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INDUSTRY AND ENERGY DEPARTMENT WORKING PAPER
ENERGY SERIES PAPER No. 38

Improving Charcoaling Efficiency in the Traditional Rural Sector

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Title: IMPROVING CHARCOALING EFFICIENCY
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IMPROVING CHARCOALING EFFICIENCY IN THE TRADITIONAL RURAL SECTOR

by

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July 1991

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Abstract

Burgeoning urban populations and incessant rural land clearing threaten the sustainability of supply of charcoal, the principal urban cooking fuel of Sub-Saharan Africa and much of the Third World. Supply efficiency improvements, such as the promotion of improved charcoal kilns, are one option to reduce urban household energy supply pressures. However, a major conclusion derived from a review of international experience is that technical interventions alone are insufficient, especially if introduced in the absence of an adequate incentive framework. The paper thus also discusses complementary supply enhancement measures, and recommends institution of community-based natural forest management schemes financed through user fees and taxes.

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ACRONYMS

Ha	hectare = 10,000 m ²
LPG	Liquid Petroleum Gas
Mcwb	moisture content, wet basis
MINAGRI	Ministère de l'Agriculture, de l'Élevage et des Forêts
MINITRAPE	Ministère des Travaux Publics, de l'Énergie, et de l'Eau
NEB	National Energy Board
Stère	1 stacked m ³
Tonne	1000 kg

INTRODUCTION 1/

Burgeoning urban populations and incessant rural land clearing threaten the sustainability of supply of charcoal, the principal urban cooking fuel of Sub-Saharan Africa and much of the Third World. The causality question, continuously debated by energy and forestry planners, is immaterial to the truth of this proposition. That is, whether urban charcoal demand is driving deforestation or agriculturally motivated deforestation is stripping fuelwood stocks, the end consequences are the same: a declining ratio of biomass resource per charcoal consumer.

The direction of causality matters, of course, for integrated energy-environment policy. The proposed solutions will vary, because effective measures to "the biomass energy problem" will cut across many disciplines including agriculture, forestry, rural development, economics and sociology. But from an admittedly narrow energy perspective, the message resembles the pitch of the appliance merchant selling on credit: "You can pay now, or you can pay later. But you'll pay more later."

Woodfuel-dependent developing countries can "pay" in many ways:

- Conversion efficiency improvement (e.g., improved charcoal kilns);
- Supply enhancement (tree planting, forest management);
- Demand management (improved charcoal stoves and cooking practices); and
- Inter-fuel substitution (e.g., kerosene or LPG for charcoal)

In the long-run, substitution is destined. Historically, every society has shifted from wood to modern fuels in parallel with structural transformation of the economy and increasing incomes. Yet the analogy is apt. Living on borrowed money often makes good sense, provided one makes changes in spending and saving patterns now to enable future retirement of debts. Countries failing to take some combination of the above four measures lose control over the fuels transition process. In lieu of stretching out the availability of domestic woodfuel resources through sustainable management, wood capital-depleted nations are left with very limited options: rapid and large-scale substitution. The macroeconomic costs may be more than a country might wish to pay, or more than it can afford. This would seem especially true in Sub-Saharan Africa, where the rate of forest resource depletion has, unfortunately, typically exceeded the growth rate of per capita incomes.

This paper focuses on the first of the above measures, improvement of the efficiency of wood-to-charcoal conversion. Specifically, it centers on means and potential for raising the technical

1/ The present paper is an revised version of a paper presented at the "Workshop on Sustaining Charcoal Production in Ghana -- Issues and Strategies," University of Science and Technology, Kumasi, Ghana, November, 1990. The workshop was organized by the Ghana National Energy Board with support from the Energy Sector Management Assistance Program.

efficiency of the carbonization 2/ process in traditional rural environments. A major conclusion is that improvements could be achieved, but that technical interventions alone are insufficient. The paper thus also deals with measures in the second category, supply enhancement, albeit superficially. Demand management and substitution are neglected not for reasons of relative importance, but for limitations of time, expertise and scope.

The knowledge base is the comparative experience of four countries (Senegal, Rwanda, Jamaica and Ghana) participating in internationally-assisted charcoal production improvement programs. The first country was a partner in a UN/FAO project (Karch 1987). The latter three were involved in ESMAP 3/ pre-investment activities (ESMAP 1987, 1988, 1990). Their experiences are summarized in the Annex. Significantly, no World Bank loan project has financed large-scale dissemination of improved techniques for traditional rural sector charcoal production. 4/ The paper's exclusion of coverage of domestically-sponsored efforts is not by desire. It is simply more time-consuming and costly to obtain information about such programs, as results are usually not as widely broadcast as the internationally-assisted projects.

Finally, an advance apology for some gross over-generalizations. A famous American politician (former House Speaker Tip O'Neill) once said that all politics are local. Similarly, all deforestation is a localized phenomenon. What is true for the east end of even the small island country of Jamaica would probably not hold for the west side.

Characteristics of Traditional Rural Production

The term "traditional rural production" has been carefully chosen to denote a specific charcoal supply system, but one that is very commonly found in the Third World. Different modes of production exist, of course, but would be susceptible to radically different technical and organizational interventions. Three basic characteristics define the traditional, rural production system.

First, production is for the urban household market, as opposed to industrial or export uses (the latter markets may demand higher quality standards and different physio-chemical properties for charcoal). Household consumption of charcoal in Africa is an urban phenomenon, confined to cities and small towns. Only very small quantities are typically consumed in rural villages or by the producers themselves. Thus, in a substantial part of the developing world, charcoal can be correctly termed a "cash crop."

2/ Carbonization: The process whereby wood is converted into charcoal in an oxygen-limited environment. Technically referred to as pyrolysis.

3/ Energy Sector Management Assistance Program. A joint UNDP/World Bank/Bilateral Aid pre-investment and technical assistance facility executed by the Bank's Industry and Energy Department.

4/ Based on reviews of Bank Staff Appraisal Reports and interviews with selected task managers covering charcoal components of projects in Burundi, Ethiopia, Madagascar, Malawi and Tanzania. The Burundi project did pilot training activities; Tanzania is nearing the end of comparative kiln testing and demonstration. The other three involve large-scale land clearing, plantation and thinning schemes.

Secondly, the location of the wood feedstock is highly scattered. The main sources of supply (in rough order of importance) are communal/traditional woodlands and state forests, followed by private farmlands and small-scale woodlots. Large plantations and other dense, intensively cultivated wood aggregations are conspicuous by their absence, apart from trials in a few countries. ^{5/} The overwhelming majority of charcoalers ^{6/} are by consequence highly mobile, as are their kilns. This eliminates the introduction of brick kilns, as an important example, and other efficient but stationary technologies.

Lastly, the techniques employed are time-tested and traditional, usually earth mound and earthen pit kilns. Befitting relative factor availability, the technology is labor intensive and very low capital.

^{5/} e.g., Malawi, Madagascar, Burundi.

^{6/} Charcoalers are usually poor peasants, and their lack of cash or access to sources of financing reduce the efficiency of their operations. In Ghana and Senegal, they often belong to specialized groups with a long standing history of charcoal making. In Rwanda and Jamaica, there is no such experience: charcoalers there are usually self-employed and have to make arrangements with wood owners each time they want to produce charcoal in a different stand of wood.

I. TECHNICAL MEASURES FOR IMPROVED EFFICIENCY

1.1 The introduction of essentially technical measures sometimes leads to improvements in charcoaling efficiency. 2/ The range of potential improvement varies considerably, as shown in Table 1 which summarizes results of comparative testing in controlled and field environments from five countries. The range of improvement thus far realized ranges from 5% to over 40%. Charcoal yields may be boosted by the additive application of three techniques: drier wood input, better process control, or larger kilns. It is difficult to quantify the relative benefits of these three techniques, however, without better process control the other two are not likely to be as effective as possible and for the best results all three should be applied simultaneously. These techniques and associated constraints are discussed in the following paragraphs.

TABLE 1

Comparative Charcoaling Yield
Traditional vs Casamance Kiin

Country	Traditional	Casamance	Relative Gain
Senegal (tests)	15% - 20%	20% - 30%	40%
Rwanda (tests)	14%	19% - 25%	75%
Rwanda (in field)	7% - 9%	13% - 22%	>40%
Jamaica 1 (tests)	15% - 17%	17%	5%
Jamaica 2 (tests)	22%	23%	5%
Ghana (tests)	22%	25%	15%
Ghana (in field)	17%	20%	15%
Tanzania (tests)	19%	23%	20%
Burundi (tests)	14%	20%	43%

2/ "Charcoaling efficiency" as here applied is defined as the ratio of the air-dry weight of the charcoal output to the air-dry weight of the wood input. This relates only approximately to energy efficiency since it is always possible to increase yield by weight by making a charcoal with a different fixed carbon content. However, the criterion is relevant in terms of "forest efficiency," the amount of tree matter needed to produce a unit of marketable charcoal.

