable supplies of modern fuels is the other driving force behind transitions between fuelwood and modern fuels. Wood and charcoal are often used not because they are cheap, but because they are available in places and quantities that fit in with the life of the urban poor. The access issue has two basic components: differential access between areas (e.g., rural versus urban, small cities versus large cities) and differential access within cities. In rural areas the vast majority of households, even the highest income classes, depend on biofuels for the bulk of their energy needs; supplies of alternative fuels are nonexistent, insufficient, unreliable, or very expensive (Leach 1988). The supply of modern fuels increases as one moves from rural villages to small and medium-size towns and then to large urban areas. For example, in India in 1979, 40 percent of household energy was supplied by modern fuels in towns with populations of 20,000 to 50,000, compared with 58 percent in cities with populations of 200,000 to 500,000 and 75 percent for the largest urban areas (Leach 1987).

Access within cities also can affect fuel substitution behavior. Accessibility frequently outweighs all other issues, including stove costs and prices, for low-income classes. For example, Leach (1988) discusses a survey in Lucknow, India, which revealed that few of the poor used kerosene, despite the fact that it cost 40 percent less than fuelwood. Major deterrents to kerosene use were shortages and long lines, rather than the price of stoves or other factors.

Factors that limit the effectiveness of policies to promote fuel switching include the paucity of data on demand and supply elasticities, the requirement for additional foreign exchange, kerosene pricing policies, problems of access in rural areas, inability of poor people to afford the required technologies, and lack of perception of fuelwood crisis by local people.

Subsidizing substitute fuels in order to conserve on fuelwood will be cost-effective only when fuelwood is cross-price elastic with respect to the substitute fuel and the demand for the substitute is own-price inelastic (Clarke and Shrestha 1989b). For example, in Indonesia, Pitt (1985) estimated that demand for both fuelwood and kerosene was own-price elastic and cross-price inelastic, resulting in a costly failure (as already noted). However, good elasticity estimates are exceedingly rare in most developing countries. Without these, promoting subsidies for alternative fuels would be shooting in the dark.

The requirement for additional foreign exchange is often cited as a serious drawback to promoting substitution of modern fuels, particularly for low-income oil-importing countries. Exhibit 8-l shows the effects of substituting kerosene for all charcoal and fuelwood used in the cities of low- and

EXHIBIT 8-l. **Amount of Kerosene Required to Replace All Urban Fuelwood Consumption in Low- and Middle-Income African Countries, and Resulting Increase in Demand for Petroleum and Decrease in Demand for Fuelwood,. Selected Years. 1978-1989**

Country	Year[a]	Amount of Kerosene to Replace All Urban Fuelwood (10^3 tons)	Increase in Total Petroleum Consumption (%)	Decrease in Total Fuelwood Consumption (%)
Low-Income				
Benin	1983	40	34	26
Burundi	1980	15	46	23
Ethiopia	1982	170	32	26
Ghana	1985	180	26	44
Guinea	1984	110	29	23
Kenya	1985	335	20	29
Malawi	1980	40	29	5
Niger	1980	35	23	20
Nigeria	1980	405	5	12
Rwanda	1978	13	27	8
Sierra Leone	1986	60	34	37
Somalia	1984	75	41	32
Sudan	1980	435	45	32
Tanzania	1981	470	74	29
Togo	1981	40	17	25
Uganda	1982	80	51	15
Zaire	1980	540	91	37
Middle-Income				
Congo	1985	32	13	50
Ivory Coast	1982	135	14	35
Liberia	1983	50	12	40
Mauritania	1984	13	8	40
Senegal	1981	55	8	27
Zambia	1989[b]	227	40	21
Zimbabwe	1980	65	11	18

[a] Byer (1987) in Leach and Mearns (1988), based on ESMAP Country Energy Sector Assignments
[b] K. Openshaw, World Bank, personal communication, 1990.

middle-income African countries. For all the middle-income countries except Zambia and including Nigeria, replacing all urban fuelwood with kerosene would raise the oil demand (and the accompanying need for additional foreign exchange) by only 5 to 16 percent, while reducing fuelwood consumption by 18 to 50 percent. Petroleum demand in the low-income countries would increase by 17 to 91 percent, and fuelwood demand would decrease by only 8 to 44 percent. These numbers indicate that for those countries where fuelwood use could be greatly reduced without significant increases in oil demand, the substitution option may be appropriate. Whether these percentage changes can be achieved, however, depends on a variety of demand factors. Development planners should analyze the driving factors for fuel demands and reliable elasticity estimates for each local area before governments make large expenditures.

Probably the most serious constraints are the distorted fuel markets in most developing countries. Many urban fuelwood markets are highly developed and effective distribution systems. In contrast, the distribution systems for commercial fuels such as kerosene and LPG often are characterized by shortages and black-market pricing and tend not to reach many peripheral areas where the poor live. Soussan (1990b) provides an example of the effects of poorly developed markets for modern fuel in Mogadishu, Somalia. If planners wish to encourage the transition from fuelwood in urban areas, they must take action to ensure that viable alternatives are available to low-income urban consumers. Without such action there is little hope of reducing the use of wood and charcoal in urban areas.

POLICY RECOMMENDATIONS

Although specific activities will vary from place to place, experience in a wide range of fields suggest four interrelated policy recommendations for governments in every region experiencing fuelwood problems:

1. Improve the information base on which policies are based.
2. Correct market failures and improve functioning of markets.
3. Develop fuelwood sector strategies.
4. Strengthen fuelwood planning institutions.

In some situations, these reforms may enable markets to solve both long-term and short-term fuelwood allocation and production problems without further central government involvement. In other cases, central government planning and allocation may be required in the short term to assist in the transition.

