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THE RURAL ENERGY PROBLEM IN DEVELOPING COUNTRIES: DIAGNOSIS AND POLICY APPROACHES. A REVIEW OF MAJOR ISSUES

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INTRODUCTION

Since the early 1970s the energy base of development of low income countries has received much attention. Initially, attention focused on commercial energy and on urban areas where modern forms of energy were mostly used. Petroleum-based and energy import-dependent modernization strategies were questioned because of instability in international economic relations, affecting prices and stability of supplies, and because oil is a non-renewable natural resource.

The prospects for commercial energy sources spreading into rural areas and among the poorer strata in urban areas in especially the low income developing countries began to receive more attention as well, and these prospects looked dim. Because these countries could not buy themselves sufficient import energy at high prices, the role and continued significance of traditional fuels began to be stressed. Particularly influential was the paper by Eckholm (1975), on 'The Other Energy Crisis: Firewood' (1975). It stated that broad strata of the population of low income countries were, and most likely would remain for a long time, dependent upon traditional energy sources: woodfuel, crop wastes and dung. The issue then arose: would these resources be available in adequate supplies to meet demands, even though these resources are in principle renewable natural resources, unlike oil?

Much has been written since about the rural energy situation. As little information was available on available woodstock resources and on patterns and trends of energy use in rural areas, large numbers of energy surveys have been undertaken. These ranged from broad macro-level studies at national, regional or global level, to micro-oriented studies for smaller-scale application at village or district level. The former may be thought useful to call attention nationally and internationally to the energy issue and policy implications, while the latter would be most useful in designing and implementing specific energy policies and programmes.

Without waiting for the results of these efforts, major policy decisions were taken to embark on rural energy development strategies, and large amounts of national and donor resources were provided for their implementation from the late 1970s. Political needs and expediency forced actions at short notice, as 'the time was ripe'. But the needed information base for judicious action and to judge the capacity to respond had not been systematically assessed.

Increasingly, evidence is becoming available on the ineffectiveness of early rural energy focused policies and projects. This has necessitated a rethinking process, which has gained momentum in the second half of the 1980s.

The purpose of this paper is to retrace the rural energy issue as it was diagnosed in the mid and late 1970s, and to review major contending views on rural energy strategies in low income countries. Is there a crisis, what are its causes and what are the implications for designing strategies and policies? It will be shown that conflicting views on these questions lead to contradictory policy options and priorities for action. Increasingly, as the research questions change, the issues are seen to be ever more complex and, consequently, the solutions and the policy process to deal effectively with them become more elusive.

Rural energy questions turn out to be intimately interwoven with other dimensions of development which, historically, have been considered to be the mandate of separate disciplines and different institutions. The rural energy issue, in turn, has fuelled new and complex inter-agency rivalries. It necessitates major changes in the institutions traditionally responsible for the forestry resources in most developing countries, but also in institutions which impinge on, or make use of forestry resources.

Energy planners saw a whole new sector, of rural energy, being added to their mandate and also foresters and forestry departments began to see a bright future for their profession. Agronomists, too, began to feel the pressure for coping with energy aspects of agricultural development strategies. Environmentalists, who had bemoaned for long degradation processes of the natural environment and the loss of eco-diversity, felt that they finally had the 'ear' in public policy discussions on development strategies. However, they are being asked to switch from the overwhelming attention for nature conservation, to better integrate environment and development aspects.

This paper is about problems of diagnosis and general issues encountered in rural energy interventions over the past 15 years. It hopes to sensitize especially social scientists to the increasing complexity of what often are considered to be technical problems. By raising issues and questions, social scientists should also become better equipped to engage in dialogue with relevant groups of technical specialists, which have so far tended to dominate the various discussions on energy and on rural energy.

The paper does not devote much space to discuss individual case studies on projects and policies, nor does the paper discuss technical issues in forestry, agronomy or energy studies. These can be found in the literature referred to, or through interaction with the technical specialists concerned. Rather, the paper attempts to sketch the broad outlines of various debates, and it tries to place policy approaches within the framework of mainstream professional and institutional settings most directly involved.

The field of rural energy studies is young and evolves rapidly, with contributions coming from many different disciplines and accessible in journals with non-overlapping readership. The uninitiated may thus be easily misled by reading only a scatter of non-systematic readings. As will become clear, also in rural energy studies, the social scientist has to know a bit about a good many topics: technical, institutional and historical, to understand the problems involved. There are as yet not many publications which attempt a broad overview of issues, in combination with a guide to the relevant literature resources. Leach and Mearns (1988) and Munslow, et.al. (1988) are, however, good introductions, though mainly focused upon Africa.

The paper is organised as follows. First some macro estimates of global woodfuel gaps are presented which have been instrumental in mobilizing public policy support, nationally and internationally, for efforts to address woodfuel issues. This leads into a brief discussion of some underlying, methodological and data problems. Next, available micro level energy studies are reviewed, including an account of major shortcomings, suggestions for improvements in questionnaires and ending with a plea for studying rural energy issues in wider historical and rural settings.

The larger part of the paper is devoted to discuss policy approaches to rural energy, whereby approaches have been reviewed from the perspective of various professional interests and within traditionally developed institutional settings. This approach is chosen to obtain insight in the why and how of the approaches actually chosen, and to point at problems and issues which impede more effective and creative approaches to deal with rural energy due to professional and institutional constraints.

The paper is uneven in its treatment largely because some issues have received more attention in the literature than others. Several debates are relatively recent or take on a new flavour. Because of the new perspective on rural energy and woodfuel, no synthesis or more comprehensive overview is possible at the present time. Rather, the paper attempts to provide the reader, probably in majority social scientists becoming interested in the subject matter, with a first orientation on approaches, issues and conflicts, and to guide him/her to the diverse literature in which contributions to the various debates can be found.

DIAGNOSIS OF THE RURAL ENERGY SITUATION

Macro Estimates of Woodfuel Gaps

By August 1981, the FAO had prepared a comprehensive overview of the status of fuelwood supplies in developing countries. The study was intended as an input for the United Nations Conference on New and Renewable Energy. FAO presented a map that showed the status of supplies relative to demand in developing countries according to six categories, ranging from abundance to desperate shortage. Some countries have areas in a number of categories. A follow-up FAO report provided more numerical detail on a regional basis.

De Montalambert and Clement (FAO, 1983b) estimated that nearly 3 billion people were facing an acute scarcity of firewood or a deficit of firewood by the year 2000. This estimate is reproduced in Table 1).

The firewood crisis was seen to be most acute in the countries of the densely populated Indian subcontinent, and in the semi-arid stretches of Central Africa fringing the Sahara Desert, though it plagues other many other regions as well. In Latin America. for example, the scarcity of wood and charcoal is a problem throughout most of the Andean region, Central America and the Caribbean (Eckholm, 1976, 101-2).

There are also wide variations within the regions. For instance, the annual rate of consumption in the early 1980s was estimated to exceed the annual rate of additions to woodfuel supplies by the following margins: in Senegal by minus 35% (suggesting a slight surplus, mostly in the Casamance, against a deficit in Dakar); in the Sahelian countries, by 35%; in Niger, by 200%; in Northern Nigeria, by 75%; in Ethiopia by 150% and in Sudan, by 70% (Anderson and Fishwick, 1984, 1).

Calculations of projected 'fuelwood gaps' tend to be readily linked to their suggested causes and to proposals for action. For instance, the influential World Bank's Forestry Sector Paper (1978) posits the problem and its causes as follows:

> *'Between 1900 and 1965, about half the forest area in developing countries was cleared for agriculture, and more than 300 million hectares (or 30 percent of the world's exploitable soils are currently under shifting cultivation', and: 'Over 90 percent of wood consumption in the developing countries is accounted for by fuelwood. Some 200 million people live within or on the margins of forests'(1978, 5-6).*

and further:

> *'The existing forest stock in developing countries (estimated at 1,200 million hectares of mature forest) is currently being consumed at the rate of 15 million to 20 million hectares a year. At this rate, assuming no growth in demand, the remaining tropical forests will be consumed in about 60 to 80 years. Allowing for population growth in developing countries, with no growth in exports, the current forest stock is likely to be consumed in less than 40 years' (p 15).*

The 1981 United Nations Conference on Renewable Energy concluded, that tree planting for fuel needed to be increased five-fold, at a cost of $1 billion per year for the next 20 years (Ambio, 1981, special issue on UNERG, 234).

In a similar vein, for sub-Sahara Africa and a few years later, it was estimated that tree planting would have to increase fifteen-fold in order to close the projected gaps in the year 2000, requiring hundreds of millions of dollars, mostly in foreign aid for the region in economic crisis (Anderson

Table I Population Experiencing a Fuelwood Deficit (De Montelambert & Clement, 1983)

Region	1980						2000	
	Acute scarcity		Deficit		Prospective deficit		Acute scarcity or deficit	
	Total population	Rural population	Total population	Rural population	Total population	Rural population	Total population	Rural population
Africa	55	49	146	131	112	102	535	464
Near East and North Africa			104	69			268	158
Asia and Pacifc	31	29	332	710	161	148	1,671	1,434
Latin America	26	18	201	143	50	30	512	342
Total	112	96	1,283	1,052	323	280	2,986	2,398

1) Total population and population with predomimantly rural type of energy consumption (total) population less that of towns with more than 100 000 inhabitants) in zones whose fuelwood situation has been classified.

- Potential deficit areas: zones or countries in which supplies still exceeded demand in 1980, but which in 2000 will have a deficit if present trends continue. This group of situations is added to the acute scarcity and deficit situations alredy identified in 1980, which will have worsened in the meantime, owing mainly to the population growth and continued dependence on fuelwood;

- "Satisfactory" situations: zones which on the whole will still have sufficient supplies by the year 2000. Two types of situations may occur: either the rsources will continue to satisfy present and future needs; or else they will dwindle, but at a rate which will still make it possible to meet requirements in the foreseeable future, although acute scarcities may occur at certain points, particularly in and around urban centres.

- Acute scarcity situations: zones or countries with a very negative balance where the fuelwood supply level is so notoriously inadequate that even overcutting of the resources does not provide the people with a sufficient supply and fuelwood consumption is, therefore, clearly below minimum requirements. These situations of acute scarcity result mainly either from particularly difficult ecological conditions or from continuous overcutting of the resources owing to high population density.

- Deficit situations: zones or countries where the people are still able to meet their minimum fuelwood needs, but only by overcutting the existing resources: the present level of supplies is insufficient to ensure provisioning on a sustained yield basis, and overcutting leads to degradation or even progressive destruction of the resources.

and Fishwick, 1984, 6), or to justify enlarged World Bank lending for forestry (Spears, 1986; and Leach and Mearns, 1988, p 6, 281). All such 'requirements' implied enormous increases in government budget allocations and at a time when structural adjustment policies, such as required and supported by the World Bank and the IMF, also advocated that government expenditures had to be drastically reduced to restore macro-economic equilibrium in the economies of poor countries.

The FAO effort appears to be the first attempt to bring together information on woodstock, wood supply and woodfuel demand in a projection model, of the type as discussed in Annex 1 of this paper. While admirable, such an effort is fraught with many methodological problems that will be taken up below. The enormity of the task to cope with the expected woodfuel deficit, raises issues about appropriate and cost effective ways of meeting these fuel wood demands. However, there are at present distressingly few documented examples of successful pilot projects or programmes, and the issues of their replicability on a larger scale do not yet arise in practice. They will therefore not be discussed in this paper.

Methodological and Data Issues

GENERAL WOOD SUPPLY ASPECTS

Supply estimates of fuel wood present a number of problems, which can be grouped under stock problems and yield/use problems.

Stocks

First, some data are presented on the extent of forest resources as of the early 1970s. Table 2 shows that there are wide variations between the regional groupings in terms of the share of closed forest in forest land, which gives some indication about the nature of forest land -- large continuous forest areas or fragmented and open forest systems. Especially the situation in Africa is noteworthy, as the ratio closed forest to forest land is lowest. Africa, the Pacific area, and to a lesser extent Asia, have below average forest endowments in terms of closed forest as a percentage of total land area. When forest area is expressed in per capita terms, Asia, Africa, but also Central America are forest-scarce areas among the less developed regions.

Gamser (1980) has noted that the information used to justify a declaration of a global wood energy crisis was not sufficient, on the basis of the information available in the late 1970s. To illustrate the nature of the problem, the following data for Africa will be useful (see Table 3).