Dry Wood Feedstock

1.2 The effect of wood drying on charcoaling efficiency can be simply stated: The drier the wood, the higher the yield. An understanding of why this should be so can be garnered by reviewing the principles of carbonization (Figure 1). Wood pyrolysis is a four stage sequential process of ignition, wood dehydration, carbonization (an exothermic reaction phase), and cooling. The exothermic phase will not start until all the water in the charge is driven out through evaporation. It takes heat energy from burning wood to evaporate the water; less wood is therefore available to be converted to charcoal during the carbonization phase.

1.3 In addition, if yield is measured on a wet or air-dry (as opposed to oven or bone-dry) basis (weight of charcoal output divided by wet weight of wood input), water increases the weight of wet wood in the denominator of the charcoal yield equation. This further depresses the apparent yield.

1.4 Knowing the specific heat and heat of evaporation of water, and the high heating value of wood, it takes only some fairly simple calculations to figure out what fraction of the wood charge will be consumed for a given initial wood moisture content. The results have been published in tabular form by FAO (Earl 1975) and CSIRO (Gore 1982).

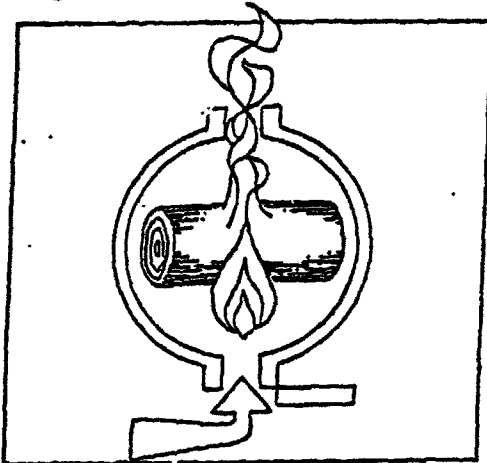
1.5 When plotted in Figure 2, the predicted effect on yield is linear with a slope of -0.38. That is, a 10% decrease in wood moisture content (wet basis) will cause a 3.8% increase in the kiln charcoal yield. Controlled tests of otherwise identical kilns in Jamaica (refer Figure 3) verified the relationship, with the outcomes of three out of four trials exactly matching theory.

1.6 It would seem to be an easy matter to realize these gains from using dry wood. Green wood at, say, 40% mcwb will dry to 20% mcwb in perhaps 30-45 days in a reasonably dry season. So a traditional kiln yielding 15% charcoal (air-dry basis) with green wood would increase output over 22.5% with the dried feedstock. This is not a trivial increment. The 50% productivity increase surpasses what could be expected from the introduction of improved kilns - such as the Casamance kiln - alone.

FIGURE 1

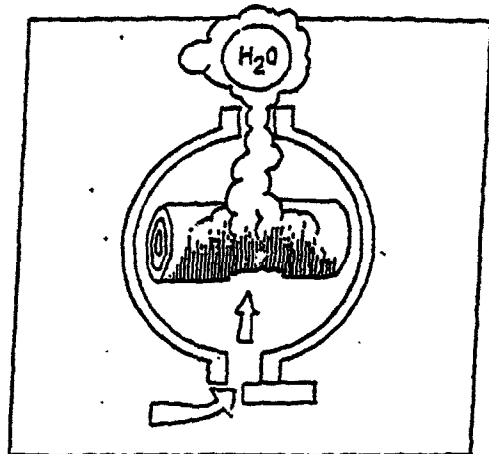
Principles of Carbonization

1. Ignition



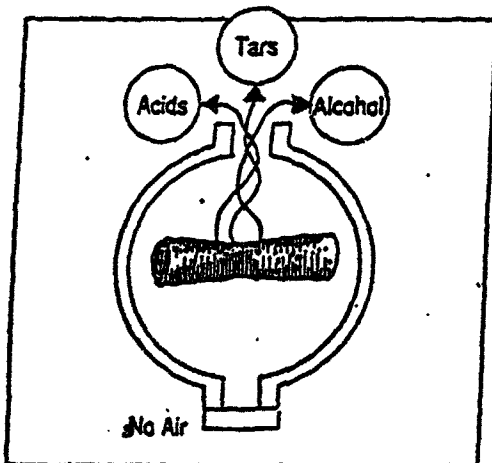
The kiln is lit, and the temperature rapidly rises.

2. Dehydration



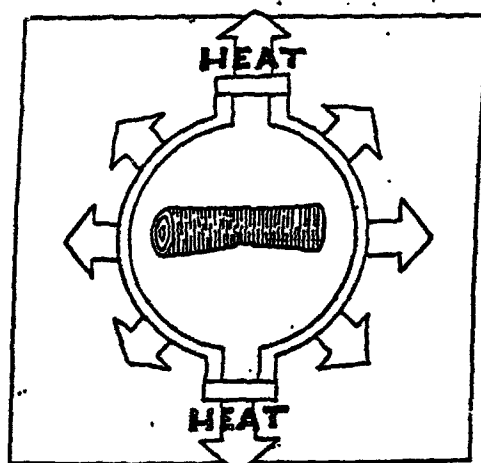
The heat of ignition starts the drying of the charge. As the process continues, the temperature rises.

3. Exothermic



When all the water is driven out, the wood begins to break down thus giving off heat. The process no longer requires external heat.

4. Cooling



Once the wood is carbonized, it must be cooled. This process stabilizes the charcoal and allows for easy handling.

1.7 However, the problems of introducing this practice in the rural sector are also non-trivial. Education and demonstration will be needed to reverse the widely held traditional belief that live, green trees produce a denser, more marketable charcoal. Then too, a large stack of drying wood represents a considerable investment in working capital to charcoalers, many of whom lead a marginal, hand-to-mouth existence. In Rwanda, this barrier was surmounted by working with the relatively better off farmers as the tree growers and wood resource owners. Thirdly, there is the risk of larceny from praedial fellow charcoalers, not to mention the potential reduction in charcoal quality from termite boreholes. Finally, the drying wood piles are an obvious tip-off to the forest control and revenue authorities, with whom charcoalers generally desire to minimize contact.

Improve Process Control

1.8 Observations made in the 1970s of traditional earth kilns revealed a number of design and operational features which are at variance with accepted thermodynamic principles of charcoal-making. These characteristics, thought to contribute to lowered charcoal yields, include:

(1) *Wood stacking* - Large and small wood pieces are distributed rather randomly throughout the kiln;

(2) *Air circulation* - While carbonization is an anaerobic process, high heat value combustion and pyrolytic gases are given off and are poorly circulated in the kiln; and

(3) *Burn-throughs* - Due to poor kiln covering and irregular surveillance, traditional kilns frequently "flare up," destroying part of the wood charge.

1.9 The commonly advocated solution to the above process control problems is the so-called Casamance kiln, named after the region in Senegal where it was developed. As shown in Figure 3, the Casamance kiln employs:

(1) A logical method of wood stacking whereby slow-to-carbonize large pieces are located near the center of the kiln, site of the greatest "heat mass";

(2) A radial platform, circumferential air chamber and updraft chimney to promote even gas circulation and propel a down-draft movement of air/gas; and

(3) Tight wood stacking and adequate vegetation/earth covering to minimize kiln collapse and air holes. In addition, the fast carbonization speed of the Casamance kiln (up to four times traditional kilns of the same size) promotes closer supervision.