Improve information

Probably the single most important step a government can take to improve its fuelwood situation is to improve the information base on which policies are formed. Among the most pressing needs are information about household demand and supply, modern and fuelwood markets, the fuelwood resource base, and forest management and tree-growing systems.

- *Household Demand and Supply Information.* Rigorous estimates of demand and supply elasticities are almost nonexistent. Until we can more confidently predict how households will respond to changing parameters, fuelwood policy interventions will be haphazard. Any successes will be fortuitous.

- *Market Information.* In-depth surveys of modern and fuelwood markets are needed to ascertain how the fuels are supplied, distributed, marketed, and priced in urban areas (and in those rural areas where the fuels have been commoditized). In addition, information is needed on land, labor, agricultural, and other forest product markets in order to identify market and policy failures and to estimate the potential for fuelwood policies to augment supply. Nontraded markets-the amount of time rural households spend collecting fuelwood and crop residues-also should be investigated in the surveys.
- *Fuelwood Resource* Base. Lack of reliable data on fuelwood resource stocking and annual sustainable yields of the local and regional fuelwood catchments for rural villages and urban areas is a major constraint to planning effective fuelwood policies. This information should be coupled with information on household demand and supply in order to identify the nature of the fuelwood problem for specific fuelwood catchments and to tailor policies and programs to local needs.
- *Forest Management and Tree-Growing Systems.* Forest management and tree-growing systems for fuelwood production need further development and testing. Block fuelwood plantations are well understood, but systems of managing the natural forest for fuelwood and other products need to be developed and tested for biological and economic productivity potentials in a variety of ecosystems and agroclimates. In addition, agroforestry systems that produce significant quantities of fuelwood as a by-product need refinement. Finally, methods to use waste by-products from wood production systems unrelated to fuelwood need to be developed and tested.

Correct Market and Policy Failures

The next step in formulating effective fuelwood policies is to identify the underlying causes of fuelwood problems in specific local areas. Identifying the underlying causes of fuelwood problems requires an examination of their economic manifestations. Unfortunately, past fuelwood policies have often been formulated on analyses based on the observable symptoms (physical manifestations) rather than the underlying causes (economic manifestations) of the problem (Panayotou 1989).

Many economic manifestations of fuelwood problems can be traced to market and policy failures that produce situations in which benefits are disassociated from costs, prices from scarcity, rights from responsibilities, and actions from consequences. For example, fuelwood harvesters (both commercial and subsistence) are able to extract the benefits from "free," open-access fuelwood resources while shifting the costs of depletion to future generations. As a result, prices (explicit and implicit) do not reflect the growing scarcities and rapidly increasing social cost of fuelwood depletion.

Many fuelwood-related problems can also be traced to policies that intentionally or unwittingly distort prices (incentives). Distorted prices (from both market and policy failures) fail to provide the signals that, in a well-functioning market, would promote the increased conservation, substitution, innovation, and efficiency necessary to bring fuelwood supply and demand into balance.

The most important market and policy failures are ill-defined, attenuated, unenforceable, or undefined property rights; unpriced or underpriced resources and absent or thin markets; and policy-induced price distortions in capital, labor, and commodity markets. Each of these failures is briefly examined in the paragraphs that follow.

Property Rights

To achieve efficiency, property rights must be well defined, exclusive, secure, enforceable, and transferable. The lack of one or more of these characteristics in local land markets is probably the single most important cause of fuelwood-related problems. Property rights problems are also the root cause of the environmental problems and fuelwood scarcity associated with deforestation, and ill-defined property rights provide perverse disincentives against tree growing. The open-access nature of forestlands in developing countries is probably the most significant impediment to solving fuelwood-related problems.[11]

Private property rights that are ill-defined or attenuated also contribute to fuelwood scarcity and provide obstacles to implementing successful fuelwood projects, especially those based on encouraging small farmers to use agroforestry systems or otherwise grow trees for fuelwood. Insecure land tenure reduces investment incentives and encourages preference for current consumption over future consumption (Feder et al. 1988).

A number of recent attempts to move land tenure from centralized control to more local or private control have demonstrated the efficiency gains that are possible. For example, Spears (1988) reports a number of

[11] For a review of the theory of open-access resource use and abuse, see Magrath (1989). The distinction between open-access and common property resources is not clear in the literature. This chapter uses the definitions of Bromley and Cernea (1989), who defined common property as, in essence, private (or corporate) property held by a group. All individuals within the group have rights and duties with respect to the property, and nongroup members are excludable. Open access, in contrast, represents situations in which there are no property rights, no one can be excluded, and no management systems can be enforced. Common property rights may be fully articulated and enforced by cooperative group action to ensure efficient management and use. Problems arise when the institutions for enforcing common property rights and management break down. See Magrath (1989) and Runge (1981) for examples.

instances in the Philippines and India when reallocating publicly owned lands to private farmers and local communities increased reforestation activities. The specific property rights regime that should be implemented, however, will vary for individual locations and situations. In many instances, the best solution may be privatization, especially when the land and production systems warrant individual or family investment. Privatization may also be best when shifting cultivation or other agricultural practices have already resulted in de facto privatization. Privatization, however, may not be best when the land area is extensive and cannot be protected from outsiders, when the value of production is too low to warrant individual investments, and when products are diverse and used by a variety of people (but not necessarily cash-valued highly).

In small, self-sustaining rural communities where strong traditions of community or tribal management of resources exist and where population and other external pressures are mild, community management of fuelwood resources may be appropriate. Indeed, traditional common property systems have been used successfully throughout history to manage resources on a sustained basis (Ciriacy-Wantrup and Bishop 1975; Runge 1981). Government ownership and control of fuelwood resources also can be efficient under certain conditions, as when the country has a strong, well-staffed forestry department with a history of successful management and control of forest resources, and either a relatively small forest resource base to manage or relatively low pressures on the forest resources. The issue is not so much that any particular group should manage the resource but that the group should be able to restrict access and have the necessary human resources available to manage the forest, and that either the land or the proceeds from the land should be distributed equitably among the affected populations.