Table 2 World Forests (ca 1973)

Region	Forest land (millions of hectares)	Closed forest (millions of hectares)	Closed forest as % of land area	Forest/capita (ha)
No. America	630	630	34	2.8
Ce. America	65	60	22	0.7
So. America	730	530	30	2.8
Africa	800	190	6	0.5
Europe	170	140	30	0.3
USSR	915	765	35	3.2
Asia	530	400	15	0.2
Pacific area	190	80	10	n.a.
World	4,030	2,800	21	0.8

Source: Persson (1974), and World Bank (1978)

Table 3	FAO African Forestry Data.	
Land area	Million ha	
Total	2865	
Total Forest Area	841	
Closed forest	187	
Other wooded land	654	
Inventoried area	78 (9.4% of total forest area)	
1976 production of forest products (fuelwood and charcoal, industrial roundwood, sawn wood, panels, and paper and paper board).		
Countries surveyed	45	
Countries for which data are based mainly on 'estimates or unofficial sources'.	33	(73%)
Countries for which fuel wood and charcoal data are based mainly on 'estimates or unofficial sources.	40	(88%)
1976 trade in forest products		
Countries surveyed	45	
Countries for which data are based mainly on 'estimates or unofficial sources.	25	(55%)
Energy consumption (million tons coal equivalent)		
Commercial energy	68.3	
Fuel wood and charcoal	90.0	

Source: FAO, Secretariat Note: Providing Forestry Sector Data Appropriate to National Situations, p 7-10.

Total 'forest area' may be lands legally designated as forest lands regardless of their actual use status. It is often unclear whether actual unproductive 'waste land' is included in forest land definitions. Discrepancies between official land use status and actual land use practice can have considerable effects on published statistics. In the contested 'margin' between official and unofficial status, land tenure insecurity will tend to prevail and this may lead to intensification of deforestation.

Closed-forest data will be guestimates as up to date aerial photographs will not generally be available and, even when available, on-ground inspection on the status of the forest will not have been possible. Estimates of available resources of wooded land outside designated forest land are only crude guesses as those lands are not under the responsibility of the Forestry Department to inventorize, while other professional departments, such as agriculture or livestock, in the past had no direct interest in such data. To them, such lands were mostly of interest as possible locations for future agricultural expansion. In addition, considerable amounts of woody materials may exist in public road side land strips, or private home gardens. Data on these wood resources are also not available. At any rate, only a small fraction of total forest land has been surveyed, as Table 3 shows.

The magnitude of the uncertainty on woodstock data is thus enormous. It is also nearly impossible to improve upon these data base effectively and within a short time period, the more so as the widening and deepening crisis in African development has left governments strapped for funds to undertake these tasks. Even where better base-line data may become available for planning action, the time lag in their publication makes them rapidly obsolete as an impoverishing population may by then have already encroached upon these natural resources.

Yield Variability

In addition to the problems of estimating stocks of forest resources, there are also considerable problems in respect of the yield of these resources. Clear distinctions have to be made between the yields of the natural forest, of managed forests and of woody materials in agricultural and residential lands, as woody biomass yields appear to differ greatly depending upon a whole range of factors. Where yield variability is important, it will have a major effect on assessments of forest (over)use trends.

Natural Forests
The productivity of natural forests varies with species composition, species density, soil fertility, topography and susceptibility to wind, in addition to climatic factors such as temperature, light and rains. Many natural forests are designated as protection forests, for instance for the upper slopes of watershed areas. They serve to protect the hydrology of the catchment area, and are thus not to be cut -- *de jure*, though not *de facto*.

The legal designation of natural forests as protection forest often means that their characteristics have not been studied systematically, except by biologists and conservationists, and certainly not from the perspective of forest exploitation. For instance, little systematic information is available on the mountain forests, even in highly densely populated Java in Indonesia. In practice, many such natural forests are exploited in an uncontrolled manner. As data on the productivity of 'natural forests' are not normally available, the extent of possibly (over)use is not known. But transect studies in the early 1980s in the Kali Konto catchment area near Malang, indicated that selective and very wasteful (over 90 percent of trees cut were left unused) cutting of the middle range of productive trees was considerable, leaving a wide gap in the age composition of the forest stand in the area. Therefore, the viability and vitality of the so-called protection forest had to be seriously questioned.

For the savanna type vegetation, typical for large parts of Africa, lack of knowledge of the rate of regeneration of the natural vegetation after prolonged periods of drought -- such as has occurred in the 1970s and 1980s -- are a major cause for concern for the populations involved, for donors and for governments.

Managed forests
The productivity of managed forests, especially of forest plantations, is usually better known because of foresters' long preoccupation to develop mono-stands of tree species for the forest industry sector or for exports: pine, fir, teak, merbau and other economically much demanded species. In principle, it should thus be possible to work towards sustainable yield-based forms of forest management.

Managed multi-species forests are rare, and Forestry Departments have not often included those species that meet the needs of forest fringe dependent populations in their forest management plans.

Many forest authorities claim to manage their forests on a sustained-yield basis, implying that there is an effective forest organization and management plan for the forest area, and that the rate of replanting keeps pace with natural incremental growth of the woodstock and new planting. Much if these allegations are pure fiction.

Major problems crop up when actual replanting schemes are compared to planned replanting schemes. Often the raw materials for saw mills or pulping plants are assumed to be available on the basis of statistics supplied by the Forestry Department. In reality, standing stocks and successful replanting rates are much lower. When such information becomes available only after the establishment of the saw mill or pulping plant, their existence will induce excessive exploitation of the existing forest resources. An example of such a misplaced plant is the large, Korean built plywood factory in Ceram on Maluku in Indonesia.

In a recent worldwide review of forest policies, it was found that the large majority of the tropical forests are not effectively managed on a sustained yield basis (Poore,et.al., 1989; see also Repetto, 1988). In this study, commissioned by the International Tropical Timber Organization (ITTO), Duncan Poore and his team applied a strict definition of forest management: that it should be practised on an operational rather than an experimental scale, and that it should include the essential tools of management. These tools pertain to objectives, felling cycles, working plans, yield control and prediction, sample plots, protection, logging concessions, short-term forest licenses, roads, boundaries, costings, annual records and the organization of silvicultural work. They must also meet wider political, social and economic criteria without which sustainability is probably unattainable (Poore, 1989, 192ff).

Given these criteria, the conclusions of the study are appalling.
In Latin America and the Caribbean the total area being sustainably managed at an operational level is limited to 75,000 ha in Trinidad and Tobago of which 16,000 ha have been declared as fully regenerated after initial logging.

The conclusion in Africa is that there are no sustained-yield management systems being practised over large areas in the six countries studied. Worse, management has been progressively abandoned, may be with the exception of Ghana. Some encouraging experiments, covering 10,000 ha, have been reported in Ivory Coast.

It has not proved possible to the study team to give an estimate of the area of forest under genuine sustained-yield management in Asia. But Asia differs fundamentally from both Africa and America in one respect. With the exception of Papua-New Guinea, all the forests under concession agreements are, at least nominally, under management. There is, however, a very great difference between theory and practice in many parts of the region. The most encouraging and complete theoretical system for operational management in the region is in place in Peninsular Malaysia (ibid, 195). In Queensland, Australia, just over 160,000 ha, the whole area of forest scheduled for logging under stringent environmental guidelines, was recently declared off-limits to loggers, because the Commonwealth considered that logging was inconsistent with the nomination of the Queensland rain forest as a potential World Heritage Site.

The overall picture shows that the area of tropical moist forest, which is demonstrably under sustained-yield management for timber production in the producer countries of ITTO (with the exception of India) amounted, at the very most, to about one million ha, out of an estimated total area of some 828 million ha of productive tropical forest remaining in 1985, in all the countries in which it occurs, not only those belonging to ITTO.

This study dealt with forest areas and timber. It is not known how many people live in the designated forest area or are otherwise directly dependent upon these areas, for fuelwood or otherwise. It is thus not known how much fuelwood, as a by-product of timber logging, is obtained from such forest areas in Latin America, Africa or Asia.

Forest yields are, of course, also a function of the form of exploitation. Clearcutting in rotations is one common form of exploitation convenient to the forest industry, and it is on such practices that tree growth data and optimal rotation length are based in well managed forest systems. Sample plots of such mono-stands are used to derive the yield data for trees in particular topographical and physical milieus. But there are other forms of woody biomass exploitation which are widely practised in agricultural lands, and where the focus is much more on individual trees rather than on forests, and where the multiple use characteristics of wood resources are more explicitly taken into account than in the forest plantations so beloved by classical foresters.

Trees in Agricultural Lands
Individual trees in agricultural and village lands grow and are used in a manner systematically different from the above mentioned managed forests (Poulsen, 1983). In managed forests, sample plot trees are exposed to competition, below and above ground, and on all four sides, whereas farm trees enjoy practically maximum available radiation on two sides and are also exposed to relatively little competition where their roots extend below those of usually more shallow-rooted crops. Moreover, farm trees may benefit from fertilizers applied to the agricultural crops. Spears

(1986), the long time World Bank forestry adviser, suggests that free standing farm trees may grow at anything from three to six times faster than the same trees under the same conditions in a plantation.

Trees on a farm do not occupy a well-defined area that can be used for yield calculation purposes. As Poulsen (1983) notes: strictly speaking, only the basal area of the stems constitutes a full-time, measurable occupancy. The ground coverage of the crowns, on the other hand, fluctuates continuously between nearly zero and a score or two of square meters per tree. The foliage is never allowed to reach such a density and extension, as this will impede (trough shading and water demands) the satisfactory development of crops on the land.

Therefore, just as it is not possible to apply trial plot data for volume/hectare to trees which do not occupy a well-defined area, it does not make sense to use growth data of a similar origin for trees growing on a single line (as a windbreak), in several lines or strips (as in shelterbelts) or widely scattered across farm land and exposed to different growth conditions.

The silvicultural treatments applied in the two major production categories, of plantation forestry on the one hand, and of individual tree growing in agricultural lands, have thus scarcely anything in common. Pruning -- of the whole stem or of major branches, and pollarding -- lopping the tree tops at certain height (above goat reach) to protect new foliage against livestock for instance, are common practices, and also coppicing is often more limited so as not to spoil the root structure. In contrast, clearcutting on plantations usually implies uprooting as well, to prepare the lands for new planting. When well developed root structures remain undamaged, tree regrowth can be much faster. Intermittent pruning provides welcome fuelwood materials and building poles for the whole life span of the tree. At the end, after some 40 to 50 years and often some 15 to 20 pruning rounds, the timber value of the stem is available as well.

Total biomass production over the life span of the tree may be very much higher than the clearcutting of the stem at the end of the rotation, the common practice in forestry for industrial usage. The branches may have provided as much as 60 to 80 percent of the total (Poulsen, 1983).

Contrasting Views on Trees

We may sharpen the distinction between different ways at looking at trees in developed and developing countries (Leach and Mearns, 1988, 48-51). Foresters from industrialized countries, and many foresters in Africa who were trained in industrialized countries, are used to thinking of trees as a means of producing large timber such as oak, beech or teak, in which case long growth periods to increase stem diameters are an advantage. In this context branches are seen as negative influences, distracting from stem diameter development. In addition, smaller stems, of 5-10 inch diameter, are in demand for the paper/cellulose industries and are thus grown specifically for such specific end-uses.

Most Third World farmers, on the other hand, are generally more interested in slimmer or smaller pieces of wood, particularly for construction poles or fuelwood. Their time frame and economic rationale for tree growing is therefore quite different.

This crucial point is illustrated in Figure 1, which shows how the net value of trees varies with stem diameter (or, roughly speaking, time), comparing the widely divergent cases of industrial forestry as exemplified by Europe, against forestry for local needs in Africa. Net revenues are derived from the wood value less harvesting costs. Revenue is maximized in the European case when stem diameter is large, since this gives economies of scale in the processing of wood for industrial timber and wood pulp. Harvesting cost also fall with stem diameter owing to economies of scale with mechanization: it is cheaper to fell and cut a few large trees than many smaller ones for the same total volume.

In contrast, net revenues from small holder forestry in Africa are maximized when trees are harvested at a young age when they have small stem diameters. This is because the major end-uses are slender construction poles, fuelwood and fodder. It implies that the whole tree is considered to be valuable: stems, branches, twigs and leafy materials, in contrast to the single stem diameter fixation of classical forestry.

Time horizons are generally shorter in developing countries (see also Figure 2). Even timber and charcoal making in Africa and Asia requires trees of little more than around eight years' growth. At the same time, the labour requirements (and hence costs) of harvesting trees by hand and machete increases substantially with stem diameter. Most farmers, unlike corporate or government plantation owners, cannot wait for long to reap the economic benefits of their investments. Thus, the preference for smaller, thinner and faster growing tree species makes sense in terms of dominant end uses and in terms of small-farmer economics (Leach and Mearns, 1988, 50 and 159-61).