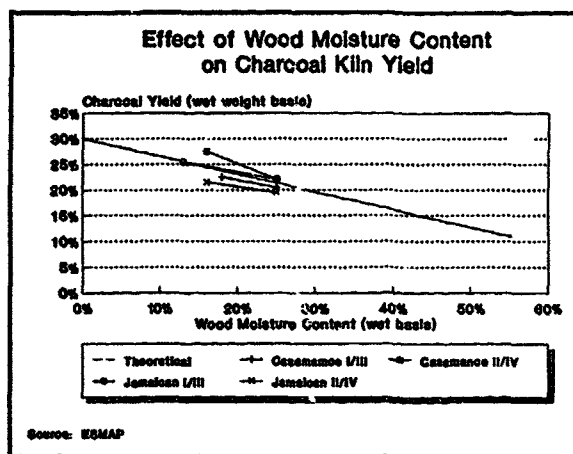
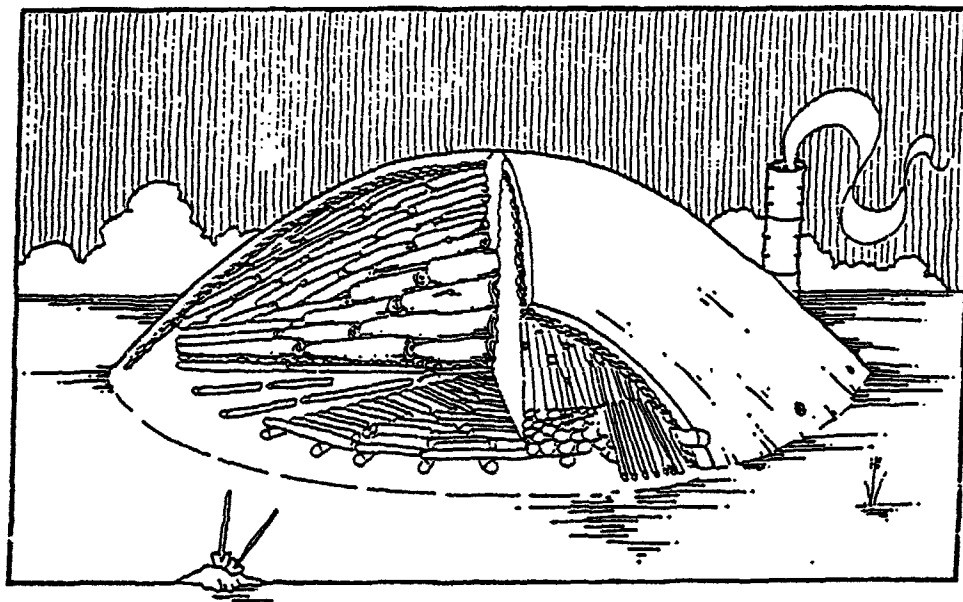


Figure 2

FIGURE 3

The Casamance Kiln



1.10 Other benefits than a higher efficiency may be obtained simultaneously, such as a better quality charcoal with a higher fixed carbon content, and thus a higher heating value. Even though this could have implications for consumer preferences, this will not be further addressed here since most consumers simply want an acceptable quality of charcoal for the lowest possible price.

1.11 In practice, a number of constraints have limited the spread of the Casamance method. In the first place, traditional charcoalers need to see clear advantages over their usual methods. These advantages could be expressed, among others, by higher revenues, larger charcoal output, less labour required, or a combination of several of such factors. Obviously, there also needs to be a government commitment and finance for large scale outreach programs to train charcoalers in the new methods. These extension programs will be able to function effectively only if the target group itself is effectively organized and convinced about the advantages; the implication is that time-consuming and staff-intensive background work is required even before outreach can begin. Then, it has been found that even the relatively low capital cost of the Casamance chimney (made from three used oil drums) presents a serious affordability barrier for traditional charcoal producers

producers. The mobility of the chimney itself has been a source of concern to charcoalers, who generally do not have the advantage of motorized transport from production site to site.

1.12 An anthropologically complex issue was encountered in Ghana related to the Casamance kiln's need for nighttime surveillance. The nomadic Sissala charcoalers expressed strong reluctance to monitor the kilns in the forest after dark, possibly because harmful spirits are embodied in the trees and come out by night ^{9/}. This phenomenon is not fully understood and it may well be that the charcoalers used these spirits as an argument for not accepting the Casamance method.

1.13 A final constraint to Casamance kiln adoption is the marketing or disposal of carbonization by-products (if collected), mainly tars and pyrolytic oils. These potentially environmentally noxious products literally go up in smoke in the case of traditional kilns, but may be condensed out in the Casamance chimney. The condensates have some marketability as a substitute for creosote in wood preservation, although this proposition has yet to be widely tested.

Increase Kiln Size

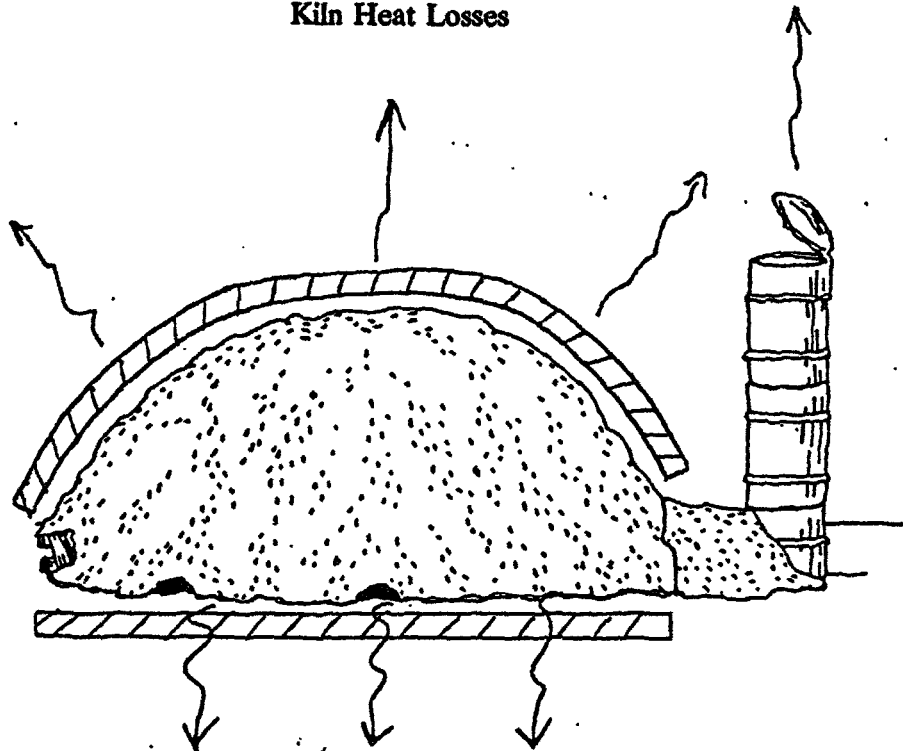
1.14 The effect of kiln size may also be simply stated: The bigger the kiln, the better the charcoaling efficiency, all other things being equal. ^{10/} The relationship may be approximated by modeling the heat losses in a typical mound type kiln, diagrammed in Figure 4. Heat will be lost to the ambient air by conduction and convection over the dome-like surface area of the kiln, and to the circular ground surface by conduction. In either heat transfer mode, heat loss will be proportional to the surface area of the kiln, which varies by the square of kiln diameter. The amount of wood in the kiln is proportional to kiln volume, a function of the cube of kiln diameter. The ratio of heat loss to carbonizable wood therefore decreases with increasing kiln size, indicating certain thermodynamic economies of scale.

^{9/} Traditional kilns are usually not supervised at night.

^{10/} More correctly, the *physical* charcoaling efficiency. Economic optimum, which depends on efficient labor utilization, occurs at between 60-100 stere (stacked m³) size for Casamance kilns (Karch, 1987).

FIGURE 4

Kiln Heat Losses



$$\dot{Q} = KA(T_c - T_a)$$

1.15 This relation is derived more formally on the following page and is plotted in Figure 5. The graph shows a rapid initial increase in theoretically predicted kiln efficiency, with the rate of increase slowing as the kiln size reaches its practical maximum.

1.16 Field measurements confirm the scale economy effect, with the most complete data sets coming from Senegal and Rwanda. Figure 6 shows the measured efficiency curve for Casamance kilns of varying size; the initial rate of increase is even higher than deduced from elementary engineering considerations alone. Recent tests in Rwanda on 100 kilns (Figure 7) demonstrate the effects rather neatly; for once, theory and practice merge!

DERIVATION OF CHARCOAL YIELD VS. KILN SIZE

$$\begin{aligned}
 \text{CHARCOAL OUTPUT} &= \boxed{\text{EFFICIENCY OF CARBONIZATION}} * \boxed{\text{VOLUME OF WOOD AVAILABLE FOR CARBONIZATION}} \\
 &= \text{EFFICIENCY OF CARBONIZATION} * \left[\left(\text{VOLUME OF CHARGE} \right) - \left(\text{VOLUME CONSUMED TO HEAT CHARGE} \right) \right] \\
 &= C * \left[K_1 r^3 - \underbrace{K_{c1} r^2}_{\text{Surface heat loss}} - \underbrace{K_{c2} r^2}_{\text{base heat loss}} \right] \\
 &= C * K_1 r^3 - K_c r^2 \\
 \text{YIELD} &= \frac{\text{CHARCOAL OUTPUT}}{\text{WOOD INPUT}} = \frac{C * [K_1 r^3 - K_c r^2]}{K_1 r^3} \\
 \text{YIELD} &= C - \frac{K_c * C}{r} \quad \text{NORMALIZED YIELD} = \frac{1 - \frac{K_c}{r}}{1}
 \end{aligned}$$

Legend:
 r - radius = diameter/2
 K_c, K₁ - constant
 C - carbonization efficiency (%)

1.17 The size of kilns constructed by rural charcoalers will be dictated by:

- (a) Access to wood and preparation tools (e.g. chainsaws);
- (b) Organization of labor;
- (c) Cash flow position of the charcoaler or the wood owner (a bigger kiln ties up money for a longer time);
- (d) Skill of charcoalers in controlling large kilns; and
- (e) Perceived risk level of losing the kiln charge due to "flare-up."