Unpriced or Underpriced Resources and Nonexistent or Thin Markets

Because open-access forest resources have no exclusive owners to demand a price and deny access when that price is not paid, there are no markets and no prices for these resources. The implicit price of the forest itself is taken to be zero, regardless of the scarcity and social opportunity cost. When open-access forests account for a significant portion of the fuelwood catchment area, markets for fuelwood may exist but the price of fuelwood will only reflect the opportunity cost of labor and capital used in its production and transportation. The price does not include the opportunity cost of the scarce natural resource (forests) used in its production, and does not reflect its true social value. Therefore, the fuelwood price that consumers face does not reflect the growing overconsumption and underinvestment in supply.

The absence of fuelwood and labor markets in rural communities also contributes to fuelwood problems. Many fuelwood projects have failed because of their reliance on the assumption that fuelwood and the labor used for fuelwood collection have market values, that is, that fuelwood collection time can be converted to income by selling the fuelwood or the labor itself (Clarke and Shrestha 1989a). When fuelwood is primarily a nonmarket subsistence good and the value of fuelwood collectors' time is very low, people will continue to use fuelwood if they have to pay cash for alternative fuels.

Inadequate markets and supplies of modern fuels in both urban and rural areas often constrain fuel substitution. For low-income households, security of access is more important than price or convenience. Rigid government controls on operating oil companies and, where applicable, state-controlled oil monopolies must be removed. In many countries, government policies severely distort kerosene and oil prices, discriminating against low-income consumers and rural areas. These distorting policies should be removed and incentives installed to encourage oil companies to distribute and market kerosene in these areas.

Price Distortions in Capital, Labor, and *Commodity Markets*

Kerosene pricing policies are one of the most common energy policy failures in developing countries (World Bank 1987). These policies directly compound the difficulties in supplying the urban poor and rural areas with kerosene, the most important potential substitute for fuelwood. Cross-subsidization from gasoline and diesel oil, combined with price controls, results in lower retail prices for kerosene than other petroleum fuels, despite the fact that all the import prices are roughly equivalent.[12] The end result is a strong financial incentive at both the supplier and the consumer levels to divert kerosene to the diesel market and away from household energy markets.

Moreover, many countries require uniform national pricing of petroleum products. Although there is usually an attempt to incorporate transportation costs in petroleum prices, the pricing structure often gives petroleum suppliers little or no incentive to market their products in rural areas. Together, petroleum pricing problems and the structure of the kerosene market (in which the poor must buy from secondary retailers or bulk breakers) have discouraged supply, aggravated scarcity, and raised the secondary retail prices of kerosene. In Kenya, for example, secondary retail prices have been observed to be as much as 75 percent above the primary retail price in urban areas and 100 to 200 percent in rural areas (World Bank 1987).

Efforts to increase fuelwood supplies by encouraging small farmers to grow trees either in small woodlots or in agroforestry systems are gaining in popularity. However, the distorted prices in labor and nonlabor agricultural input, capital, commodity, and foreign currency markets provide

[12] Retail kerosene prices are often 25 to 40 ‘percent lower than diesel oil prices (World Bank 1987).

significant disincentives to tree growing for fuelwood by small farmers (Mercer 1990; Repetto 1988; Southgate 1988).

Many of the market failures (especially those arising from insecure property rights and unpriced resources) directly result from the failure of governments to establish the legal foundations of markets. The existence of market failures does not necessarily justify eliminating markets or other government intervention. Policy intervention is justified only when the ensuing benefits exceed the costs of intervention.

Develop Fuelwood Sector Strategies

Once planners have dealt with the prevalent market and policy failures, they can formulate fuelwood sector strategies to manage supply and demand. In most countries, planning should be based on the realization that there is rarely a single fuelwood sector. Rather, a variety of fuelwood demand centers usually exist with their own specific fuelwood catchment areas, which may or may not overlap. In order to determine the most efficient balance in consumption between modern fuels and wood, planners should identify the actual and potential fuelwood growing stock and the productivity and accessibility (economically and environmentally) of each catchment area. Once this situation has been assessed, the most appropriate combination of demand and supply policies (for each catchment area) can be formulated. Supply and demand policies are reviewed in the paragraphs that follow. It should be noted, however, that because the fuelwood sector is only one part of a dynamic household energy system, successful policy intervention requires a strategic planning approach.

Supply Management

The extent of forest cover that needs to be managed to produce a sustainable (economically and environmentally) wood supply must first be determined. Planners can then formulate policies to provide the correct incentives to ensure sustainable production. The available strategies remain encouraging tree growing or improved forest management, or imposing corrective taxes or stumpage fees. Once property rights are secured and access to “free” resources is prohibited, fuelwood prices will adjust (probably upward). If fuelwood prices rise high enough in comparison with other opportunities, land owners (private or communal) will have sufficient incentive to plant trees or otherwise manage forests for fuelwood production. If the prices are not high enough to encourage tree growing and if positive environmental effects associated with tree-growing for fuelwood are found to exist, production incentives such as subsidies, extension services, and demonstration projects may be required. Multiproduct agroforestry systems and natural forest management for multiple use under private or community control are usually the most efficient systems. Because the bulk of commercial fuelwood for the foreseeable future will come from natural forests, proper management systems for woodlands will be essential.