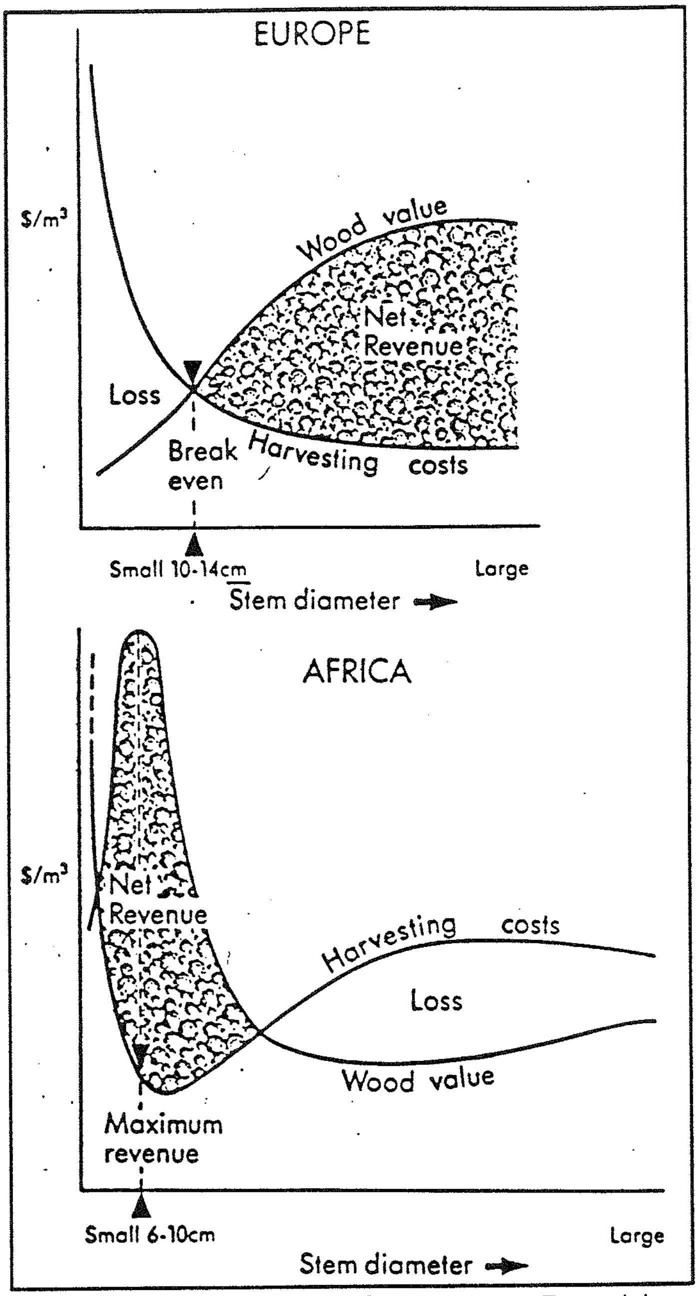


Figure 1 Wood Value as a Function of Stem Diameter: European and African Forestry Compared (Refsdal, 1987)

The above distinction is often captured by the terms single purpose and multipurpose wood production or forestry. The most common types of tree stocks on farms will be woodlots, trees in croplands and hedges. By combining different species of wood and applying different rotations, overall wood resources management can be organized in such a way as to meet the differential needs of farmers for wood products. This may be illustrated in Figure 2.

For example, if the farmer wants to produce poles, but the existing density is too high, a thinning plan can be proposed to improve production. If the trees are already overgrown, the wood could be used to produce charcoal or timber, while the production of existing trees in cropland may be enhanced by improving pollarding systems.

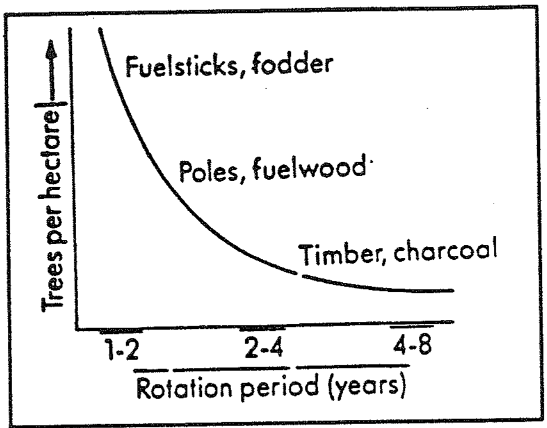


Figure 2 Nested Rotation Cycles for the Improved Management of Trees and Harvesting of Wood Products on Farms (Van Gelder, 1987)

WOOD FUEL DEMAND ESTIMATES

In addition to the generally grossly inadequate data on existing woodstock and on their differential yields, there are three more steps which need to be taken to arrive at 'woodfuel gaps' as presented initially by FAO and since then in the 60-odd national energy assessment studies which have been undertaken under the auspices of the joint UNDP/World Bank Energy Assessment Programme in the first half of the 1980s. These steps pertain to (a) estimating the fraction of woodstock used for fuel; (b) fuel demand estimates, and (c) estimating rates of inter-fuel substitution, implying that woodfuel projections have to be embedded in overall energy development scenarios and covering all sources of present and future energy sources and options.

First, major judgments have to be made about the fraction of existing woodstock resources which will be used for fuelwood purposes. With multi-purpose functions of trees such judgments are arbitrary, and actual usage of different or even of the same tree products are influenced by changes in the effective demand for different woodstock end-uses at different times and in different locations.

There are conflicting, because alternative, end-uses for existing bio-mass resources. This economic aspect of biomass production is often ignored in studies which treat the production of biomass as a 'technical-biological' issue. For instance, the Commonwealth Science Council's effort "Assessing Biomass Energy Resources in Developing Countries", aims to develop a common accounting framework for assessing biomass resources (Wereko-Brobby, 1986 and SEARET, 1987). The use of woodstock for fuel is only one of the possible uses of wood and in many cases a low valued use of woodstock compared to its use as building poles, or of leafy materials for fodder, and this affects the emphasis in biomass production decisions and classification of flows in such accounting systems.

Most macro-level demand projections assume arbitrary and constant norms for energy needs per capita, regardless of the actual supply situation. Even as a first approximation this is proving to be inadequate as more micro-oriented surveys (see below) indicate that there are substantial differences in energy consumption on a per capita basis between countries, regionally within countries and among different socio-economic classes. Moreover, the planning assumption of constant demand figures for the sake of making projections is unsatisfactory as supply and demand interact upon each other, leading to changing demand patterns and possibly inducing new action to augment supplies (see Annex 1).

Some aspects and problems of inter-fuel competition and possible implications for woodstock resources will be taken up later on in this paper. At this point it needs only to be pointed out that for long term fuel demand projections the effects of inter-fuel substitutions could well be significant. This applies not only to wooodstock resources, which are basically slow growing and thus require a long term planning perspective. But also the prospects of new sources of energy, such as solar/wind/hydro and biogas, will have to be factored in. At present the contribution of these sources is marginal in most countries and situations, but the effects may become significant in twenty years time, if in the near future a major and sustained research and development programme for these sources were to be launched. New energy sources, as well as conventional commercial energy development issues will not be treated in this paper. Some of the major issues and trends over the past 15 years have been briefly sketched elsewhere (Van de Laar, 1990b).

When supply estimates of woodstock and demand estimates for rural energy are combined, indications are obtained about the question whether there is a rural energy problem. Clearly, the margins of uncertainty in the supply estimates and also in demand estimates discussed earlier in this paper, are enormous, for the reasons outlined here. Unreliable supply and demand data can produce grossly exaggerated or underestimated 'gaps' in future fuelwood resources.

While those who made the early projections by FAO, or by UNDP/World Bank are aware of the shortcomings in the data and in their projection models, their results have played, and continue to play a major role in national and international policy circles.

The conclusion to be drawn from the discussion so far is that, even though there may be no generalized wood energy crisis, there certainly appears to be a problem, which is likely to intensify over time. Inadequate data should not deter from attempting to formulate policy relevant research which might be of use in coping with the woodfuel problem, and reviewing these efforts to date is the subject of part 2 of the present paper.

MICRO - ENERGY SURVEYS: AN OVERVIEW

INTRODUCTION

Prior to 1973 rural energy studies were considered pointless, as their likely conclusions were thought to be obvious. Between 1973 and 1981, oil importing countries wanted their energy sector explicitly studied in the wake of the large increases in international oil prices. By default, most attention was devoted to commercial energy at the national level as the information base for non-commercial energy was either too weak or non-existent. Thus a number of *ad hoc*, and mostly micro level energy surveys were undertaken, often inspired by the general increase in public policy attention for rural development and food production. These studies identified a large number of previously unsuspected problems. By the mid-1980s enough information had been collected to put rural energy studies, a broader concept than rural energy surveys, in their own perspective. Stock-taking of issues and problems seems to be in order, and this is the objective of this paragraph.

Many shortcomings, problems and issues of available rural energy surveys have been discussed in the report: 'Have Planners Understood the Poor People's Energy Problem? Socio-Economic Aspects of Energy Technologies. A literature review', (referred to as SEARET, 1987).

This report gives an extensive --state of the art-- assessment of the literature in the two fields studied: rural energy surveys, and women and energy technology. The bibliography on rural energy surveys contains over 600 titles, including about 500 actual surveys, of which 360 were obtained and examined during the course of the research. In addition, there are about 100 general works on survey and planning methodology. The bibliography on Women and Energy Technology contains some 900 references. Though many studies are not easily accessible, starting point for work in this area must be the materials collected by the Technology and Development Group of the University of Twente, in Enschede.

It was already noted that the field of rural energy studies is relatively new. Much work is done simultaneously in a number of different locations. Dissemination of findings is limited as many surveys remain unpublished. The learning process from work done by others is therefore restricted and this implies that mistakes are repeated time and again. Fortunately, recent household energy survey methodologies testify to lessons from earlier surveys being recognized and incorporated. See for instance the manual prepared by Leach and Gowen (1987, also available in French, 1989), prepared for the World Bank, which provides much of the basic information to engage in planned energy studies.

The focus of the present discussion is to point at a number of common shortcomings in past energy surveys, which has led to wrong or incomplete diagnosis of the actual rural situation. This has, in turn, restricted their relevance or usefulness for policy and planning strategy discussions.

General Problems and Issues in Rural Energy Surveys

Information collection methods can be divided into five categories: questionnaire surveys, participant observation, direct measurement, the use of 'key informants', and group interviews. The majority of the published rural energy surveys have relied, however, on only <u>one</u> method -- the household sample survey by means of a questionnaire.

SEARET identified only two major initiatives in rural energy research to <u>integrate</u> a number of methods of collecting data. These are the 'Energy and Rural Women's Work' (ERWW) programme coordinated by ILO since 1982 (ILO, 1986; Cecelski, 1986) and the 'Participatory Action Research' (PAR) programme of the East-West Centre in Hawaii, and the Chulalongkorn University Social Research Institute in Thailand. (Bajracharya, 1984; Morse, et.al., 1984).

Brokenshaw and Castro (1983) have argued that surveys of traditional fuels have three basic types of errors: instrument error, procedural error, and error in generalization or extrapolation. Rural surveys in many developing countries are usually designed to capture information on a variety of issues, only one of which is energy. Frequently, the interviewer and the interviewee define the same terms differently. For instance, there is no clear definition of firewood. To the interviewer, often an urban dweller, firewood is roundwood; to the interviewee, firewood is anything that comes of a tree, including leaves and twigs. This basic gap in understanding often creates a dramatic overestimate of the demand or consumption of roundwood for fuel.

The possibilities of procedural error in the administration of the survey are also great. Interviewers must be trained in interviewing and in the subject matter, to avoid misunderstanding and to avoid negative interaction. Where a few questions on rural energy are simply 'added-on', much interviewer training is focused on the main (other) purposes of the questionnaires. Most surveys depend on the memory of the respondent, which can be a major source of error in either direction. There are often idiomatic units of measure, such as bundle, head-load, picul or stere, with varying volume or weight. Respondents also should have the ability to average use over the year when some fuel types are available only during part of the year, in season.

Errors in generalization are probably the most serious problems of rural energy surveys. Inappropriate sample frames, conversion errors and measurement errors due to differences in fuel type, quality and moisture content and thus in calorific values tend to pile error upon error. The cumulative effect of errors in number of fuel wood bundles, bundle weight, wood density, moisture content, and family size multiplied by inaccurate population estimates, could well lead to margins in the aggregate estimates as large as the estimates themselves (for an hypothetical example see SEARET, 1987, 26).

Questionnaires, though almost exclusively used in the past, are thus often not very reliable. Moreover, questionnaires are also not very efficient methods of collecting information when there are little differences between groups, such that very similar responses may be obtained. Past surveys were also often too limited in scope, focusing on average use and aggregate rural energy data. But it is not so much average and aggregate energy aspects which are of most interest for policy, but variations in access and use by different socio-economic groups in society.

Issues for Improved Questionnaire Design

To obtain better information on issues of rural energy, questionnaires should be better designed and the results better presented. Questionnaires should more systematically be combined with other, and apparently little used information collection methods, even though this may make rural energy surveys more costly to conduct.