1.18 These parameters are quite rigidly fixed in traditional production systems, so success again becomes a function of overcoming barriers to socio-economic change.

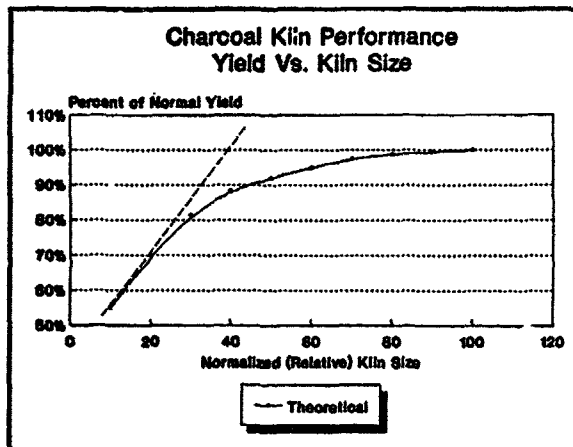


Figure 5

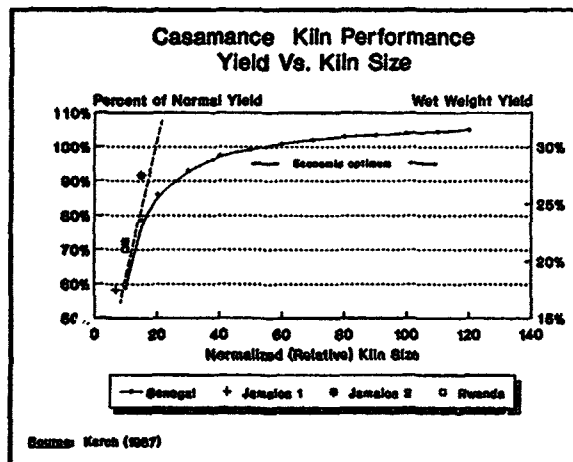


Figure 6

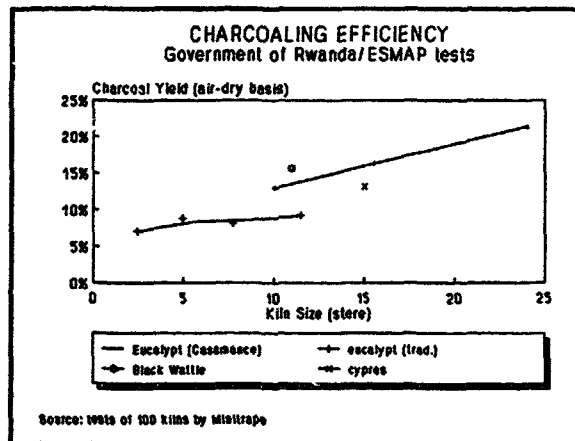


Figure 7

II. THE QUESTION OF INCENTIVES

2.1 The preceding discussion identified substantial scope for improvement, but substantial constraints as well. Consequently, the question of incentives becomes of paramount importance. In fact, the signal lesson from the sample country experience is that *improved charcoal production programs have better success when all of the following elements exist:*

- *Demonstrable benefits*, as appreciated by traditional charcoalers;
- *Rural credit or subsidy mechanisms* for making improved technology affordable;
- *Organized producers* obtaining a share of the output or other profit-sharing incentive;
- *An adequate legal framework* built around the mutual interests of local/traditional communities, regional authorities, and central government; and
- *Perceived wood scarcity*, as manifested through physical or economic indicators.

2.2 Without charcoalers being truly convinced of improved charcoal production techniques, no extension program will ever be effective. Without financing, the up-front cost of even low-capital innovations (such as the Casamance kiln) becomes unaffordable. Without organization, the interests of individual charcoalers are not adequately advanced to promote participation; the situation of the effectively disenfranchised Senegalese *sourghas* ^{11/} and individual Rwandan *charbonniers* ^{12/} serve as examples. Without legal status, the avenue for the exchange of usufructuary rights and stewardship responsibilities, central to the effective management of woodlands resources, is blocked. Also, if charcoalers are made to pay for the volume of wood converted into charcoal instead of the number of bags of charcoal produced, they would use wood resources more efficiently. And without perceived scarcity, charcoalers are not motivated to economize the use of or replace a shrinking wood resource relative to growing urban populations.

Signaling Wood Scarcity

2.3 This last incentive, wood scarcity, is of sufficient complexity and importance so as to warrant an expanded discussion. For most foresters or geographers, various physical aggregates are the relevant measures of wood scarcity, including the quantity of utilizable biomass resources, indicators of accessibility, growth rates, and maximum sustainable yields, all in proportion to the woodfuel-consuming population. From the economic viewpoint, the primary indicator of scarcity of marketed goods is their price.

^{11/} Traditional charcoalmakers primarily from the Fulani tribe in neighboring Guinea. Because of their status as foreigners, their indebtedness and the fact that administrative paperwork is handled by their employers, they are completely dependent on (and often exploited by) their patrons.

^{12/} They have to negotiate with wood owners to fix a price for the volume of wood used, but can hardly do the same with charcoal transporters as these unilaterally set the price according to the market conditions in Kigali.

2.4 Figure 8, based on ESMAP calculations using Rwanda data, suggests that wood price should influence charcoalers' choice of kiln technology. If charcoal producers are economically "rational," then a price of US\$ 0.75/stere represents a breakeven or indifference point between the traditional Earth Mound and Casamance kilns. If charcoal wood costs more than this price, incomes will be higher using the Casamance method, and *vice versa*.

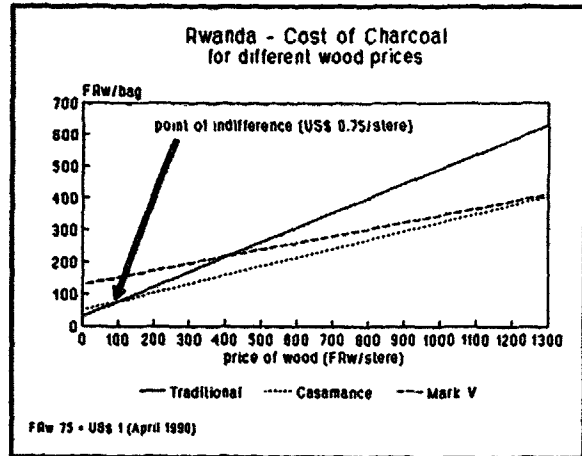


Figure 8

2.5 To give the reader a sense of scale, the Rwanda calculations are compared with estimated wood costs in Ghana, for example, in Figure 9. Through observation of cash and in-kind transactions between chiefs and Sissala charcoalers operating in the Transition/Savannah Zone, ESMAP and the Ghana National Energy Board (NEB) have estimated that charcoal wood is obtained at a price on the stump equivalent to US\$ 0.25/stere. In Rwanda, the government has enacted a ban on live tree felling in the most deforested zone which used to be the major charcoal producing area. An estimated 85% of charcoal is now made from smallholder and communal Eucalyptus plantation wood, costing about US\$ 4.00/stere to produce. ^{13/} It may be due to other factors, but Rwandan traditional *charbonniers* have quite readily taken up improved charcoal production techniques.

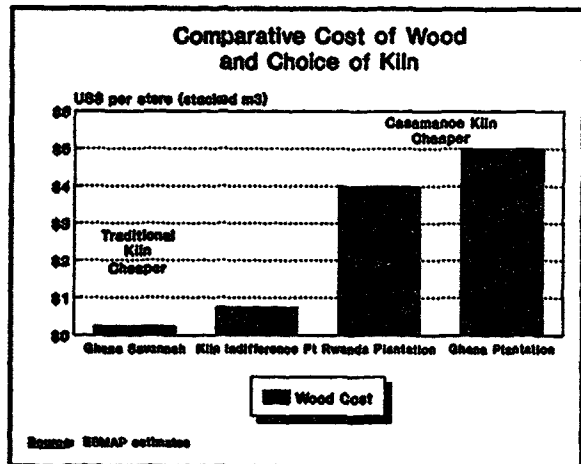


Figure 9

2.6 The natural scarcity hypothesis holds that wood price will rise in parallel with physical scarcity. However, it is argued in the following sections that a country's (or region's) entry into a condition of wood scarcity is not necessarily signaled to or perceived by woodfuel producers and consumers. If and when the perception becomes widespread, it occurs with a significant lag. At that time, it may be too late to meet household energy demands through intensified management of an already dwindled resource. This is the connection to the earlier quoted "...pay more later" analogy. As will be seen, there may be opportunities for resources policy-makers to initiate preemptive signaling measures in advance of the onset of true scarcity. These interventions take the forms of administrative fiat, quotas, and user fees.