The other major policy to augment supply-stumpage fees-will be successful only when access to the forest resource can be limited. In general, given the inherent political, administrative, and institutional difficulties, attempts to collect stumpage fees are not recommended to central governments. Developing alternative innovative tax systems such as the Malawi kiln tax and solving the open-access problem should come first. In this regard, however, transferring land tenure rights to local communities, either permanently or in long leases, may prove to be an effective system for collecting the fees. To be successful, local communities or their representatives need to have a direct financial interest in collection of the fees. When local communities act as mediators between forest harvesters and the forest service or directly set and collect the fees, the costs may be considerably reduced and the prospects of enforcement enhanced.

Demand Management

There are two basic approaches for managing demand: speeding up the transition to modern fuels and increasing the efficiency of the use of fuelwood. As already discussed, urbanization and rising urban incomes drive the transition to modern fuels. An unfettered supply system that can guarantee access to the modern fuels in the quantities demanded is essential.

Experience suggests that subsidization of modern fuels is an ineffective way to influence fuelwood consumption. The more appropriate way to encourage fuel switching is to improve access to the fuels. Sometimes governments fail to provide the institutions, infrastructure, and policy framework to encourage accessibility of modern fuels to low-income groups and rural areas, and sometimes government policies directly distort the incentives for oil companies to provide access. After these policy failures are corrected, several policy approaches remain available. Governments can improve the transportation infrastructure, especially to smaller towns and rural villages. Governments can help increase the supply of LPG cylinders to low-income families and provide incentives to expand retail outlets in low-income areas and rural areas. And when the cost of the modern fuel stoves is a major constraint, governments can provide incentives (e.g., loan programs) or subsidies to help low-income families purchase the stoves.

The promotion of efficient firewood and charcoal stoves also has a place in demand management policy, but careful planning and assessments are required before ambitious programs are undertaken. Targeting urban markets is generally most effective. Consumers must be convinced that the stoves will reduce their expenditures on fuel and investments of time, improve the kitchen environment, and reduce disease due to indoor air pollution. Extension efforts will be needed to train consumers and stove producers to produce better stoves; in addition, marketing and distribution networks must be developed. If stove makers see large profits from producing fuel-efficient stoves and consumers perceive substantial benefits from using improved stoves, urban-market-oriented stove programs will be successful.

Strengthen Fuelwood Planning Institutions

A critical issue for fuelwood policy formulation is the performance of the institutions that are involved in forming and implementing biomass energy policy. Unfortunately, because fuelwood does not fall clearly under the jurisdiction of a single ministry, particular attention must be paid to the institutional arrangements that address fuelwood issues. The problem of coordination between different state agencies is exacerbated by the lack of effective channels for the involvement of local people in the planning and implementation process. Many of the policies that appear to offer the best hope for dealing with fuelwood problems are based on the premise that local people will actively participate in the design and execution of projects. However, it is far from clear how this widely advocated participation can be translated into effective and durable institutional structures.

The following basic principles are essential for reform of fuelwood planning institutions:

- The institutions should be responsive to *energy needs*. Energy production capabilities should be based on defined needs of target groups.
- The institutions should contain effective channels for the participation of fuelwood users and providers in all stages of planning for local communities.
- The institutions should permit *multisectoral cooperation*. Although the energy and forestry ministries are expected to continue to take a leading role in the planning process, other institutions (particularly those with extension capabilities) may be the most appropriate agency for implementing plans.
- The principle of sustainability in environmental, economic, and institutional terms should be fully integrated into the *procedures* of energy planning institutions. In many cases the public has accepted policies for sustainable energy development, but governments have paid insufficient attention to changing the operations of implementing institutions to account for the new policy directions.
- In some cases, reforming forestry institutions by creating self-financing forest commissions to supervise commercial operations may increase efficiency and effectiveness. In addition, some funds may need to be funneled to an agency that would help rural communities and individuals manage nongazetted forests, provide extension services to farmers on tree-planting and agroforestry techniques, and provide information on the market for forest products.

- The government should give control over local resources to local communities and support other local initiatives to increase forest resources.
- Positive action is needed to create effective *management structures* and to enhance *management skills* in parastatal, private, and nongovernmental organizations as well as government agencies.
- *Fuelwood planning* should become more flexible. Indigenous technical knowledge should be incorporated into the planning to complement the conventional expertise of national and external personnel.

The new policy approach concerns implementation as much as it does principles for sustainable planning. National governments should demonstrate a desire to create these mechanisms for implementation, perhaps with donor support.

SUMMARY

The fuelwood debate demonstrates that forest-sector policies must address events far beyond those inside forest areas. Indeed, events outside the forest, in agricultural areas and cities, often dictate the circumstances that create the fuelwood problems and condition the solutions to the problems. Nearly all fuelwood is consumed outside the forest, and a large proportion is produced outside the forest from trees and plants in the agricultural landscape. Similarly, many policy options (including some, such as urban fuel switching, which seek to address problems in woodland areas) are focused in nonforest areas. Fuelwood problems and policies thus should be seen as part of a wider land resource management policy.

From this viewpoint, the links between forest policies and policies in other spheres-energy, agriculture, and fiscal, for example-are a central issue. Fuelwood problems cannot be addressed by only one set of professional experts working in one ministry. Effective intersectoral institutional links must be established before viable fuelwood policies can be created and implemented.

These links will provide the context in which effective policy reforms can be introduced. Many of the technical interventions will prove ineffective without the introduction of policy reforms to permit effective markets to operate, to produce prices that reflect real costs, to change land tenure relationships, and to generate community participation. If the mistakes of the past are to be avoided, the government must review the proposed policy changes before making decisions about project investments.

Fuelwood problems and intervention opportunities are highly variable and specific to localities. There is no generic approach to these issues, and individual activities need to be incorporated into a strategic approach that sets the overall policy direction for a country or region, but has the potential to account for locally specific circumstances when detailed, local-level projects are designed.