FUEL TYPES AND END-USES

It is important to carefully distinguish different fuel types and to link them to different end-uses such as lighting, cooking and heating. There need not be direct correspondence between fuel type and end use due to possibilities for inter fuel substitutions. The relations between fuel types, fuel sources and seasons needs to be explicitly established as well.

In past energy surveys insufficient attention was given to fuel sources such as dung and crop residues. In many countries there are, however, no reliable data on numbers of livestock. The production of dung per animal is rarely consistent between sources and sometimes within sources, and large country-to-country difference in dung production exist because of difference in breeds, diets, and herd management practices. Estimates of crop wastes present similar problems. Though data on crops are usually better than for livestock, they are still unreliable. More importantly, the presence of woody materials in agricultural lands was not recognized. This neglect, again, leads to serious overestimates of fuel wood demands as a cause of deforestation.

An example of the implications of alternative estimates of causes of deforestation is given in Table 4. Not only is the loss of tree estimate in the second case dramatically lower than in the early estimate --a reduction of two-thirds-- but there are also major shifts in the incidence of contributing factors.

Table 4 Changing Views on the Causes of Deforestation in Sudan

	Original estimates (NEA 1983)		Revised estimates (Gamser 1988)	
	(million cubic meters of tree loss per year)			
Firewood	24.94	(33%)	13.13	(59%)
Charcoal	46.53	(62%)	2.93	(13%)
Land clearance	1.75	(2%)	5.04	(23%)
Overgrazing, fire, poles	2.13	(3%)	1.12	(5%)
TOTAL tree loss	75.35		22.22	

NEA = National Energy Administration.
Land clearance = mechanized agriculture plus shifting cultivation.
Source: cited from Leach & Mearns (1988), 14.

HOUSEHOLD COMPOSITION

Energy consumption is usually given on a per capita basis, often not correcting for age composition. But a number of activities requiring fuel, such as cooking, are done on a household basis. The composition of the household may also vary over time: within the day when some family members are elsewhere or when friends join and stay for a meal as well; between the seasons when members are looking for income opportunities or pay social calls elsewhere; and between years when the area is a labour immigration or emigration area. Unfortunately, household surveys are usually limited to only very short periods of one or a few weeks, and in only a few countries are they annually repeated to allow analysis of energy use trends

ACCESS TO FUEL SOURCES

Access to fuel sources is a very complex matter which is often not spelled out in the required degree of detail. Relevant aspects include the following:

(a) Ownership of assets with fuel generating capacity. This includes ownership of land, livestock, trees or income from wage jobs. In this respect, Indian surveys score well compared to Africa where much less attention is paid to such differentiation in energy use (SEARET, 1987, 31). It is important to realize that the issue of tree rights and tree tenure has received much attention in recent years. Such rights can be held separately and independent from rights to lands. There are *de jure* and *de facto* rights. Public lands and 'commons' often provide opportunities for those without property rights and assets to meet fuel requirements. The traditionally defined 'forest commons' are often important sources for tenants and the landless to meet fuel requirements.

(b) Distance to the source of fuel is obviously important, as the majority of users would prefer to obtain fuel in the vicinity of the homestead or the place of work. There are considerable impediments to travelling large distances for obtaining fuel. The distance factor implies that the issue of relative fuelwood shortages or surpluses will be highly variable between relatively small geographical areas. Land use data and population distribution data should be combined at considerable levels of disaggregation. Dramatized 'wood fuel gap' estimates over large geographical areas, a common practice to attract attention in public policy at the national and international level, become rapidly meaningless, and thus may induce misguided responses.

(c) The factor time is important in two ways. One is the consequence of distance as discussed, which also influences the type of fuels collected. But time could also be an important factor if interpreted as the opportunity cost of time. This will occur when there are conflicts with other domestic chores, especially important for women who often combine household work with bearing the brunt of agricultural work. They may be engaged in other, off-farm income earning activities as well. In times of peak labour in the agricultural season, there may be too little time to collect fuel. In times of bumper crops the cash income obtainable may outweigh the cost of buying preferred fuel instead of gathering oneself. Conversely, in times of harvest failure there will be greater need and more time to collect fuel from other non-crop sources and over greater distances. More time energy may also be devoted to making charcoal for the urban fuel market, as a survival strategy. The concept of the opportunity cost of time may explain that charcoal prices may decline in years of bad harvests but may rise in years of good harvests, in response to people changing their time allocation to meet non fuel-related phenomena. Inelastic demand, resulting from structural inefficiencies, and supply interact to cause wide price fluctuations (Dewees, 1989).

THE IMPACT OF EXTERNAL FORCES ON WOOD FUEL USE PATTERNS

Energy surveys in rural areas should be linked not only to the self-provisioning requirements of the rural population. Forces outside the rural communities may affect the rural energy situation to a considerable extent, and thus one needs to find out how fuelwood and charcoal markets for the urban population function. To this day very little empirical work has been carried out.

The pull of urban fuel markets may be felt in rural areas some hundred or more kilometres away. Near urban areas commercialization of rural energy sources exerts much stronger pull factors; changes in relative prices of different fuels may be important, and disruption in electric power and/or in the supply of kerosine will induce fuel switching behaviour. Fuel switching need not be irreversible. Moving up-market, out of traditional fuel sources, may be reversed in times of slow economic and income growth. In addition to income, relative fuel prices, convenience and stability of supply are the driving forces in fuel switching behaviour in urban areas (Leach and Mearns, 1988, Chapter 6).

Changes in transportation and expanding road systems facilitate fuel switching downward, back to wood based fuels. Such investments allow urban fuelwood markets to function faster, cheaper and over wider geographical areas. When road user charges cannot be applied, as is often the case, the public sector will in fact finance fuelwood and charcoal traders to operate urban fuelwood markets more profitably. In as far as woodcutting, especially in forest reserves, is prohibited, fuelwood trade is often illegal which makes measurement and incorporation in energy surveys and sources difficult, if not impossible.

From Establishing Fuelwood Gaps to Socio-Economic Analysis

The validity of the concept of a wood energy 'gap' being derived from conventional energy surveys is limited, even after inclusion of the suggestions for improvements in survey design as discussed above. It may serve the useful purpose of calling attention, in an often dramatic way, to an existing or emerging problem in the public policy debate and in circles of development cooperation between rich and poor countries. But even then the effort may be counterproductive if the magnitude and complexity of the problem is interpreted to be so enormous as to induce fatalism in response. By declaring the problem insoluble paralysis sets in, the opposite of what is intended and aimed at.

The identification of 'gaps' by themselves tells little about the dominant causes of the gap, as a demand problem or as a supply problem, nor about effective ways to bring *ex ante* and *ex post* supply and demand confrontations closer together. The analysis is incomplete and thus cannot serve to justify specific policies. Jumping from gaps to alleged causes and to specific action may easily lead to jumping in random or ineffective directions, as will be shown in the second part of this paper.

Future energy studies should be specifically designed not only to collecting facts on current consumption and sources of fuelwood supply, but they should solicit insights in the dynamics of rural energy situations, on the character of driving forces which cause energy problems, and on behavioral responses by those affected by such problems.

Where demand for energy is initially shown to exceed available supplies, we have a measure of unmet demand. As in actual fact such a gap cannot exist, reactions must set in to equilibrate supply and demand, through measures which reduce effective demand and measures which lead to increased supplies. Many such reactions may be forthcoming spontaneously, and need not necessarily be initiated by public policy. For analysis and policies the more interesting and important question is therefore not to refine estimates of unmet demands. Rather, the focus should be directed differently: to analyze how people react under stress, in situations where a first analysis may have shown the existence of tension in respect of rural energy provision.

The scope of energy studies should thus be 'widened' in different directions: within the energy sector, by distinguishing gender aspects, or by placing energy studies in the wider context of rural development situations and rural dynamics. Such studies should try to incorporate a historical perspective on how situations of current energy stress have arisen.

The capacity to respond in such fuelwood shortage situations is not the same for all groups of the population. Hence, attention should be directed to differential response patterns for different socio-economic groups. Various mechanisms may exist or emerge by which the burden of adjustment is shifted to specific groups, especially the poorest members of the community, or those in structurally weak positions, such as women (ILO, 1986; Cecelski, 1986).

Energy needs, in this wider context, are just one set of needs, next to and competing in terms of time and land resources with other needs such as food and income. By analyzing forces behind the data, perhaps a more meaningful perspective can be obtained on the feasibility and viability of proposed rural energy strategies and policies. Studies of this type call for different kinds of skills than those normally possessed by energy specialists or foresters. Social scientists could play a useful role in interdisciplinary studies of the type as proposed.

To facilitate the design of broader-based energy studies, at least the following elements should be included.

ENERGY DYNAMICS

A number of studies have identified indicators which can be used to assess the fuel situation in a community in a more dynamic perspective (Leach, 1985, Howes, 1985 and SEARET, 1987). The indicators distinguished by Leach are reproduced in Table 5:

Table 5 Indicators to analyze energy situations in rural areas.

Fuel preferences/Expanding the resource base:

- Use of less preferred stem wood(fuelwood) species.
- Use of lower quality types of firewood (twigs, scrub, roots).
- Cut firewood from living tree.
- Use of crop residues and/or dried animal manure.
- Purchase firewood.
- Increase proportion of commercial cooking fuel (e.g. kerosine), initially as supplement, finally as a total replacement.

Time adjustments:

Increasing time through:

- Increase fuelwood collecting time from usual source.
- Adopt more distant fuelwood sources.

Saving time through:

- Increasing the amount of fuel carried on each fuel collection trip.
- Increase number of household fuel gatherers.
- Use animals or vehicles for fuelwood transport.

Reducing consumption:

- Reduce fuelwood consumption for least essential end-uses (e.g. water heating).
- Use fuel more economically (e.g. more careful fire-tending).
- Change cooking methods and reduce consumption of cooking intensive foodstuffs.
- Reduce the number of meals cooked per day (with associated increase in the use of leftovers).

Such indicators, which maintain a focus on energy, have thus far been used to a limited extent. The most common indicators used are fuel collection time and distance to fuel sources. The effects of shortages of traditional fuels are described by a number of authors. Most of the surveys reviewed by SEARET give only anecdotal data on fuel shortages and occasionally provide physical data on availability and accessibility (SEARET, 1987 for references).

GENDER ASPECTS

Energy issues, problems and priorities tend to be interpreted differently by men and women, but most energy surveys have not addressed this fundamental fact, neither in the survey design, nor in the choice of the respondents . Such contrasting views are summarized in Table 6 (Hoskins, 1983). Women are generally more knowledgeable about the burning characteristics of different types of wood and on wood requirements for various tasks (Molnar, 1981). The perceptions of children, who often have the task to collect fuelwood are usually ignored or neglected, and thus a possibly important additional perspective on energy collection and sources may be lost. Gender aspects also turn out to be crucial in relation to issues of land and tree tenure while trees are often instrumental in causing or settling disputes over lands. (Some of the recent research findings on this very complex issue will be taken up in a forthcoming paper).