^{13/} Rwanda is quite fertile and farmers employ efficient production techniques. For comparison, Pioneer Tobacco Company estimates a production cost of US\$ 5.00/stere for their plantations situated near Wenchi (Ghana).

Natural Scarcity

2.7 In the standard economic paradigm, scarcity is self-correcting. Over time, as demand rises or supply falls, the price and perceived scarcity of fuelwood smoothly increases. Consumers are thus induced to conserve or switch to alternative fuels; simultaneously, producers are motivated to plant trees or otherwise enhance supply. The supply/demand balance is thereby restored, and the scarcity "problem" turns out not to be a problem at all. Similar logic can be put forth for oil, bananas, and other commodities.

2.8 This model relies a number of assumptions, among them well-defined property rights, absence of monopoly elements, and free flow of information. That these suppositions are frequently violated in woodfuel markets is well known. The existence of seriously household energy-deficient areas such as Ethiopia or Mauritania is evidence that scarcity is not always self-righting.

2.9 An alternative characterization of urban woodfuel market behavior has been put forth by Douglas Barnes, and is based on plausible reasoning and woodfuels price time-series from over 30 countries. The hypothesis, illustrated graphically in Figure 10, divides the real woodfuels price path into three phases: relative abundance, growing scarcity, and significant scarcity. The key feature is the relative abruptness of the Phase 2 transition. In effect, prices flare up because tree stocks have been severely eroded with the rapid growth in demand. Fuelwood availability is pushed farther from the urban centers, and deforested rings may begin to appear around the city. Farmers and others begin to perceive the fuelwood scarcity, but trees continue to be harvested from savanna and farms to meet woodfuel needs, and there is no replanting.

Finally, in the third phase, the price of charcoal in the urban market reaches approximate parity with modern substitutes (e.g. kerosene). At this stage, farmers have more of an incentive to plant trees for woodfuels and other tree products (Barnes 1990).

2.10 However, rising prices alone are probably not sufficient to sustain spontaneous tree planting. Complementary programs, such as seedling distribution and forestry extension, as well as adequate forest product market information and public awareness, may be necessary. Because of the time lags involved in creating the incentives, the situation may become very severe before enough incentives develop to stimulate tree planting. Until tree stocks are depleted and biomass energy becomes unavailable locally, or until stumpage fees rise to more realistic levels, people will continue to harvest "free" fuelwood to satisfy household energy demands (Spears 1983).

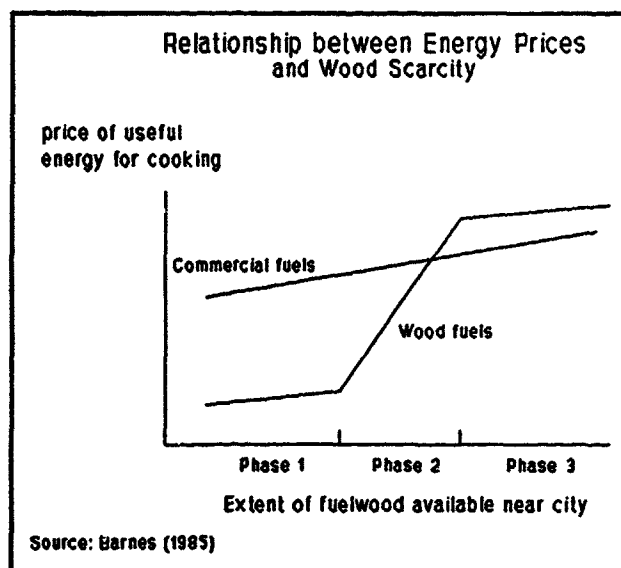


Figure 10

2.11 Figure 11, a 37 year time-series of inflation-adjusted charcoal prices in Port-au-Prince, Haiti, appears to be a real life illustration of the phased transition model. At the turn of the century, over 60% of Haiti was covered by dense forest and firewood was abundant. Starting in about the mid-1960s, a period of rapid urbanization began, coincident with off-shore investment in light manufacturing and assembly operations. Since urbanites are 90% dependent on charcoal for their cooking needs, demand for this fuel increased rapidly. At the same time, very high population density and associated land hunger resulted in large forest areas being cleared for agriculture. After years of flatness or decline, charcoal prices began to rise rapidly.

2.12 By the mid-1980s, Haitian forest cover had been reduced to an estimated 3.5% of surface area. Charcoal prices in real terms had more than doubled, to the point where it was equally costly to cook with charcoal as with kerosene (see Figure 12). In the space of a generation, twenty years, Haiti was transformed from woodfuel abundance to significant woodfuel scarcity. Poor urban households, of which there are many in Port-au-Prince, now spend upwards of 20% of their income on charcoal. Meanwhile, the country suffers from deep balance-of-payments deficits, so that even incremental kerosene/LPG imports represent a significant burden. The remaining natural forest cover, even if placed under sustainable management, is no longer sufficient to meet wood demand.

2.13 Small-holder extension programs and tree planting efforts began in earnest in the early 1980s, but it is difficult to replace the volumes already lost. One difficulty is that farm gate (stumpage) prices for wood have not increased as rapidly as charcoal retail prices. In fact, as shown in Figure 13, returns to producers have not increased for over ten years. This is a reflection of the tenuity of rural land tenure, and a lack of organization, information and market power. To summarize, the Haitian situation is serious, and may be getting worse.

2.14 It is interesting to ponder where a less densely populated nation such as Ghana might be in this stylized woodfuels history. Unfortunately, the economic indicators are not very clear, partially for a lack of long-term data. A linear regression analysis of the data plotted in Figure 14 shows a slight uptrend in real charcoal prices in Accra. But on the other hand, a sack of charcoal was just as expensive in 1979 as it is today,

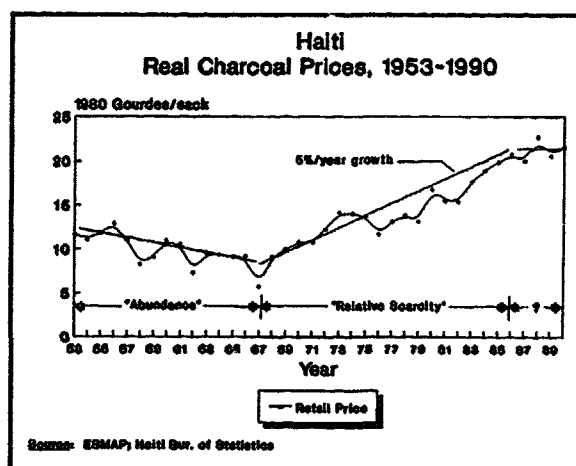


Figure 11

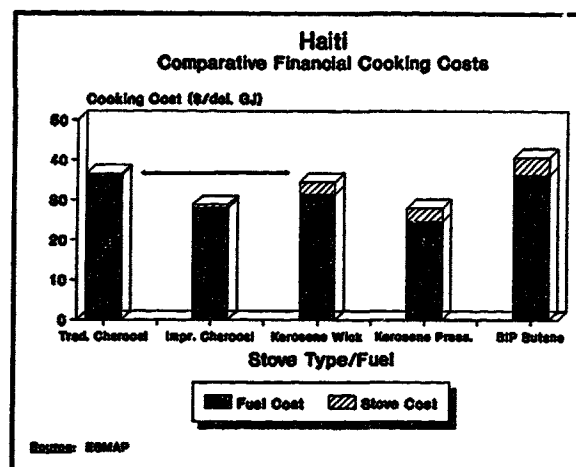


Figure 12

suggesting relative abundance. Ghana would certainly have time to stave off woodfuel scarcity on a national level, although localized shortages are known to be occurring.

2.15 Three policy options are discussed below for sending clear signals in advance of significant physical woodfuels scarcity: applying an administrative fiat; providing quotas; and levying user fees or taxes.

Administrative Fiat

2.16 An administrative fiat is an obvious option, and one which has been applied in the south-eastern savannah zone in Rwanda in 1987 and in 1989 in the Afram Plains in Ghana. Charcoal making has been banned there, indefinitely in Rwanda and for a minimum of ten years in Ghana. Surely this action sends a powerful message to the charcoal producers in these countries! Another advantage with such administrative orders is that, provided the political will is present, they are not difficult to enforce.