In addition, fuelwood policies need to be set within the context of a sustainable development approach; the need for small-scale, long-term activities must be recognized, and principles of local control and participation enshrined in the planning process. Donor organizations must address the procedural reforms needed to permit the funding of small-scale projects over far longer time horizons and with greater devolution of control over project decisions. Small-scale in this sense refers to individual components of projects. The total effort for a country or region need not be small, but ways should be sought to encourage and support numerous small-scale activities by urban and rural communities and entrepreneurs.

ANNEX

A BRIEF TYPOLOGY OF FUELWOOD SITUATIONS

Fuelwood stress needs to be seen as part of a wider resource management crisis: it cannot be separated from the general development of specific localities. The same is true of solutions to these problems; generic approaches to planning are doomed to failure because they miss the diversity and complexity of these problems. This annex advances a typology of fuelwood situations based on the environmental and development characteristics of broadly similar regions within the third world.

The criteria for developing this typology are as follows:

- The biomass resource potential of different areas, equating to agro-climatic zones;
- The characteristic rural economy;
- Constraints on access to the resource base for fuel use by different sections of the local community;
- Exports of wood resources from the areas; and
- Structural changes affecting the fuelwood situation in a locality.

The following paragraphs run through a list of characteristic fuelwood situations, based on these factors.

1. *High Woody Biomass/Low Population Density:* These areas consist mostly of moist tropical forests and woodlands with pockets of clearance but large areas of climax vegetation, such as Amazonia, Zaire Basin, Indonesia, and isolated areas of Southeast Asia, West and southern Africa, and tropical islands. The potential supply of fuelwood in these areas is greater than demand, but fuelwood stress can be associated with large development and sudden population influxes. Localized problems can be addressed through the management of natural woodland areas or the encouragement of multipurpose tree cultivation on private farmland.

2. *High Woody Biomass/Medium to High Population Density:* These areas typically have a complex mosaic of land uses; intensive farming may coexist with vestigial woodland areas. The areas include

coastal/island localities of South and Southeast Asia, the Caribbean, West Africa, and Central America, and inland zones such as the East African Highlands and parts of southern China. Most of the farmland is privately owned; large plantations, largely of tree or shrub-based crops, are common. Tree crops are an important part of the production system. Fuelwood problems are common, especially where population densities are high or land is unevenly distributed. Communal areas can be under severe stress as woodlands are cleared for agriculture. Land tenure and gender are key issues. For those areas with secure land tenure, the best option is farm forestry or agroforestry, based on multipurpose tree production. For tenants and landless groups, policy reforms to improve access to common property resources, where these exist, or to private farmlands should be examined.

3. *Medium Woody* Biomass/Medium *to* High *Population Density:* These areas consist of river plains and deltas, drier coastal plains, and inland areas, including the Indo-Gangetic Plain, China, South America, and Africa. They are characterized by intensive arable production, mainly through peasant farming, and large-scale cash-crop production. Landlessness is common and poverty is endemic; so are fuelwood problems. Residues are often the main fuel. Policy options aimed at the landed class center on encouraging private tree planting and better use of residues. For the poor, indirect strategies, conservation, and measures to improve management of land resources are likely to offer the best opportunities.

4. Low Woody Biomass/Low Population Density: These areas include the montane areas of the Himalayas, the Andean and Ethiopian plateaus, Lesotho, and the southern Arabian peninsula. Substantial woodland clearance, especially in valleys and lower slopes, is common. So are complex mosaics of land use. Many areas are extremely remote. Fuelwood problems are widespread and acute, especially where agriculture is found on more marginal woodlands and where out-migration has made the maintenance of traditional land management practices, such as terracing, more difficult. The acute poverty and remoteness of these regions exacerbate all problems, including fuel provision. The best policy opportunities are in improved management of existing land uses, both on small farms and in the remaining areas of natural woodland.

5. Low Woudy *Biomass/Low Population Density:* These areas consist of the semiarid and arid areas of Central Asia; northern China; the Indian subcontinent; the Saharan and Sahel/Sudan belts; central, eastern, and southern Africa; and Latin America. The economy is dominated by pastoralism, with some isolated peasant farming. There are fuelwood problems in areas where traditional land management systems are still workable, but resource stresses are common in many places. Fuelwood is a less serious problem than many others. The key to these areas is the management of existing land systems, particularly action to permit the reestablishment of woodlands in areas where they have been degraded and the support of communal management systems. Integration of trees into the spreading areas of cultivation will provide additional fuel resources and have other environmental benefits.

6. *Urban Areas:* In urban areas, use of fuelwood is common, but it is based on commodity relationships. The importance of wood and charcoal as fuels varies with the size of the urban area, the prosperity of the population, and the availability of commercial alternatives. The use of fuelwood in cities generally has a negative impact on the rural supply areas. Policy options center on fuel-switching strategies, which require action to improve market structures for commercial fuels such as kerosene and LPG.

7. *Transition Zones:* The boundaries between environmental zones are not sharp lines; there are invariably transition zones through which one dominant set of conditions gives way to another. Within these zones, environmental conditions tend to be particularly vulnerable to disruption, and change in both the economic and environmental landscapes may be rapid. Fuelwood problems are often serious in these transition zones precisely because they are marginal. Moreover, because these areas are so complex and heterogeneous, attempts to identify prescriptive policy options are futile. In areas affected by urban fuelwood demand, fuel-switching or conservation strategies in the city are often the best way to protect the rural environment. Similarly, in agricultural colonization zones, agroforestry, extension services, land-tenure policies, and communal management of natural woodlands can play crucial roles in developing agricultural systems, both in the home and the colonization areas.

REFERENCES

Agarwal, B. 1986. Cold *Hearths and Barren Slopes.* London: Zed Press.