Table 6 Men's and Women's Differing Interests in Trees and Related Resources (Hoskins, 1983)

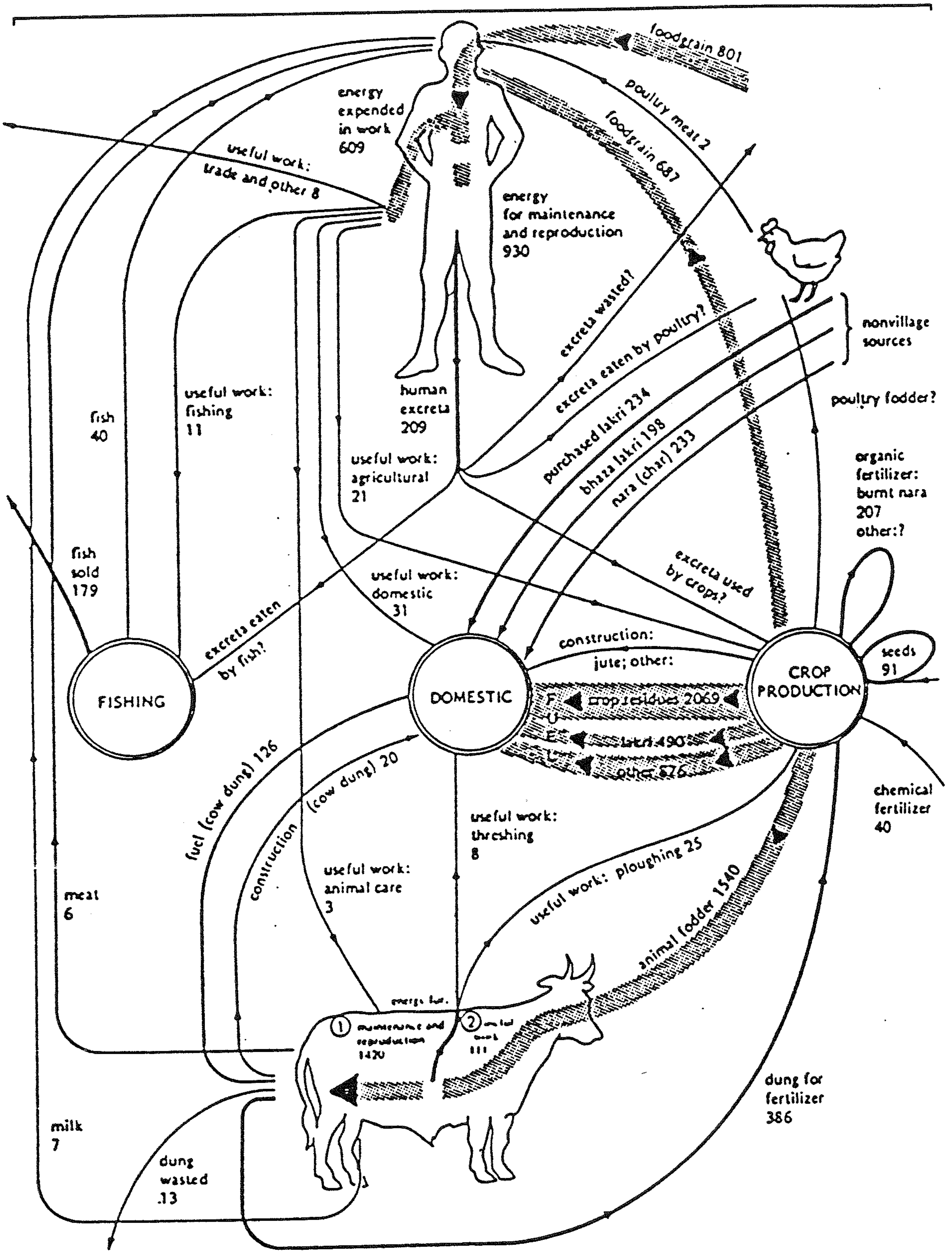
	WOMEN	MEN
Primary Tree Products	Daily fuelwood collection near the household. Concern over availability of preferred species. Interest in access to building poles for local use.	Interest in building poles and timber trees as cash crop as well as local use. Interest in fuelwood mainly as cash crop.
Secondary Tree Products	Major involvement in collecting human food and having available fodder for small animals near home site. In certain areas where cattle are kept at the household, women are in charge of gathering fodder.	Herders apt to be involved with large animal grazing but not limited to areas near the home site. Little interest in collecting wild food products from natural vegetation.
Tertiary Tree Products	Collect numerous products needed in the household and for barter or sale. Women's employment or extra cash income may depend on access to tertiary products as raw materials.	Some men make medicines especially herders for their animals. Men may use tertiary products but they often use fewer and quite different ones than those used by women of their own communities.
Soil	Use limited to areas near household. Special interest in soil quality in gardens and in fields with subsistence crops.	More choice of area for farming as men are more mobile and may have access to fertilizer. Interest generally focuses on best soils used for cash crops.
Water	Generally responsible for locating and transporting household water. Often also responsible for water delivery for introduced projects (i.e. poultry, watering newly planted trees). General concern over percolation of water into garden and field-crop soils.	Herders generally take animals to water source so may be more concerned with water lifting than delivery or source availability close to home. Concern also over percolation of water into soils of fields.

ENERGY AND RURAL DEVELOPMENT

Expansion of energy studies in a wider socio-economic setting may be attempted with help of the framework as given in table 7. It provides a useful overview, in using energy as an entry point to different stages of physical and socio-economic degradation in rural areas (Cecelski, 1986).
The diagram reproduced in Figure 3, from Briscoe (1979) illustrates energy flows in a Bangladesh village by fuel type and social class. It is part of a study which places energy in the wider rural development context of a village. The risk with detailed village level studies is, however, that they may inadequately incorporate external forces on village dynamics, in this case the commercialisation process of fuel wood resources.

Table 7 Energy as an Entry Point to Different Stages of Physical and Socio-Economic Degradation (Cecelski, 1986)

	Fuel Access/types	Labour time	Income	Food/Agricultural Productivity	Migration	Priority
I	Free access to high quality wood	Minimal	Forest-based industries and trade, food processing still viable	Little erosion. Nutrition based on a variety of local cultivated and gathered products	Minimal	ENERGY FOR LABOUR/TIME SAVING to increase efficiency and productivity of specific tasks, e.g. improved animal traction for water lifting, hydro grain milling, better drying for fish, herbs, more efficient beer brewing.
II	Access limited and increasingly privatised. Type of fuel used corresponds to income level - poor use mostly residue fuels due to lack of cash to purchase more convenient fuels.	Increasing time for fuel gathering, cooking, water collection and agriculture	Forest-based industries and incomes declining	Falling due to erosion, diversion of organic matter to fuel. Rich coopt best lands and other resources. Diets depend increasingly on purchased foods.	Male migration becomes an economic necessity for poor households	ENERGY FOR COOKING AND RURAL EMPLOYMENT to save time and raise incomes, e.g., energy and resource-based income activities.
III	All high quality fuels commercialised and severe penalties for infringement on private resources.	Satisfaction of basic needs alone requires all household time, with negative effects especially on women's health.	No natural resource-based or fuel-intensive industries or employment	Yields of staple crops falling dramatically. Food from relief or purchase. Nutritional and health status poor	Outmigration of "ecological refugees" to cities	ENERGY FOR RECLAMATION OF LAND AND LIVELIHOODS to both reclaim wastelands and generate incomes, e.g. through social forestry and infrastructure works.



Notes: The study included 330 people, 48 cattle, and 43 acres of agricultural land. The term useful work refers to actual mechanical work output, which is on the order of 10 percent of total work. The denominator for each estimate is 1 person X 330.

Figure 3 Daily per Capita Energy Flows (kilocalories) in Ulipur, Comilla District, Bangladesh (Briscoe, 1979)

POLICY APPROACHES TO RURAL ENERGY

The search for strategies and policies to cope with rural energy problems has been of rather recent origin, in many cases not more than 10 to 15 years. Rural energy programmes involving tree growing necessarily require a long term perspective. A period of 15 to 20 years is needed to be able to systematically evaluate such experiences, and therefore few such evaluations are currently available.

Policy responses to a newly acknowledged rural energy problem are inevitably conditioned by the professional background of the analyst and by the operational culture and working environment of the institutions which are assigned, or take the lead in coping with the problem. Professional practices interact with training and education and with long standing institutional routines, which have also shaped bodies of laws, regulations and entrenched modes of operation.

Such attitudes and practices have not emerged in a historical vacuum, but were a response to the priorities and needs of the times. Many such interests and needs persist and are not in the least diminished by the fact that a new and major problem area is vying for attention in public policy debates. Conflicts may sharpen as there are often clear opportunity costs involved in alternative approaches in respect of finance, class interests and land use options.

To sketch the arena in which wood fuel issues have to be dealt with, the formulation by Poffenberger (1990, xx) will do:

> *'Besides foresters and forest inhabitants, other groups have their own forest use priorities. Politicians and administrators in government agencies often struggle to have forest lands transferred to their control. In some cases they seek to have the land reclassified for resettlement projects, industrial export zones, state plantations, or privatization. Citizens concerned about the environment raise their hands in protest over the irresponsible exploitation of forests. They hope to protect unique flora and fauna. They lobby for bans on logging operations and sometimes for the exclusion of forest communities. Social scientists bring still another perspective to the debate, their concern is often for the people living near or in the forest. Contending that commercial exploitation does not answer economic needs, many argue for the rights of indigenous tribal and farming communities. Each group has its own view, yet all have been relatively ineffective in developing alternative management systems responsive to diverse, and sometimes conflicting, national and local priorities'.*

Energy Specialists/Economists

INTRODUCTION

An institutional division of labour has developed whereby energy departments became responsible for economizing on fuel and fuelwood use, while the task of supply enhancement tended to be handed over to the forestry departments (Munslow, et.al.1988, 9)

Energy specialists have contributed to energy demand management studies, fuel switching options, incentives and price sensitivity for fuel switching, and energy saving investment policies .

In early writings on the rural energy crisis the argument was made that sky rocketing prices of fuelwood would lead to the substitution of dung for wood. As dung was also seen as the key source of alternate fertilizer to those who suffered most from oil price related fertilizer price increases, agricultural production, especially of the poor, would suffer most.

Three points can be made of this line of reasoning. The rising prices for fuelwood were often quoted without reference to the rate of inflation, and the income burden on households cannot be assessed without some information on possible compensations through other market involvements, such as rising sale prices for (net) food suppliers . The production effect of the use of agricultural residues and dung depends much on the precise circumstances in which it happens (Barnard and Kristopherson, 1985). The fertilizer value of the stalks of crops such as millet and sorghum is relatively low and they are difficult to recycle; often they are burned in the fields, though in some countries, such as in Sudan, some find their way to the urban fuel market. Dung, which has lain in the open for a couple of days in a hot dry climate, loses much of its nitrogen and is not particularly effective as a fertilizer. The use of these materials as fuel does not deprive the agricultural system of a great deal (Foley, 1988). While substituting dung fore wood may have been significant in places, the fuel switching debate has centred on substitutions between traditional woodfuel and modern fuels, such as kerosine and electricity.

Fuel switching is only relevant for those areas where different fuels can be used side by side. In general this will occur in urban and peri-urban areas where fuel sources other than fuelwood and charcoal are in use, such as kerosine, biogas, electricity, and oil and gas. Energy specialists, therefore, tend to study mostly urban energy markets.

While energy specialists and energy economists have a good grasp of problems and issues in commercial energy, they have little knowledge and experience with wood and other biomass fuels, firewood and charcoal. What is now required of energy specialists/economists, is to widen the scope of energy studies to incorporate woodfuels and, in doing so, also incorporate urban-rural fuel interaction processes. This was not done in the past, due to neglect of the traditional woody energy sector and because these products are only partially traded, which makes it very difficult to obtain relevant comprehensive data on basic aspects of woodfuel use as a basis for energy demand planning. The data situation is still poor but at least some evidence is becoming available.

The relative competitiveness of different fuels is technologically, and socio-culturally linked to the efficiency and convenience of different fuels in different end uses. For some end-uses the scope for fuel switching is limited for reasons other than technological possibilities. For instance social factors have impeded the acceptability of improved, energy efficient stoves. In some societies the use of dung is still preferred in the face of existing alternatives, due to its slow and steady burning characteristics.

Where all fuels are traded, the competitive position is partially determined by the fact that some fuels, such as kerosine, oil and electricity, will bear the full resource cost, while traditional fuels do not. As this is generally the case for wood fuel, this tends to make fuel wood the low cost fuel option. Alternative options will then have to be made so attractive that they can compensate for this difference in initial resource cost positions.

The efficacy of traditional economic policy instruments within the framework of the neo-classical tradition is subject to a number of assumptions about the functioning of markets and of the behaviour of economic actors to prices. With the incorporation of woodfuel and non-marketed resource use behaviour there is thus a need to re-examine the appropriateness of conventional policy instruments.

It is at present realized more widely than before that the efficacy of these instruments is less than was thought some five to ten years ago, as may be surmised from comparing older publications on the subject with more recent ones (Clarke and Shrestha, 1990; compared to, for instance: Anderson and Fishwick, 1984). Especially when account is also taken of some of the tools and findings of 'transaction cost economics'. This 'new institutional economics' school incorporate the idea that responses to price incentives are neither instantaneous nor costless. Such factors as incomplete information of economic subjects, the *ex ante* and *ex post* cost of rule making, rule adaptation and rule enforcement possibilities and costs, explicitly feature in such approaches (Williamson, 1985; Van de Laar, 1990a).

We will point at some pitfalls in the neo-classical approach to energy demand management, by briefly reviewing conventional economic policy approaches to energy markets, and their (in)applicability or (in)efficiency when the energy market is extended to include fuelwood and charcoal.

First let us put fuelwood trade in some perspective. It should not be assumed that trade in fuelwood is small, even where much fuelwood is locally gathered by the local population and thus not traded. In most developing countries the internal trade in wood products, especially fuelwood and charcoal, is very large. In Africa alone the annual value of traded fuelwood and charcoal is probably in excess of US$ 2,000 million, while the annual total 'value' of these products (including self-collected fuelwood) may be in the region of $ 6,000 million to $ 8,000 million. The trade in wood energy supports a large number of people in processing, distribution and marketing, yet the value of the wood -- the raw material on which the whole trade depends -- is in most cases insufficient to ensure that it will remain a renewable resource. The actual stumpage fees collected by African governments for fuelwood and charcoal could be in the region of $ 30 million per annum or about 2 percent of the selling price of the finished products (Openshaw and Feinstein, 1988, 43). If trees are treated as a mineable resource not only will it adversely affect the economies of these countries but will surely cause long term environmental damage.