2.17 The prohibition on live tree felling enacted in the savannah zone in Rwanda seems to have resulted in a smooth transition to plantation wood sources, minimizing adverse impacts on consumers. Charcoal prices (in constant 1982 terms) in Kigali rose steadily at 6.2% per year from 1984 until 1988, with no real price hike as result of the ban. Because of several efficiency improvements by transporters ^{14/} and a reduction in retail margins, charcoal retail prices in Kigali actually dropped, and they are now lower than they were prior to the ban in 1987 (see Figure 15).

2.18 One caveat is that bans are a rather blunt policy instrument which can potentially lead to high cost solutions unless compensating measures are planned for. In the Ghana case, the price of charcoal in Accra in the short-run would be expected to rise as 20% of its charcoal supply is cut off, but should rather rapidly return to earlier levels as production is shifted to other districts. However, the resulting new distribution of production may be sub-optimal. The situation seems not satisfactory, akin to dealing with electricity supply/demand imbalances through the imposition of rolling black-outs.

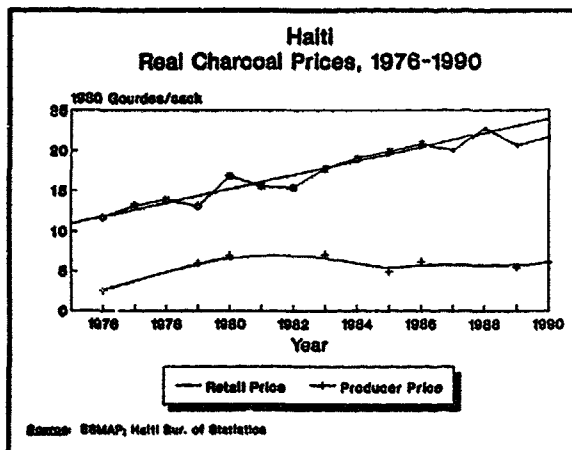


Figure 13

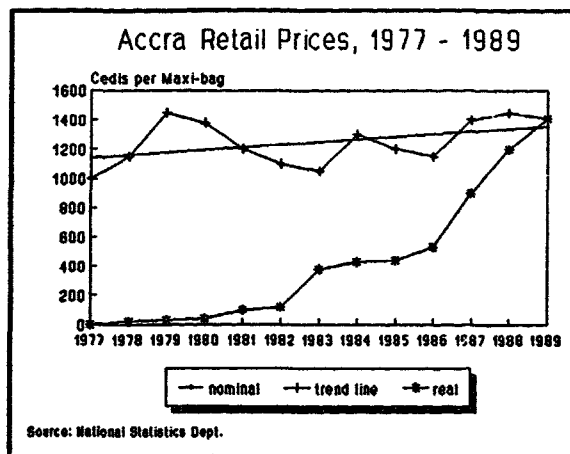


Figure 14

^{14/} Principally better road access and shorter haul distances.

Quotas

2.19 A second option is the institution of a quota system.^{15/} A sensible quota in the fuelwood context is a natural forest management system where the cut is limited to the rate of natural regeneration. As shown in the USAID-Government of Niger Guesselbodi Forest Management Pilot Project, with proper management, sustainable fuelwood yields can be doubled. Another advantage is that management costs were found to be roughly one-half of plantation costs. The quotas can be realistic and consistent with demand levels provided they are applied over a large enough forest area. Put into large-scale practice as in the World Bank financed Niger Household Energy

Conservation and Substitution Project, natural forest management systems involve zoning of areas around urban centers according to their fuelwood production potential. In parallel, incentives are created for local people to manage wood resources rationally by vesting them with property rights contingent on adequate management, guaranteeing them stable urban market demand for fuelwood produced, and earmarking finance for resource management costs (e.g. technical assistance). A problem is assuring a secure and continuing source of finance.

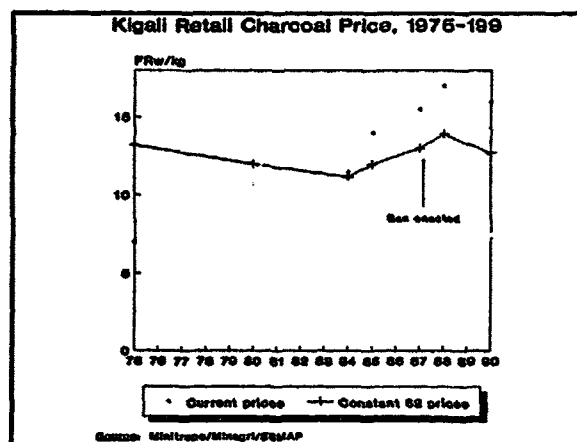


Figure 15

User Fees/Taxation

2.20 Fees are collected by many governments for the use of wood resources in state forests, and by traditional authorities for similar uses of communal or tribal woodlands. As a policy instrument, user or "stumpage" fees serve two ends. First, they are a convenient source of finance which can be fed back for forest development and management if not subjected to annual appropriations. Second, user fees can be used to signal wood production costs, thus providing long-run incentives for tree-growing and for efficient carbonization and consumption. Since the majority of wood destined for urban household markets is taken from *de facto* open access land, market prices do not contain a replacement cost element. Woodfuel market prices in most developing countries reflect only harvesting and transport costs. Even in Rwanda, a country where most of the charcoal stems from plantations, wood prices do not reflect true economic costs due to very low self-ascribed values for wood growers' labor.

2.21 There are admittedly strong organizational and administrative challenges in implementing effective stumpage fee collection systems. In some countries, the cost of collection exceeds the revenues derived, but this is usually more a reflection of unrealistically low fee levels. Cooperation can be enhanced through revenue sharing among traditional local entities, regional government, and central government. Product taxes, such as a levy on transported bags of charcoal, represent second-best solution from an efficient use of resources standpoint but are a more easily implemented revenue raising measure.

^{15/} From an economic efficiency viewpoint, the effects of quotas and taxes are identical. However, the distributional impacts may be quite different.

Practical Results

2.22 The experience with improved charcoal making of the four countries under consideration in this document is presented in more detail in the Annex. To summarize, technical improvements are possible in all four countries, albeit with mixed results. In Ghana and Jamaica, the technical improvement potential is small (see Table 1.), mainly due to the longstanding experience and tradition of charcoal making in these countries. Since charcoalers are there not convinced of the potential benefits, it will be difficult to provide the incentives that would facilitate them to adopt the improved charcoaling method.

2.23 Even though the technical improvement potential is much larger in Senegal and Rwanda than in Jamaica and Ghana, actual improvements were only effective in Rwanda and not in Senegal. In the latter, policy measures did not accompany technical efforts to improve charcoal making, and this mainly accounts for the failure. Localized efforts have met with success, but on any larger scale the program is still in its infancy, and private sector charcoalers are not generally interested in adopting improved techniques.

2.24 In Rwanda, certain policy and other measures did accompany the technical effort which resulted in charcoalers adopting the improved techniques. First of all, there was a strong signal from the village level that wood became scarce in certain regions which resulted in an administrative fiat which was announced by the central Forestry Department. Secondly, the wood pricing policy was changed to enable large quantities of plantation wood at large distances from the capital to be utilized economically. The third measure was a quota system put in place by the Forestry Department which limited on an annual basis charcoal transport from certain zones and encouraged charcoal transport from zones with ample wood resources. The fourth measure which is currently being considered for implementation is the levy of a small tax on charcoal, with an amount depending on the existence of a village level wood resource management plan and the use of improved charcoaling techniques. The outreach program to train and sensitize charcoalers and wood owners is currently donor financed, but will be selfsupporting when the taxation proposal is operational.

2.25 The outreach program itself mainly consists of a systematic professionalization of charcoalers, which implies technical, financial, organizational, and managerial training. An association of professional charcoalers has been created and operates since a few months, forming a link between member charcoalers and wood owners.

III. CONCLUSIONS

3.1 The basic lesson from international experience in promoting improved rural sector charcoal production is this: Improvements are possible, if conditions are right. Before setting out, it is incumbent to determine the scope for technical efficiency gains.

3.2 A corollary finding is that technology alone will not do the trick. Complementary efforts are required to:

- Organize charcoalers and uplift their socio-economic status;
- Provide incentives through an exchange of resource rights and management responsibilities, and implementation of policies designed to signal scarcity; and
- Assure a stable source of financial assistance for charcoalers, and for forestry extension services.