Alam, M., J. Dunkerley, K.N. Gopi, W. Ramsay, and E. Davis. 1985. *Fuelwood in Urban Markets: A Case Study of Hyderabad. New* Delhi: Concept Publishing Co.

Armitage, J., and G. Schramm. 7989. "Managing the Supply of and Demand for Fuelwood in Africa." In *Environmental Management and Economic Development,* eds. G. Schramm and J. Warford. Baltimore: Johns Hopkins University Press.

Arnold, M., A. Bergman, and P. Harris. 1987. "Evaluation of the SIDA Supported Social Forestry Project in Ortissa, India." Swedish International Development Authority.

Bajracharya, D. 1980. "Fueiwood and Food Needs Versus Deforestation: An Energy Study of a Hill Village Panchayat in Eastern Nepal." *Energy for Rural Development RSI Program Report* PR-80-2. Honolulu: East-West Resource Systems Institute, East-West Center.

Bajracharya, D. 1983. "Deforestation in the Food/Fuel Context: Historical and Political Perspectives from Nepal." *Mountain Research and Development* 3(no. 3):227–40.

Bandyopadhyay, J., and V. Shiva. 1987. "Chipko: Rekindling India's Forest Culture." *Ecologist* 17:26–34.

Barnard, G., and L. Kristofersen. 1985. *Agricultural Residues as Fuel in the Third World*. London: Earthscan Publications.

Barnes, D.F. 1986. "Understanding Fuelwood Prices in Developing Nations." Agriculture and Rural Development Department, World Bank, Washington, D.C.

_______ 1990. "Population Growth, Wood Fuels, and Resource Problems in Sub-Sahara Africa." Energy Series Paper No. 26. Washington, D.C.: World Bank.

Barrow, E. 1988. *Trees and Pastoralists: The Case of Pokot and Turkana*. ODI Social Forestry Network, Paper No. 6b.

Bird, N., and G. Shepherd. 1988. *Charcoal in Somalia*. London: ODA.

Bowonder, B., S. I'rasad, and N. Unni. 1987. "Deforestation Around Urban Centres in India." *Environmental Conservation* 14:23–28.

Bradley, I'., N. Chavangi, and H. Van Gelder. 1985. "Development Research and Energy Planning in Kenya." *Ambio* 14:228–36.

Briscoe, J. 1979. "Energy Use and Social Structure in a Bangladesh Village." *Population and Development Review* 5:615–42.

Bromley, D.W., and M.M. Cernea. 1989. "The Management of Common Property Natural Resources: Some Conceptual and Operational Fallacies." World Bank Discussion Paper No. 57. Washington, D.C.: World Bank.

Byer, T. 1987. "Review of Household Energy Issues in Africa." World Bank. Unpublished manuscript.

Catterson, T.M. 1984. "The AID Forestry Program in Africa: A Status Report." Paper presented at USAID Bureau Forestry Program Evaluation Workshop, Lome, Togo, May 7-11.

Christiansson, C. 1988. "Degradation and Rehabilitation of Agropastoral Lands: Perspectives on Environmental Change in Tanzania." *Ambio* 17:144–52.

Ciriacy-Wantrup, S., and R. Bishop. 1975. "Common Property as a Concept in Natural Resource Policy." *Natural Resources Journal* 15:713–29.

Clarke, H.R., and R.M. Shrestha. 1989a. "Traditional Energy Programs and the Theory of Open Access Forest Resources." *Energy Journal* 10:139–55.

_______ 1989b. "Traditional Energy Programs with an Open Access Forest Resource: Policy Implications." *Energy journal* 10:45–57.

Cline-Cole, R.A., H.A.C. Main, and J.E. Nichol. 1990. "On Fuelwood Consumption, Population Dynamics and Deforestation in Africa." *World Development* 18:513–27.

Dewees, P.A. 1989. "The Woodfuel Crisis Reconsidered: Observations on the Dynamics of Abundance and Scarcity." *World Development* 18:513–27.

Dowd, J. 1989. "The Urban Energy Transition and Interfuel Substitution in Developing Countries: A Review of the Literature." World Bank. Unpublished report.

Dunkerley, J., M. Macauley, M. Naimuddin, and P.C. Agarwal. 1990. "Consumption of Fuelwood and Other Household Cooking Fuels in Indian Cities." *Energy Policy* 18:92–99.

Eckholm, E., G. Foley, G. Barnard, and L. Timberlake. 1984. *Fuelwood: The Energy Crisis That Won't Go Away*. London: Earthscan Publications.

Elkan, W. 1988. "Alternatives to Fuelwood in African Towns," *World Development* 16:527–33.

Energy/Development International. 1986. "Economics and Organizational Aspects of Private Tree Farming in Increase Fuelwood Production in Developing Countries." A report submitted to USAID per Grant No. LAC-5728-G-SS-4075-00.

Energy Sector Management Assistane Program (ESMAP). 1990a. Indonesia: *Urban Household Energy Strategy*. ESMAP Report No. 107A/90. Washington, D.C.: World Bank.

_______ 1990b. *Zambia: Urban Household Energy Strategy*. ESMAP Report Washington, D.C.: World Bank.

ETC. 1987. *SADCC Fuelwood Study*. Leusden, The Netherlands: ETC Foundation.

Fearnside, P. 1986. "Spatial Concentration of Deforestation in the Brazilian Amazon." *Ambio* 15:74–81.

———. 1989. "The Charcoal of Carajas: A Threat to the Forests of Brazil's Eastern Amazon Region." *Ambio* 18:141–43.

Feder, G., T. Onchan, Y. Chalamwong, and C. Honglabarom. 1988. *Land Policies and Farm Productivity in Thailand.* Baltimore: Johns Hopkins University Press.