Forest resources are in practice similar to 'open access' resources, as neither state nor communal management systems at the present time are very effective in managing the resource. This is an initial oversimplification and we shall return to this topic later on in the paper.

The 'open access' character of many forests and tree resources has a number of implications for the manner in which the resources are used. The main effects can be summarized as below (ibid, 8-13):

(a) Overconsumption of fuelwood. It is an axiom of consumer behaviour that the cheaper a good is priced, the more of it will be consumed. Overconsumption in this context means that the marginal social cost of woodfuel consumption, as measured by the concepts of marginal extraction, user and external costs, is greater than the marginal social benefit.

(b) Wastage and inefficient transformation. With cheap wood there is little incentive to save wood by, for instance, improved charcoal making practices or by investing in wood saving improved stoves. Such projects are therefore likely to fail regardless of the technical efficiency improvements which could be obtained from such technologies.

(c) Transfer of rents to urban consumers and middlemen. As formerly wooded areas are not replanted, this implies a net transfer of resources from the rural areas to urban consumers, or to the middlemen if markets are not competitive.

(d) Disincentives to tree planting. Wood from open fields competes with wood from plantations, and this places the latter in an unfavourable position to recoup plantation costs and to obtain a profit from tree planting.

(e) Drain on government revenues. The underpricing of wood means that the government dos not obtain sufficient revenues to take care of adequate replanting of woody resources. It may also find itself to have to subsidize afforestation and reforestation to stabilize the soil and to prevent erosion affecting agricultural lands.

Neo-classical economists advocate market-oriented instruments, also for forest management, which attempt to offset these inefficiencies. These instruments and policies are reviewed below.

The potential benefits of developing wood markets and of charging for fuelwood resources are clear, as they would counteract many of the above negative tendencies. The issue then is whether increased stumpage fees can be levied, efficiently collected and whether compliance can be effectively enforced. The crux is implementation and burden shifting processes.

DIRECT FOREST REGULATION: TAXES AND QUOTAS

These policies attempt to achieve socially optimal rates of forest utilization either by (a) taxing forest harvests to equalize collection costs with social costs, or (b) imposing quotas on harvests to restrict use to socially desirable levels.

A practical difficulty with such policies is that it may be impossible to obtain information about the cost and benefit functions relevant to different categories of users, particularly since households themselves generally collect fuelwood. This difficulty, together with prohibitively large cost of policy implementation, suggests that welfare gains might be entirely offset by administrative costs. In fact, such plans may be more expensive and less simple than enforcing property rights directly.

Tax and quota policies have distributional consequences which cannot be ignored. This is particularly the case when resource-users are low-income households who depend upon forest resources for subsistence and yet are not compensated for losses in income implied by tax collection.

SUBSIDIES FOR SUBSTITUTE FUELS AND TECHNOLOGIES

Often subsidies for substitute fuels are used as instruments of fuelwood demand management. Thus kerosine, which is often the nearest commercial substitute for fuelwood, is subsidized in a number of countries such as Indonesia and Malaysia. Other countries such as India and Thailand subsidize biogas plants.

There are, however, major reservations concerning the feasibility and desirability of subsidy policies in the present context. If fuelwood is obtained merely as a <u>by-product</u> of forest clearing for farmland or for timber harvesting, then a policy of fuel subsidy will be ineffective. Similar arguments can be advanced, if overgrazing of livestock, and the consequent destruction of young trees rather than fuelwood collection, is the major source of deforestation.

A general efficiency problem with a subsidy policy is that the policy may have non-specific impacts since non-target groups (such as industries which use the substitute fuel as an input), which do not contribute to fuelwood problems, will benefit from the subsidy. For instance, a kerosine subsidy has the undesirable effect of providing an incentive for retailers to adulterate gasoline with kerosine. Such spill-over effects may be very large compared to the benefit share which reaches the intended target group to induce them to refrain from fuelwood collection activities. In this respect, at least, subsidies on substitute fuels contrast with the effects of taxes on fuelwood use since the latter policies are directed solely to the group generating dis-economies.

Subsidizing substitute fuels is most efficient when the demand for fuelwood is cross-price elastic with respect to changes in substitute fuel prices (to ensure that the substitution process works well), but where the demand for the substitute fuel itself is price inelastic (to ensure that the subsidy bill for the government does not increase explosively). Unfortunately, in countries which are heavily dependent upon fuelwood this does not seem to be the case. For example, in Indonesia, where kerosine is being subsidized as an alternative fuel to wood, demand for both fuels is 'own' price elastic but cross-price inelastic (Pitt, 1985, cited in Clarke and Shresta, 1990, 48). Furthermore, if fuelwood collection costs decrease as the size of the initially overexploited forest stocks increases, then subsidies need also to increase over time to maintain the competitive position of substitute fuels.

There is also considerable scepticism about the efficiency and effectiveness of fuel subsidies in the African context. Foley (1985 and 1988) analyses the impact of subsidies and pricing on kerosine/woodfuel substitution. He concludes more generally that a fuel switching strategy will not ease the woodfuel scarcity problem. Leach and Mearns (1988) note that in the case of Africa, the setting of the 'correct' price differences between modern fuels and woodfuels on a city-by-city basis is problematic, due to often rapidly moving woodfuel prices and wide variations in prices between cities. Because the economic infrastructure in Africa is generally less developed than in Asia, the probability of irregular kerosine supplies tends to be greater as well, thus acting as an impediment to fuel switching.

Subsidies for commercial substitute fuels will give wrong market signals to private woodfuel producers. While consumers are encouraged to reduce consumption through using the substitute, private producers will not find fuelwood production less attractive.

Subsidies, once introduced may become a permanent feature in developing countries since, politically, it may be difficult to abandon such policies even where their continuation is economically undesirable. Even if the subsidy policy is effective for the management of forest resources, it may not be feasible in low-income, oil-importing developing countries, due to the additional foreign exchange burden implied in importing commercial fuels. For example, in Nepal, where consumption of petroleum products is less than 4 percent of total energy consumption, their value is about 10 percent of all imports but over 30 percent of the value of exports. The financing of energy imports in many African countries absorbed small shares (around 10-15%) of export earnings in the 1960s, but accounted for large and growing shares in the early 1980s, e.g. for 44% in Ethiopia, 63% in Kenya, 77% in Senegal, 44% in Sudan, 24% in Liberia and 23% in Niger (Anderson and Fishwick, 1984, 4).

There are also major equity issues associated with the subsidization of substitute fuels. Subsidies can benefit privileged groups more than the poor. As an illustration, it has been calculated for Indonesia, that the poorest 40 percent of the population used only 20 percent of the kerosine, thus for every rupiah of subsidy benefitting the poor, four rupiahs benefitted the relatively well-off (as cited in Clarke and Shrestha, 1990, 49).

A major practical problem with subsidy schemes in developing countries is simply their reliance on the assumption that fuelwood collection procedures do have a market valuation by either selling fuelwood or through other activities. If this is not the case then it is fuelwood, and not any positively-priced commercial fuel that will be used. In many poor areas, fuelwood has a very limited market since it is mainly collected by users themselves as a virtually free good. Moreover, where labour is in surplus for much of the year, the market valuation of an individual's time will often be close to zero. This situation is perhaps more typical for densely populated Asian countries than for much of Africa where labour shortages for agriculture and soil conservation is often observed. So, rural communities will tend to use fuelwood even if substitute commercial fuels are cheap. For instance, in Nigeria, villagers are willing to travel twice as far to obtain fuelwood from existing forests at half the price of commercially produced wood and three times as far for free fuelwood (Cecelski, et.al. 1979). In more direct terms, subsidies will be ineffective simply because of absolute constraints on purchasing power. These constraints effectively trap people into using traditional, non-commercial fuels since, even where collection involves substantial time and effort, this time and effort cannot be converted to a cash-earning activity that would permit the use of more convenient and socially-less-expensive commercial fuels.

Coping with rural energy problems from an overall energy demand perspective could lead to contradictory courses of action, when seen in the overall context of commercial energy pricing policies. For instance, increasing the price of commercial fuels, to induce savings in oil imports and in foreign exchange, may induce consumer response to economize in the use of commercial fuel. However, raising the price of commercial fuels may also induce a switching to cheaper sources of energy, e.g. those that do not bear the full resource cost. Deforestation may accelerate!

National commercial energy policies and rural energy policies may be in conflict with each other, but not necessarily so. For instance, to reduce the pressure on deforestation a case could be made to subsidize the cost of commercial energy, say kerosine, in rural areas to the level where it effectively competes with woodfuel. While the required subsidy rate may be relatively large, the volume of commercial energy consumed in rural areas is so small relative to commercial energy, and non-household energy use in urban areas, that the cost of the subsidy on urban households and industrial energy costs and on the balance of payments will be small (Foley, 1985). In other words, the rural energy crisis does not necessarily require a rural fuelwood solution, if an effective way could be found for taxing industrial consumers to subsidize rural energy household consumers.

Alternatives to using the price instrument to reduce energy demands are investments in energy savings. Much has been of the energy efficiencies of introducing improved cooking stoves in rural areas.

IMPROVED STOVES

The issue whether stove programmes should be self-standing programmes or should be made a component of wider-based rural development programmes, is a complex one. It raises difficult questions of focus, priorities, implementation strategies and styles and of timing relative to other activities, which cannot be taken up here. In general, the numerous exhortations for integrated development which have abounded over the last twenty years have often given rise to more problems than answers when it comes to project design and implementation.

Numerous types of improved stoves have been developed and have been distributed in pilot projects. Technical experiments have suggested that two or three-fold increases in the fuel efficiency of cooking would be possible over traditional 'three-stone' methods (Anderson and Fishwick, 1984, 5). Regretfully, stove programmes have largely failed when they were introduced on a larger scale in rural communities. This failure is not so much for technological reasons but, rather, because they were placed in an inappropriate development context (SEARET, 1987 Chapter 3; O'Keefe & Munslow, 1988 and 1989; Munslow et.al. 1988, 139ff; Cáceres et.al.1989).

Most stove programmes are concentrated on rural households where both the fuel itself and the traditional 'stove' (the three stone fire support) are usually non-monetary items of household expenditures. To try to achieve energy savings by improved stoves is often perceived to be neither a major preoccupation nor a priority for action for most people in rural areas compared to other problems and survival needs of the rural poor. To have to buy an improved stove to save on fuelwood use then does not make sense. For the poor, an expense of $3 to $6 per stove is a sizeable expense.

A consensus seems to be emerging at present that the promotion of improved stove programmes by themselves are not worth the bother in rural areas, unless they are linked to a wider fuel saving approach including better wood harvesting methods and fuel drying methods. In urban areas improved stove programmes may have some impact (ESMAP, 1988).

Recently a comparative international evaluation of the impact of stove programmes has become available (Cáceres et.al.,1989). It contains a number of interesting findings on the wider aspects and impacts of stove dissemination programmes. The principal reason for using mud stoves was smoke removal, whereas for ceramic stoves it was fuel savings. However, for the majority of users, the main economic return is the time saved through faster cooking and less time spent in fuel collection or a reduced fuelwood budget. These time savings could then be used, in some areas, for obtaining income through other activities in complex survival strategies for poor households.

All programmes studied measured a statistically significant decrease in fuel consumption, though samples were often small and procedures somewhat doubtful due to staffing constraints. For an average fuel saving of 20 percent, as in Kenya, these programmes are a much more cost-effective method of reducing household fuel expenditure than increasing the supply of charcoal through upgrading its efficiency of production and establishing peri-urban forests for fuelwood or subsidizing kerosine. The introduction of stoves in rural areas will not directly lead to a reduction in deforestation, because most people, in the cases studied, do not cut trees down for domestic firewood use. Most of the fuel that is used is either agricultural residues, small dead twigs, or wood that has been felled from their own land (Joseph, 1989, 56).

The numbers of stoves disseminated have been limited so far and considerable problems have been encountered in setting up low cost, yet profit-making stove producers.

Perhaps the most interesting findings relate to the design of dissemination strategies for stoves in future. Evidence from Sri Lanka and Nepal indicate that governments can implement effective programmes at a national level but that performance at a state and district level can be variable. Appropriate national level tasks may be limited to assure that sufficient funds are made available for research and development including evaluation, to exchange information, to enable field work by government agencies, and to provide training.

Two main strategies have been undertaken by governments, aid agencies and commercial enterprises with regard to dissemination in rural areas. In the first strategy, objectives are stated in terms of numbers of stoves disseminated and amount of fuel saved; targets are large and there is a large central organisation. In the second strategy, the main objective is to ensure that each stove provides both economic and social benefits to the user and the producer; targets are much more flexible and decision-making on how the project is to be implemented is carried out at a village or district level. The larger programmes, usually run by men, are effective in building large numbers of stoves, but the acceptance rates among users (women) is lower than for the smaller programmes. The quality of construction is much lower in these large programmes and therefore fuel savings are lower (Joseph, 1989, 55-56).