3.3 In countries where adequate forest cover remains, a natural forest management system is favored (guided by realistic local quotas), financed by a workable combination of user fees and taxes. Where significant physical scarcity is already in evidence, establishment of multiple-use plantations and promotion of large scale inter-fuel substitution will play primary roles.

3.4 Technical measures to improve charcoaling efficiencies in the rural sector include, first of all, executing a better process control (more densely stacking of wood, better circulation of hot gases, and closer supervision during the carbonization phase); secondly, making an effort to dry wood before the kiln is ignited as dryer wood gives a considerably higher charcoal yield; and lastly, larger diameter kilns should be made as these give higher yields than most small-scale, traditional kilns.

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ANNEX

FOUR COUNTRIES' EXPERIENCE IN IMPROVED CHARCOAL PRODUCTION

Senegal

Background

Fuelwood is not only the most important national energy source in Senegal but also, in the form of charcoal, it is the key fuel for urban households. This is causing an increasingly negative impact on the rural environment, contributing to deforestation and subsequent loss of soil fertility, lowering water tables and declining agricultural productivity. With a high urban population growth rate, Senegalese cities are demanding more charcoal. Because of urban growth and the intensity of urban fuelwood consumption in the form of charcoal, cities are casting a growing "urban shadow" over the countryside, with charcoalers cutting trees to supply urban demand. This is in contrast to rural fuelwood consumption where firewood is primarily gathered in the form of twigs and deadwood rather than being cut from live trees.

The Government of Senegal has instituted some controls on the commercial charcoal supply network, including: fixing a quota for charcoal production; specifying production zones for charcoalmakers; and controlling charcoal transport through a permit system. However, quotas are not based on current estimates of sustainable yields. In addition, because of bureaucratic loopholes, fraud and insufficient staffing, the controls have not been effective. Specifically, a 1989 ESMAP report found that localized quotas had not been rationally allocated and could be changed through a somewhat arbitrary readjustment process. Disorganized record-keeping made it difficult to follow-up on violations. Finally, the Forestry Service, charged with responsibility for controls enforcement, was found to be severely understaffed, having only one agent for every 80,000 ha of protected forest.

Concerning woodfuels pricing, a 1987 law increased stumpage fees on wood taken from natural forests by over three-fold. While a large increase in percentage terms, the new level still only represents one-seventh the cost of wood production through reforestation. The government would like to have wood priced at half its economic value in the forest in the medium term, and achieve full economic pricing in the longer run.

The Casamance Kiln

The Casamance kiln was developed between 1977 and 1980 to meet the specific requirements of the UNDP/FAO project "Mise en Valeur des Forêts de Basse et Moyenne Casamance & Assistance au Service Forestier." The project was located in the Casamance region of southern Senegal. The overall objective of the project was to place the Casamance forests under management and to provide income from the sale of forest products, including charcoal, to finance timber stand improvement and planting costs.

The traditional carbonization method, large earth mound kilns, was thought to be wasteful. However, no one had actually measured it. Three months of measurements established that the local methods were some 80% more efficient than originally estimated. This set a lower bound for an improved technique's performance. Evidence that local charcoal makers had previously tried several "improved methods" was found in the remains of metal kilns and metal pit covers which were scattered throughout the forest. As the project leaders, a Peace Corps Volunteer and his Senegalese forester counterpart would later write, "These gave a good indication of the way not to go."

The way to proceed was not so obvious, and the story of how the Casamance kiln came to be developed makes some interesting reading. The first step was to study the local, traditional method to see if any obvious improvements could be made. Concurrently, a literature search was undertaken. The Swedish Skorstensmila (stack with chimney) was rediscovered in an English translation of a French document which quoted the original Swedish. As could be expected, much was lost in the translation chain. After much persuasion, local charcoal makers reluctantly agreed to try it.

After much experimentation and discussion, a hybrid design evolved sharing features of both the Swedish and Senegalese kilns. This Casamance kiln prototype was lit and gave a yield over 50% better than the measured traditional kiln output. From this point on, research was directed to kiln refinement. A follow-up effort sponsored by USAID trained several hundred charcoalers in the construction and use of the low-cost kiln.

Results

There is no question that the creation of the Casamance kiln was a major technical and developmental achievement. However, the technique has had only a minor effect on Senegalese charcoal production efficiency since the kiln has not been widely adopted by charcoalers on a national basis. This can be explained by several reasons. First, the kiln is more complex than the traditional method, requiring installation of a metal chimney which must be replaced regularly due to corrosion and poses problems in transportation from one site to another. Second, since the bulk of forest fees are calculated based on the amount of charcoal placed on the market, wood savings would have little effect on the amount of fees paid. Thus, forest operators -- who do not do the carbonization but who pay the fees -- have no particular interest in using the new technique. Third, *sourgas* are unorganized, in a precarious legal situation and totally dependent on their employers for survival so the reduction in work time through use of the Casamance kiln might not justify the complications and investments involved. Realizing these problems, the Ministry of Environmental Protection has attempted to organize *sourgas* in collectives; the results were encouraging but, due to lack of financing, it has not been possible to continue this experiment.

Rwanda

Background

Rwanda, continental Africa's most densely populated country (275 persons/km²), relies heavily on woodfuel for its energy needs, and about 80% of the total energy balance stems from wood and charcoal. Some 400,000 tonnes, or 15% of the total wood consumption in 1987 was transformed into charcoal, which, due to its commercial intensity, is quite harmful to the environment. Per capita charcoal consumption is relatively high compared to other countries: an average figure of 0.51 kg/person per day for a household of 8 was identified through mensurative surveys. A MINITRAPE/ESMAP study in 1986 revealed that 80% of the charcoal consumed in Kigali originated in the southeastern savannah zone. Environmental damage to this zone motivated the Government in early 1987 to establish a ban on charcoal production there. Instead, charcoal production was promoted in the forested southwestern zone. A survey in late 1987 revealed that more than 80% of the charcoal indeed originated in the southwestern part of the country. Even more interestingly, most of it was Eucalyptus, indicating that the ban had not only caused a change of production area, but also a switch from natural forest wood to planted wood.

The high land pressure in Rwanda will increase the rate of urbanization, which in turn, is likely to increase the use of charcoal. Charcoal as a fuel will therefore become even more important in the near future, and it will stay that way for quite some time to come. To ensure the supply of charcoal and to alleviate deforestation problems, a MINAGRI/MINITRAPE/ESMAP project was launched to improve the efficiency of charcoal making in Rwanda. The three objectives were: (a) Establishing a self-sustaining program to disseminate more efficient charcoaling methods in Rwanda; (b) Initiating a more effective wood pricing policy; and (c) Increasing public awareness about deforestation and encourage tree planting as a cash crop.

The following outputs were expected to be carried out by the project: (i) Training of 300 traditional charcoalers in improved carbonization techniques; (ii) Reduction of the consumption of wood for charcoal production in rural areas; (iii) Generation of revenues and incentives for tree planting by forestry projects, communes and private wood-lot owners; (iv) Study of the needs for and ways to introduce a fee to facilitate the efficient use and production of charcoal; (v) Support to the current charcoal stove program, creating a comprehensive approach to Rwanda's charcoal problem; and (vi) Increased awareness about deforestation and the potential solutions.

Results

The project confirmed in practice the wood savings potential resulting from improved charcoaling techniques. It measured more than 100 traditional and improved kilns, and concluded that the efficiencies under field conditions are much lower than previously expected: approximately 7-9% (by weight) for traditional kilns, and 17-19% for the

Casamance kiln. Traditional charcoalers were quickly convinced once they saw the difference in output between the two different kilns: double the amount of charcoal, obtained 20-40%

Table I: Consumption and Savings Figures for Traditional and Improved Charcoal Techniques

	Unit	Traditional	Casamance
Weight efficiency	(%)	7.5%	16.0%
,, (bags/stere)		1.0	2.0
Size of average kiln	(steres)	7.5	15
Wood used/kiln	(kg)	3,600	7,200
Charcoal produced/kiln	(kg)	270	1,152
Wood used/kg of charcoal	(kg/kg)	13.3	6.3
Wood saved/kg of charcoal	(kg/kg)	-	7.1
Average number of kilns per charcoaler	(/month)	2	0.60
Total number of kilns (without project)	(/month)	12,346	-
Number of charcoalers		6,173	-
Charcoal produced (tonne/year)		40,000	-
Total number of kilns (with project)	(/month)	11,667	159
Number of charcoalers		5,834	265
Charcoal produced (tonne/year)		37,802	2,198
,, (%)		94.5%	5.5%
Wood saved (tonne/year)		-	15,569
,, (US \$) a/		-	357,096
,, (ha) b/		-	173

a/ Based on an average cost of production of US \$11 per stere of plantation wood.

b/ Based on 6 year old plantation with a total productivity of 15 tonnes/ha.