Fitzgerald, K., G. McGranahan, and D. Barnes. 1990. "Interfuel Substitution and Changes in the Way Households Use Energy: Estimating Changes in Cooking and Lighting Behavior in Urban Java." Washington, D.C.: World Bank, processed.

Floor, W. 1987. "Household Energy in West Africa." Washington, D.C.: ESMAP, World Bank, processed.

———. 1988. "Why Bother about Household Energy?" In *Proceedings of the ESMAP Eastern and Southern Africa Household Energy Planning Seminar, 727-33.* Washington, D.C.: World Bank.

Foley, G. 1986. "The Economics of Fuelwood Substitutes." *Unasylva* 38:12–20.

———1987. "Exaggerating the Sahelian Fuelwood Problem?" *Amhio* 16:367–71.

———. 1988. "Discussion Paper on Demand Management." In *Proceedings* of *fhe ESMAP Eastern and Southern Africa Household Energy Planning Seminar,* 61-84. Washington, D.C.: World Bank.

Foley, G., and P. Moss. *1983. Improved Cooking Stoves in Developing Countries.* London: Earthscan Publications.

Fonzen, P., and E. Oberholzer. 1989. "Use of Multipurpose Trees in Hill Farming Systems in Western Nepal." In *Agroforestry Systems in the Tropics,* rd. P. Nair. Dordrecht: Kluwer Academic Publishers.

Freeman, P.H., and T. Resch. 1986. "Large Plantations of Rapidly Growing Exotic Species: Lessons from the Bandia, Senegal." *Rural Africana* 23–24:87–93.

French, D. 1986. "Confronting an Unsolvable Problem: Deforestation in Malawi." *World Development* 14(No. 4):531–40.

George, S. 1988. A *Fate* Worse Than Debt. Harmandsworth: Penguin Books.

Gill, J. 1987. "Improved Stoves in Developing Countries: A Critique." *Energy Policy,* (April):135–44.

Goodman, G.T. 1987. "Biomass Energy in Developing Countries: Problems and Challenges." *Ambio* 16:111–19.

Gregersen, H., S. Draper, and D. Elz. 1989. "People and Trees: The Role of Social Forestry in Sustainable Development." Washington, D.C.: Economic Development Institute, World Bank.

Heermans, J. 1986. "Implications for Managing Sahelian Brushland." Paper presented to World Bank Workshop on Desertification Control and Renewable Resources Management, Oslo.

Heermans, J., and G. Minnick. 1987. "Guide to Forest Restoration and Management in the Sahel." Niamey, Niger: Ministry of Hydrology and the Environment, Forestry Land Use and Planning Project.

Hyde, W.F., and D.E. Mercer. 1990. "Valuing Fuelwood for Urban Areas in Developing Nations: A Methodology for Analyzing Urban Energy Policies." Washington, D.C.: Industry and Energy Department, World Bank.

IPC. 1989. "The Malawi Charcoal Project: Experiences and Lessons." Frankfurt: Interdisziplinaere Project Consult.

Islam, M.N. 1987. "Rural Energy and Rural Development." University of Reading Geographical Paper No. 99, Reading, England.

Ives, J. 1987. "The Theory of Himalayan Environmental Degradation: Its Validity and Application Challenged by Recent Research." Mountain *Research and Development* 7:189–99.

Johnson, V., and K. Tompkins. 1989. "Fuelwood Scarcity in Swaziland." *International Journal of Ambient* Energy 10:59–1 02.

Joseph, S. 1987. "An Appraisal of the Impact of Improved Wood Stove Programmes: Synthesis of Experience." In *Stoves for People.* Proceedings of International Workshop, Guatemala, October 1987. Utrecht: Foundation for Woodstove Dissemination (cited in Leach and Mearns 1988).

Leach, G. *1986. Household Energy in South Asia.* London: International Institute for Environment and Development.

———*1987. Household Energy in* **South** *Asia.* London: Elsevier Applied Science.

———. 1988. "Interfuel Substitution." In *Proceedings of the ESMAP Easfern and Southern Africa Household Energy Planning Seminar.* Washington, D.C.: World Bank, pp. 92–120.

Leach, G., and M. Gowen. 1987. *Household Energy Handbook: An Interim Guide and Reference Manual.* World Bank Technical Paper No. 67. Washington, D.C.: World Bank.

Leach, G., and R. Mearns. 1988. *Beyond the Woodfuel Crisis: People, Land, and Trees in Africa.* London: Earthscan Publications.

McGrath, W.B. 1989. "The Challenge of the Commons: The Allocation of Nonexclusive Resources." Environment Department Working Paper No. 14. Washington, D.C.: World Bank.

Mahat, T., D. Griffin, and R. Shepherd. 1986. "Human Impact on Forests of the Middle Hills of Nepal." *Mountain Research and Development* 6:223–32.

McGranahan, G. 1486. "Searching for the Biofuel Energy Crisis in Rural Java." Ph.D. dissertation, University of Wisconsin-Madison.

Mercer, D.E. 1990. "Economics of Agroforestry." In *Agroforestry and the Social Sciences,* eds. W. Bentley and W. Burch. London: Oxford University Press.

___. 1991. "Application of Household Production Theory to Selected Natural Resource Problems in Less Developed Countries." Ph.D. dissertation, Duke University, Durham, N.C.

Moench, M. 1989. "Forest Degradation and the Structure of Biomass Utilization in a Himalayan Foothills Village." *Environmental Conservation* 16:137–46.

Monbiot, G. 1989. "The Transmigration Fiasco." *Geographical Magazine* (May):26–30.

Munslow, B., Y. Katerere, A. Firf, and P. O'Keefe. 1988. *The Fuelwood Trap.* London: Earthscan Publications.