The use of subsidies to facilitate the introduction of improved stoves raises the familiar problems of subsidies, already discussed more extensively above. The early adopters of the technological intervention are in majority the wealthier strata of the population who do not need the subsidy as they can pay. When the numbers of acceptors rapidly increases as the technology proves to be acceptable and worthwhile, the costs of the subsidies tend to rise rapidly. Eliminating the subsidy would then provide an impediment to the poorer strata who then would want to buy and who might need the subsidy.
To organize one's thinking about different production and distribution options in stove programmes the use of a decision matrix maybe a useful. It enables the decision-makers to see the pros and cons of different options. A hypothetical example of such a decision matrix is given in Tables 8 and 9 (from Bene, 1989).

SAVING RURAL WOODFUEL BY INVESTING IN URBAN FUEL SWITCHING

In urban areas, and especially in the non-household sectors, major energy savings and cost reductions per unit of energy output can be obtained through process investments, either in using energy saving technologies or in retro-fitting existing energy using facilities (Van de Laar, 1990b). While the private rate of return on energy cost reductions and the returns to society may be large, it does not follow that the pressure on deforestation will be reduced. Reducing energy cost per unit of output may lead to lower prices, which, through expanding demand for the product may induce greater overall energy use. Though energy savings obtainable in the urban sector may be large, there is also no automatic process to insure that the use of the resources saved promote policies which aim to reduce pressures on deforestation. For instance, if the resources saved are used to expand the radial roads from urban to rural areas, the reduction in transport costs may widen the area from which rural wood resources can effectively compete in urban energy markets.

While incomes, and to a lesser extent energy prices, are important in discussing fuel switching options, other factors play a role as well. Risk-minimization and the ensured stability of supply are the critical concerns for urban consumers (Munslow et.al. 1988, 116).

Leach, (in ESMAP 1988 113) goes so far as to say that energy policy can do little about the basic energy use trends. However, there is much, in his view, that energy departments can do to reduce barriers to fuel switching towards modern fuels, which are faced by the mass of the urban population.

Table 8 Production Options (Bene, 1989)

1. PRODUCTION OPTIONS	Village or women's group	Village or town artisan	Labour-intensive workshop	Capital-intensive factory
1.1 Significance				
Links to Community	EXCELLENT	GOOD	POOR	POOR
Production Levels:				
Year 1	1,000	1,000	1,0000	0
Year 2	2,000	10,000	10,000	20,000
Year 3	5,000	20,000	20,000	20,000
Training costs	VERY HIGH	HIGH	HIGH	LOW
Capital Cost (R)	1,000	4,000	8,000	20,000
Payback Period (Yr)	4	3	4	6
Internal Rate of Return	n/a	n/a	22%	16%
Minimum Price (R)	10	15	20	15
Consumers' Maximum Price	20	20	20	20
1.2 Permanence				
Chances of Survival	POOR	EXCELLENT	GOOD	FAIR
Responsiveness to demand	GOOD	GOOD	POOR	POOR
Access to credit	POOR	POOR	GOOD	EXCELLENT
1.3 Stimulation				
Links to local economy	EXCELLENT	VERY GOOD	GOOD	POOR
Employment:				
Full-time equiv.	20	20	20	5
People deriving income	40	30	20	5
Use of local materials	100%	100%	80%	50%
Skill creation	HIGH	HIGH	HIGH	LOW

Table 9 Distribution Options (Bene, 1989)

2. DISTRIBUTION OPTIONS	Traditional trade	Commercial mechanisms	Government structures	NGO networks
2.1 Significance				
Links to community	EXCELLENT	UNKNOWN	POOR	VARIES
Sales Levels: (Units)				
Year 1	5,000	0	1,000	1,000
Year 2	10,00	5,000	2,000	2,000
Year 3	20,000	10,000	5,000	5,000
Establishment Costs (R)	2,000	40,000	10,000	10,000
Promotional costs	20,000	40,000	30,000	30,000
Mark-ups	25%	25%	15%	10%
Minimum Retail Price (R)	20	20	18	17
Consumers Maximum Price (R)	20	20	20	20
2.2 Permanence				
Chances of survival	EXCELLENT	FAIR	GOOD	POOR
Responsiveness to demand	GOOD	GOOD	POOR	POOR
Access to credit	GOOD	GOOD	n/a	n/a
Outside interference	LOW	LOW	HIGH	HIGH
2.3 Stimulation				
Links to local Economy	GOOD	UNKNOWN	POOR	VARIES
Full-time Employment	4	6	2	2
Skill creation	LOW	MEDIUM	LOW	LOW

But fuel-switching away from fuelwood is not an irreversible process. With rising cost of oil based products and inadequate real income growth, poorer strata in urban areas may find themselves forced back to fuelwood use.

The most ambitious investment strategy proposed to reduce pressure on rural wood resources is to embark upon an enlarged and accelerated process of rural electrification. Such suggestions feature in discussions about 'energy transitions on a global scale' and comparing industrialised and urbanised countries with developing countries over a long term perspective. The geographical distribution of exploited oil resources and rising international oil prices in the early and late 1970s and again at the present time as a result of the conflicts in the Middle East, and the fact that for a large number of the poorer countries oil imports imply a major burden on their balance of payments, make this option non-feasible in the foreseeable time (Van de Laar, 1990b).

But even if resources were available on a vastly larger scale than can be currently envisaged, an accelerated programme of rural electrification in developing countries may not help the remoter rural areas where the bulk of the remaining closed forest wood resources are located.

In a number of countries energy authorities base their planning on the development of integrated grid systems spreading from major urban areas. Rural areas will be at the end of the chain and will be opened up last through low capacity feeder lines. Energy departments tend to be strongly opposed to the development of non-integrated stand alone systems which could provide relief in rural areas in the more immediate future. This institutional opposition by energy authorities implies that alternative institutional formats will have to be developed to promote such stand alone systems (Van de Laar, 1990b). Moreover, the effects of rural electrification on the use of fuelwood will be slight, as electricity will be used for lighting, while most fuelwood is used for cooking/heating.

A further point needs to be made on the desirability of such an energy strategy for rural areas. The substitution of commercial sources of energy for traditional sources of energy such as wood implies a substitution of a non-renewable energy source for a renewable energy source. In the long run, the switch to oil based forms of energy will not be sustainable.

Foresters

The task to augment wood resources in response to the recognition of the existence of a rural energy problem in most countries has fallen on Forestry Departments and on foresters. To understand their response and the evolution in their approaches to the problem, one must understand the historical context of forest policies, Forestry Departments and the training of foresters.

For most of the period up to the mid-1970s the forestry sector in many developing countries continued along the lines of forestry organization and policy frameworks developed in the colonial period. In fact, there is a remarkable degree of similarity between continents and between different colonial experiences, even extending into countries which were not colonized. Hence the need to briefly look at the origins of colonial forestry policies to identify some of their main characteristics.

These historical origins of the forestry profession have fostered a narrow outlook in two ways. It led to a narrow disciplinary focus on timber, but the forestry profession is also narrow in other directions: institutionally it was preoccupied with state lands and state revenues, and it had a strong anti-people bias. Together, these forces lead to enormous inertia and vested interests to resist basic changes to conventional structures of authority, responsibility and knowledge (Leach and Mearns, 1988 4). Because forest resources are a major national asset, forest departments are powerful in that they are largely self-financing. They contribute to national treasuries rather than draw from them.

HISTORICAL BACKGROUND

Those who feel that they need a wider base to obtain the minimally necessary historical background on how control over forest lands came to be established in different parts of the world and under different colonial traditions, are referred to some of the contributions in Poffenberger (1990). Peluso, for instance, documents the consolidation of state control over Java's forests from about 1900 through the Dutch colonial era, Japanese occupation and independence. Perhaps more than anywhere else in South East Asia, the Dutch colonial state was able to control forest use effectively by strictly enforcing land-use regulations, using law and policy, wielding power through foresters and police (Poffenberger, 1990, 3).

Sajise and Omegan (Poffenberger, 1990) trace the changing patterns of land use and deforestation in the Cordillera Mountains of northern Luzon in the Philippines, from pre-colonial times to the present, with the United States, building upon Spanish colonial influences on forestry policy. Hafner examines the forces driving deforestation in Northern Thailand during the 20th century. Though Thailand was never colonized by a western power, the Northeast was considered as pioneer territory where Lao and Thais migrated to in the period.

Turning to French West Africa, Elbow and Rochegude (1989, 4ff) note that the ancestor of today's Sahelian forest codes is the colonial decree of July 4, 1935. Perceiving the threat to the environment posed by over-exploitation of natural resources, its response was to assume the responsibility for managing the resources of the forest. Its aims were to conserve forests and to protect and restore the degrading ecology of threatened areas. The spirit and the essential provisions of the 1935 decree survive in the present forest codes of the independent Sahelian countries. The state continues to assume virtually all management rights and responsibilities within the domain of the forests. Current forest codes of Mali, Niger and Senegal consist largely of lists of prohibitions that are enforced through a system of fines and permits (ibid. 6).

The Indian Forest Law has become the model in most of the British colonies also in Africa. It set the stage for a pattern of land use whereby foresters dealt with forest land, as state land, and agricultural authorities with other lands. Disciplines developed which were hardly professionally interacting with each other. It is thus a suitable model to illustrate the origins and nature of forest policies.

Two factors have shaped the origins of British colonial forest policy in India (Shyamsunder & Parameswarappa, 1987), while the growth and development of the forest industry in India is closely linked to the establishment of the railway system. On the one hand it needed substantial amounts of wood for railway tracks and fuel, and on the other hand facilitated the commercial exploitation of wood resources, especially of timber (Guha 1983).

In 1800 a commission was appointed to inquire into the availability of teak in the Malabar forests (Kalabar) and regulations were introduced inhibiting the felling of teak below 53 cm in girth. The forest wealth of India was considered to be inexhaustible and it was concluded that the exploitation of the forests could continue unabated. The commercial motive was recognized.

Up to 1850 shifting cultivation was the most commonly practised form of agriculture in India. Dr. Cleghorn from Shimoga reported in 1848 that the whole district was covered in smoke in the summer months from the burning of forests from shifting cultivation. This report prompted the British Association for the Advancement of Science to suggest control of burning practices. The anti-people motive was expressed.

In 1855 Lord Dalhousie issued the "Charter of the Indian Forests", outlining forest conservancy for the whole of India. Dr. Brandis was appointed superintendent of forests in 1956 and later became inspector-general of forests. Subsequently, the Indian Forest Department was established in 1864 under the jurisdiction of the Government of India. The Indian Forest Act of 1865 was promulgated, and the element of state ownership and state control over forest land began to found expression.

The aim of the Forest Act was to create forest reservations to meet national and regional long-term needs for resources such as water supply, soil conservation. But the merits of a particular block of forests chosen for reservation were determined by a revenue officer, not by a forester.

In the 1894 Resolution it was acknowledged that parts of some forests may fall under different ownership, the resolution established the following forest classes as state property:

1. Forests, the preservation of which is essential on climatic or physical grounds.
2. Forests that afford a supply of valuable timber for commercial purposes.
3. Minor forests; and
4. Pasture lands.

Regarding class 2 forests the resolution states that 'wherever an effective demand for suitable land exists and can only be supplied from forest areas, the land should ordinarily be relinquished without hesitation' (ibid.334). The principle of timber concessions on demand was formalized. Over time, major areas were also released to accommodate the agricultural needs of a growing population.

It is important to note the peculiarity of India's natural forests. None of them have been uninhabited wildernesses over which the colonial power laid a 'monarchical claim'. They all had people domiciled in them. In fact, until the late 19th century at least 80 percent of India's natural resources were common property, with only 20 percent being privately utilized The Forest Act as amended from time to time, however, is not aimed at protecting forest dwellers as living beings amongst other living beings. It is aimed only at the utilization of living things and their products (Chhatrapati Singh, 1986, 2) .

The rights of forest dwellers have until very recently received little attention from jurists due to the belief that such rights were abolished by the British a long time ago, and hence to pursue this issue would be to flog a dead horse (Singh, 1986). It was the practice of traditional Indian rulers, who had asserted 'absolute rights', not to interfere with the lives of forest dwellers, including their use of forest produce. It subsequently took the British almost eighty years of confrontation and suppression before the colonial powers could devise a sufficiently complex legal mechanism to overcome resistance and gain control over common land and its resources, by making amendments to the original Forest Act.

According to the Indian Forest Act of 1927, no person can claim a right to private property in forest land merely because he is domiciled there, or even if his forefathers have lived there for centuries. Nor do such people have any rights over forest produce (ibid, 10). Although occupancy rights were abolished in the plains there still exist a large number of exercise and user rights in the hill areas.