Cost of wood/stere	FRw	US \$
Government plantation	1,472	20
Communal plantation	563	8
Private plantation	443	6
Average	826	11

stere of wood	480 kg
m3 of wood (air dry)	640 kg
bag of charcoal	35 kg

faster compared to their traditional kiln. That most likely explains why more than 60% of the traditional charcoalers ^{16/} trained by the project continued to produce charcoal with the newly acquired technique. It was observed that a few charcoalers who had received training in the Casamance kiln actually started training additional charcoalers who could not attend the

^{16/} A total of 265 charcoalers were trained under the project of which approximately 180 retained the Casamance technique. A main reason for not continuing with the improved technique was problems in obtaining wood.

project's training sessions. In its first year of implementation, it became clear that the financial resources allocated to the project were not sufficient to establish a self-sustaining dissemination program. Consequently, a reinforcement of the project was requested (and obtained) to enlarge the scope of work.

The project evaluated the charcoal sector, and studied the existing wood and charcoal pricing practices and policies. It recommended a different wood products pricing policy based on a pragmatic approach. The Government is currently identifying means and ways to implement this policy. It is based on: (i) The fact that the value of the end product depends on the nature of the end product (firewood, polewood, wood for charcoal making); (ii) The tree species (pine, eucalyptus, acacia); and (iii) The fact that the value at the place of production proportionally decreases with the distance between that place and the largest market for that particular end product.

In addition to this pricing policy, a charcoal taxation policy was proposed to facilitate the switch from traditional to improved charcoal making as well as to accelerate the use of improved charcoal stoves. Although the Government has expressed its keen interest in the taxation policy, it concluded that it was too early to start implementing it.

The next phase of the project (underway) will mainly focus on strengthening the position of the charcoaler by establishing professional charcoaling associations, and creating links between wood owners and these associations. In addition, a public awareness campaign will be launched to facilitate the aforementioned activities.

Jamaica

Background

Charcoal has received little attention in Jamaica for two reasons: (a) It is perceived as a minor fuel, accounting for only 3 percent of total energy use (but 37 percent of household energy use); and (b) Non-commercial forestry has not been a major concern of the Government, as Jamaica has traditionally been perceived as a land of abundant forest resources. However, current perceptions are changing. Analysis reveals that the demand for wood and forest resources is pressing toward the short-term limits of exploitation, and exceeding them, especially in accessible areas.

There is little concrete information about the consumption and production of woodfuels in Jamaica, as these activities take place in the informal economy, unregulated by the Government. However, the use of charcoal appears to be increasing in urban areas, concurrent with a fall in Jamaican families' real incomes. This is substantiated by household energy surveys that show an increase in charcoal use from 19,000 tonnes/annum in 1979 to 44,000 tonnes in 1983. A conservative estimate of total current consumption is 60,000 tonnes.

Charcoal is produced in traditional earth mound kilns in Jamaica, with an efficiency (air dry weight basis) of about 15 percent. Therefore, at least 400,000 tonnes of wood are used each year to produce charcoal. This is more than double the annual cut for sawlogs and lumber. While commercial cutting of wood is controlled by the Department of Forestry and Soil Conservation, most wood for charcoal is obtained on Government or private lands through a system of connived trespass. The exploited areas are generally dry woodland zones of slow regenerative capability, located on the fringes of remaining productive forest. When coupled with the island's steep upland slopes and thin soils, land degradation in these areas is a source of increasing concern. Charcoal making is obviously not the only contributor to such degradation, but is closely linked by opening up previously intact forest to agricultural expansion.

An ESMAP pre-investment study undertaken in 1987/88 attempted to assess the measures required to create a more sustainable system of charcoal production in Jamaica. This included an investigation of the overall charcoal supply system as well as the associated environmental impacts. A major component was a test/demonstration of the suitability of the Casamance kiln for wide scale dissemination in Jamaica. About 25 local charcoalers built three traditional and five Casamance kilns under the supervision of a Senegalese expert, and comparative yields and cycle times were recorded.

Results

Test results showed that carbonization times were reduced from three days to less than one day when the Casamance method was used. Interviews with the participants at the end of the program revealed enthusiasm for the Casamance method, with most of the trainees saying

that its speed would improve their cashflow. Several participants indicated a desire to obtain a Casamance chimney so that they could continue to use the kiln.

However, the yield results for the two types of kiln did not prove a conclusive advantage for the Casamance method. Follow-up efforts executed by the Ministry of Mining and Energy in conjunction with the Forestry Department were aimed at isolating the individual effects of wood moisture content and kiln size on kiln performance.

The follow-up testing program verified that wood moisture content and kiln size are important variables. It was realized that the small scale and individuality characteristics of Jamaican charcoal production place serious limits on the ability to capture thermodynamic economies of scale associated with the Casamance kiln.

Despite the apparent lack of incentives for wide-scale adoption of new charcoal making techniques, the pre-investment study seems worthwhile, especially in relation to its small cost (<\$ 100,000). Many of the technical conclusions in this paper's main body are derived from the Jamaica experience. In addition, the involvement of Government counterparts sensitized the energy/forestry establishment to the parallel issues of organization of charcoal producers, management of wood resources on public and private land, and introduction of a financial cost for wood.

Ghana

Background

Charcoal is far and away the dominant fuel in urban Ghana. Various surveys have established that charcoal is the principal cooking fuel for almost three-quarters of the populations of the capital, Accra, and the second city of Kumasi. Other urban centers are nearly as charcoal dependent. In total, over 500,000 tonnes of charcoal are consumed annually on a national basis.

The source of this charcoal is concentrated in the so-called "charcoal triangle" in the center of the dry Transition Savannah zone, located some 500-600 km from Accra. There, semi-nomadic traditional charcoalers carbonize dense, slow-growing trees in earth mound kilns. Only about three species, which are known to make a heavy and preferred charcoal, are harvested. Felling takes place principally on traditional "stool" lands under the nominal control of tribal chiefs. These sources are augmented by both legal and surreptitious entry into state forests.

Localized deforestation has resulted from the commercial intensiveness of wood resource exploitation. Farmers claim to have noticed changing micro-climates on their lands, as well as increased soil erosion and attendant decline in soil fertility. In one charcoal-producing district, the farmers recently successfully lobbied their local government council to institute a ten-year ban on charcoal production. The district historically supplied about 20% of the capital's charcoal. The ban has been viewed with some trepidation by central government administrators and politicians, who are concerned about welfare effects on their large urban constituency should the ban idea spread. This concern has served to focus attention on the sustainability of the present charcoal supply system, and means for its improvement.

An ESMAP/Government of Ghana "Charcoal Production Strategy Project" was initiated in 1989 to look comprehensively at the feasibility for improvements in three areas: (i) traditional rural production; (ii) carbonization of sawmill residues; and (iii) charcoaling of forest logging residues. The activity, executed substantially under the direction of the Ghana National Energy Board (NEB), is now drawing to a close.

Results

Two principal lessons learned have derived from the pre-investment activities in the traditional rural sector. First is that the traditional charcoalers operating in Ghana's Savannah are quite competent; the performance of their kilns under controlled conditions exceeded expectations by 50%. Based on follow-up field observations made by NEB, this high efficiency level is reasonably maintained in actual practice. So, while the Casamance kiln was shown to have an efficiency advantage, the scope for improvement seems not as great as originally thought.

Secondly, unexpected sociological problems encountered in the Casamance demonstration/training program provided valuable illustrations of the difficulties of rural technology introduction. The charcoalers' resistance to the training activities increased as the program went on, eventually leading to the discontinuance of the training course. The reasons are not entirely clear, but may be due to:

- (a) Charcoalers' aversion to kiln night surveillance requirements of the Casamance method. The Sissala (traditionally migrant charcoalers from far North-east Ghana) normally "turn down" and abandon their kilns at night. They avoid staying in the dark in the forests, where they believe evil spirits lurk.
- (b) Intra-village conflicts between the dominant farmer ethnic group and the more recently settled Sissala. Longstanding resentments surfaced over the charcoalers' destruction of trees and farm lands, and higher cash incomes.
- (c) Charcoalers' fear of the district forestry authority who came to witness a portion of the Casamance demonstration. The official became upset upon viewing the noticeable forest destruction in sections of the reserve adjacent to the training site, the result of on-going illegal charcoaling activities.

Expanding on point (c), the greatest impacts of the demonstration were perhaps not on the charcoalers, but on the government energy/forestry officials participating in and observing the course. For many, this was their first first-hand exposure to the laxity of wood resource management, and links between urban charcoal demand and environmental degradation.

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