O'Keefe, P., and B. Munslow. 1988. "Resolving the Irresolvable: The Fuelwood Problem in Africa." In *Proceedings of the ESMAP Eastern and Southern Africa Household Energy Planning Seminar.* Washington, D.C.: World Bank, pp. 25–50.

Openshaw, K., and C. Feinstein. 1989. "Fuelwood Stumpage: Considerations for Development Country Energy Planners." industry and Energy Department Working Paper. Washington, D.C.: World Bank.

Panayotou, T. 1989. *The Economics of Environmental Degradation: Problems, Causes, and Responses.* Washington, D.C.: U.S. Agency for International Development.

Pearce, D., and R.K. Turner. 1990. *The Economics of Natural Resources and the Environment.* London: Harvester/Wheatsheaf.

Pearce, D., A. Markandya, and E. Barbier. 1989. *Blueprint for a Green Economy.* London: Earthscan Publications.

Pellek, R. 1983. "Depletion of the Mauritanian Forest." *Journal of Forestry* (May):320–21.

Perlack, R.D., R.B. Shelton, and A. Sabadell. "Fuelwood Substitutes and Increased Fuelwood Supplies: An Examination of Issues and Evidence." Draft. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Pitt, M.M. 1985. "Equity Externalities, and Energy Subsidies: The Case of Kerosene in Indonesia." *Journal of Development Economics.* 17:201-1 7.

Redclift, M. 1987. Sustainable Development: *Exploring the Contradictions.* London: Methucn.

Repetto, R. 1988. "Economic Policy Reform for Natural Resource Conservation." Environment Department Working Paper No. 4. Washington, D.C.: World Bank.

Robinson, P., and I. Thompson. 1989. "Fodder Trees, Nurseries, and Their Central Role in the Hill Farm Systems of Nepal." ODI Social Forestry Network, Paper 9a.

Runge, C.F. 1981. "Common Property Externalities/Isolation, Assurance, and Resource Depletion in a Traditional Context." *American Journal of Agricultural Economics* 67:368–72.

Ryan, P. 1990a. "ESMAP: Woodfuels Development Strategy." Washington, D.C.: ESMAP, World Bank, processed.

___. 1990b. "India: Woodfuel Supply Situation." Washington, D.C.: ESMAP, World Bank, processed.

Saxena, N. 1987. "Commons, Trees and the Poor in the Uttar Pradesh Hills." ODI Social Forestry Network, Paper 5f.

Shepherd, G. 1988. "The Reality of the Commons: Answering Hardin from Somalia." ODI Social Forestry Network, Paper 6d.

Shiva, V. 1981. "Social, Economic and Ecological Impact of Social Forestry in Kolar." Bangalore, India: Indian Institute of Management.

Singh, J., U. Pandey, and A. Tiwari. 1984. "Man and Forests: A Central Himalayan Case Study." *Ambio* 7 3:80–87.

Smil, V. 1983. "Deforestation in China." *Ambio* 12:226–31.

Smith, K. 1983. "Biomass Combustion and Indoor Air Pollution: The Bright and Dark Sides of Small Is Beautiful." In *Proceedings of the Conference on Biomass Energy Management in Rural Areas.* Paris: UNESCO.

Soussan, J. 1984. "Fuelwood Strategies and Action Programmes in Asia." Bangkok: AIT.

———. 1988. Primary Resources and Energy in the Third World. London: Routledge.

———. 1990a. "Common Issues and Processes in African Energy Policy." The Netherlands Ministry of Foreign Affairs, Directorate General for International Cooperation, The Hague.

———. 1990b. "Alternative Energy Supplies for Urban Areas in Somalia." Report to the Overseas Development Administration (ODA), London.

Soussan, J., and P. O'Keefe. 1986. *Energy and Urbanization in Kenya.* Stockholm: Beijer Institute.

Soussan, J., E. Mercer, and P. O'Keefe. 1991. "Funding Local Answers to Fuelwood Problems." Natural Resources Forum.

Soussan, J., P. O'Keefe, B. Munslow. 1990. "Urban Fuelwood: Challenges and Dilemmas. *Energy Policy*, July/August.

Southgate, D. 7988. "The Economics of Land Degradation in the Third World." Environment Department Working Paper No. 2. Washington, D.C.: World Bank.

Spears, J. 1988. "Containing Tropical Deforestation: A Review of Priority Areas for Technological and Policy Research." Environment Department Working Paper No. 9. Washington, D.C.: World Bank.

Susman, P. 1985. *Energy and Development in Island* Economies. Stockholm: Beijer Institute.

Teplitz-Sembitzky, W., and G. Schramm. 1989. "Woodfuel Supply and Environmental Management." Industry and Energy Department Working Paper No. 19. Washington, D.C.: World Bank.

Tyler, C. 1990. "The Sense of Sustainability." *Geographical Magazine* (February):8–13.

Wardle, P., and M. Palmieri. 1981. "What Does Fuelwood Really Cost?" *Unasylva* 33:20–23.

World Bank. 1986. "Deforestation, Fuelwood Conservation, and Forest Conservation in Africa: An Action Program for FY86–88." Washington, D.C.: Agriculture and Rural Development Department, Operations Policy Staff, World Bank.

———. 1987. "Review of Household Energy Issues in Africa." Washington, D.C.: Energy Department, World Bank.

World Bank/ESMAP. 1990. "Niger: Household Energy Strategy." Washington, D.C.: World Bank.

World Bank/UNDP. 7988. "Tanzania Woodfuel/Forestry Project." Activity Completion Report No. 086/88. Washington, D.C.: World Bank.

World Resources Institute. 1990. *World Resources 1990–91.* Washington, D.C.: World Resources Institute