When population increased and land use conflicts sharpened, the forest police was established to essentially keep the people out of the (dwindling) forest resources. Antagonism between the forest department and the population inhabiting the forest fringes and adjacent lands is strong. Currently more than 100 foresters are seriously injured or killed each year by smugglers while protecting forests and wildlife (Shyamsunder and Parameswarappa 1987, 335).

In the post-colonial era traditional colonial forestry policies in India as well as in many other countries were continued largely without change. It no longer intended to serve the industrialised countries. Instead, the contribution which the forestry sector could provide to national development was stressed. Operationally it made little difference. Forest exploitation was for exports and for incipient forest industries which were being set up, to protect soil fertility and to guard against soil erosion.

A NEW BEGINNING: 1978

The year 1978 can be identified as marking a watershed in thinking and policy. In that year the World Forestry Congress took place in Jakarta with as theme 'Forests for People'. At the highest political and administrative levels foresters united around the Jakarta Declaration, which obligated them to place human beings at the centre of all forestry activities.

The FAO had given a major impetus to this declaration in its publication 'Forestry for Local Community Development' (1978), while also the World Bank's Sector Policy Paper of 1978 implied a major shift in World Bank lending policies for the forestry sector, in line with the new emphasis on benefits of forestry for local communities. A few years later, the United Nations Conference on Energy and Renewable Resources (Nairobi, 1981) kept the fire burning, and UNDP with the World Bank had launched the joint Energy Sector Assessment Programme (ESAP) in 1980, which was the major international effort for most developing countries to have their energy sectors analyzed in a more systematic and comprehensive manner than had been practised before. In all, some 60 countries benefitted from this programme in the next 5 to 6 years.

In a political climate where energy issues, both commercial/urban (oil) and rural (fuelwood) had taken centre stage, these calls for action were well received by developing countries, by the donor community and the different international organizations of the United Nations.

FORESTRY APPROACHES

The approaches to meet the rural energy crisis were generally in line with traditional approaches of Forestry Departments. The basic message was to plant more trees (FAO, 1978; World Bank, 1978). This was promoted through scaled down versions of the conventional plantation model for mono-culture forestry development. In rural areas they took the form of village woodlots, and for the peri-urban areas fuelwood plantations were proposed. The initiative was often by the forest department and also the management, directly or indirectly through supervision of villagers, was carried out by forest departments, conform well established, routinized forest department institutional practices.

This starting point in itself is an anomaly, when considering resources available to Forestry Departments in relation to the enormous scale of the problem as analyzed by FAO and the coping tasks that seemed to follow there from. Farmers outnumber foresters by 1,000 to 10,000 to 1. If their families spend, say, only 10 days per year on planting and care of trees, as an 'off-farm' activity, their combined labour inputs would outweigh that of the foresters by 40 to 400 to one. (Anderson and Fishwick, 1984, 7).

Right from the beginning, thought should have been given to appropriate institutional approaches to the promotion of tree growing as the conventional approach based on forest department own sources and methods could not ever be adequate to the task. The replication of limited examples, if successful, would not be realistically possible. Investment in research, training and education should receive high priority in contrast to the actual organization and management of scattered fuelwood programmes and projects.

Village Woodlots

The promotion of village woodlots by Forestry Departments implied a transgression by the Forestry Department beyond the conventional model of forestry development on state land. Foresters were leaving 'their' forest land. The focus on fuelwood seemed justified as fuelwood had been estimated to be by far the largest household energy source in developing countries, accounting for upwards of three quarters of all wood used.

After only a few years of intensively promoting woodfuel plots, by national government and by the donor community, a number of problems were encountered. Assumptions underlying the village fuelwood lots strategy often proved unfounded or wrong and a literature developed to counter many of the initial assumptions and policy prescriptions (Foley and Barnard, 1984; FAO, 1985; Arnold, 1987; Munslow et.al. 1988; Leach and Mearns, 1988; O'Keefe and Munslow, 1989).

First, gap analysis of energy shortages at the macro level need not be applicable in specific micro-regional environments. Contrary to expectations, it was discovered that fuelwood is gathered or harvested by villagers in their immediate vicinity, and is primarily drawn from trees and other woody plants outside the forest. To meet such needs, trees have been incorporated into crop and grazing systems across a wide spectrum of agro-ecological, land use and population density situations. Fuelwood collection is not the main driving force behind deforestation.

Second, the focus on fuelwood proved to have been equally misplaced. It obscures, and conflicts with the broad systems approach to trees that should be applied to understand existing farming practices. Farmer surveys in fuelwood projects have consistently confirmed farmer preferences for tree systems which provide multiple outputs and benefits. They have also shown that generally they value fuelwood for own use as a lower priority than some other tree products, such as fodder, poles for construction, fruits, gum-arabic and other 'minor forest products' (Foley and Barnard, 1984; FAO 1986).

Third, there are many pressures on villagers' labour time and on suitable arable land which often preclude the scope for expanding forest areas just for fuel wood. Competition for agricultural land, and changing land tenure arrangements determine differential access for segments of the rural population and, in some areas, there may be shortages of labour time to be devoted to fuelwood lots. It is not easy to get fuelwood plots started, despite planners' assumptions that there is a fuelwood crisis, with the implication that villagers would eagerly respond to fuelwood supply initiatives.

Additional problems with village wood lots relate to the manner in which the project is carried out. In general, it was found to be pointless to grow fuelwood as an expensive commodity, when it is popularly perceived as being free and a residue product. But international aid agencies have kept trying to grow 'residues' and to charge the people full production costs for them (Munslow et.al. 1988, 12). When Forest Departments run nurseries and expect villagers to buy the seedlings at full cost, the disincentives to villagers to cooperate increase further as they can obtain seedlings for free in the natural environment.

Once village woodlots begin to grow new sources of conflict often arise over the disposal of the product. Is the Forestry Department to be in charge, in part to recoup its costs of nurseries? Was the fuelwood to be given to villagers who had contributed free labour, or was the fuelwood to be sold, inside or outside, the village boundaries? How was the fuelwood to be valued relative to the other use values of woody resources, such as poles and fodder? Are the patterns of demand for wood products in line with the fuelwood orientation of supply? Has the initial species selection been in line with effective wood demands, and can existing projects focused on fuelwood be changed to focus on multipurpose trees, a not insignificant question in view of the expected long life of newly planted trees?

Further misconceptions relate to the assumed homogeneity of the village implying the absence of socio-economic and cultural cleavages within communities. In Asia cultural diversity and the effects of the caste system are well known, but also in Africa social homogeneity of villages cannot be assumed. It turns out that community wood lots need be organised for smaller groups than the village community at large, to reduce internal conflicts and enhance group solidarity. Unfortunately, the choice to target fuelwood projects on more homogenous groups of women or of the village poor, often implies that these groups do not have sufficient power to defend themselves and their (fuel) wood project against pressures from the village power elites, or against external pressures. In addition, especially for such groups, growing woodfuel tends to have low priority compared to growing food or obtaining income to buy food.

Where land and thereby implicitly wood resources are locally abundant relative to population densities, villagers could not be expected to respond favourably to the new Forestry Departments' initiatives to set up mini fuelwood plantations.

Moreover, planting trees is only one of several options open to the rural populations as a means to bring a local tree resource under management.

With population pressure, people respond first by conservation and management of existing trees in a number of ways. Initially, this may constitute no more than preserving and protecting desired species during land clearing. Control systems to limit the quantities of products harvested, or the size and grazing patterns of livestock herds, are other forms of management at this level.

As pressures increase further, more intensive forms of management are adopted to increase the lifetime contribution of existing trees. Different pollarding, pruning and coppicing techniques can be applied, which have growth-stimulating properties as long as root-systems remain in tact. The next stage of intensifying tree management is likely to be intervention to stimulate regeneration; through protecting, transplanting and cultivating naturally germinating seedlings. Enriching fallow through selective encouragement of nutrient restoring and other desirable species are other techniques.

It came to be realised that, almost everywhere, people appreciate the value and usefulness of trees, and know how to grow them <u>if they want them</u>. The assumption that major educational efforts are needed just to convince people that trees are beneficial, is rarely justified. Establishing why more tree growing is not taking place spontaneously is one of the most important steps in planning farm and community forestry (Foley and Barnard, 1984, 18-19).

In view of these findings the central message of the FAO 1985 paper ('Tree Growing by Rural People'), reviewing progress in meeting the rural energy 'crisis' from the late 1970s, was no longer '<u>plant more trees</u>', the central message of the 1978 paper. The central message was changed to '<u>manage existing wood resources better</u>'.This shift in emphasis, of course, is not as stark as put here. Moreover, major time lags may be expected before such new insights trickle down in strategies, policies and programmes.

This changing perception by FAO implied the need for fundamentally different approaches to forestry intervention in village lands. It has focused attention on various *social forestry* approaches, which imply major reorientations of priorities, attitudes, substance of activities and research (Gregersen, 1989).

For instance, the forays of foresters into village lands imply major changes in the foresters' approach to people. Instead of mistrusting rural people, for their encroachment of forest lands and for agricultural practices interpreted as environmentally harmful, foresters are now expected to work with the people, and to link up and build on local knowledge systems of farmers.

This new role requires major attitudinal adjustments of foresters as well as of villagers, to change mutually antagonistic behaviour to cooperative behaviour. The forester was to change from policeman to extension agent. The enormity of the task to bring about such a transformation becomes somewhat clearer when it is realised that in a number of countries the salaries of the 'agents forestier' are partially, and officially, based on a percentage of the fines collected from those who contravene provisions of the Forest Act!

Instead of foresters running plantations themselves, they had to become advisers, acknowledging that farmers use trees for many other things than for timber and pulp. They have to acquire more detailed knowledge about different, locally better known endogenous tree species, rather than about *exotic* species, which feature in many forest department plantations. To list just one example. Many villagers prefer fruit trees which historically were considered to fall within the domain of agriculture by the forester, and to be part of forestry by the agriculturists. Result: there are few would-be extension workers who know much about fruit trees at all.

Foresters also have to adjust to working effectively with professionals in other disciplines, concerning themselves with problems and issues in rural development. This represents a major change from the historically grown pattern where foresters were mostly preoccupied with 'their' forest lands, which were legally protected against intruding people. This institutional setting implied that foresters did not have to interact much with other disciplines.

Many of the problems, of how people interacted with trees in different types of lands, had not been recognised beforehand, leave alone that they had been carefully and systematically studied.

Ironically, much of the old, historical antagonism between foresters and village communities initially increased rather than diminished when the forest department began to push for the setting up of village fuelwood plots, the more so when foresters had recourse to the forest law, to push their often authoritarian views. In some cases, such as in Mali, the forestry department currently attempts to inhibit that shelter belts planted by villagers even be harvested after they were successfully established.

The historical origin of forestry policies and foresters' training and institutional practices may thus turn out to be more of a liability than an asset in meeting the new challenge of social forestry, as it is now beginning to be understood.

The experience with village woodlots for fuel is that integrated rural development strategies should include attention to biomass interventions, whereby woody biomass is to be interpreted as multi-purpose woody resources. This has been also the central message of the extensive studies undertaken in the SADDC region, and published in brief in the book: 'The Fuelwood Trap' (Munslow, et.al. 1988). The question and the problem is: how is that to be done effectively and efficiently? Further questions relate to the distribution of tasks and roles between the already large number of institutions dealing with rural development in general, and how do all these institutions relate to different classes of people in different types of land?

In thinking about how to make this transition in the outlook of foresters it should be realised that traditional forestry research, at the global level, at present is not only narrowly focused on the traditional preoccupations of classical forestry, this research is also highly fragmented. Foresters are nowhere near setting up the equivalent of a network analogous to the International Agricultural Research Centres under the CGIAR structure, which has been so effective in structuring and guiding international research efforts in agriculture. Different research orientations and insights are basic to anything the forestry sector will be able to undertake to implement its new mandate to assist in people's development, under social forestry initiatives.

The recognition that trees are more than fuelwood to satisfy energy needs, and also more than timber, as foresters tend to think, might be seen as a step forward in understanding trees. But the 'new wisdom' of recommending the planting of multi-purpose tree species does create problems when account is taken of pronounced shifts in demand for different categories of wood products.

Shifts in demand for tree products have been, apparently, one of the driving forces of forests and forest development. Growing needs for essential products have widely meant that trees maintained and planted for other purposes such as shade or fruit have eventually been diverted to such other higher priority, and thus higher valued uses. Economic pressures and market forces thus have a tendency to reduce the variety of tree species in the direction of stressing the stimulation of those species which have the highest economic value. As in agriculture, selectivity --the replacement of low yielding varieties, and thus genetic erosion --a reduction of bio-diversity, among trees and as a habitat for fauna, go hand in hand in the drive to increase yields in forest lands, also when land is not diverted to agricultural purposes. They may also determine the choice species to be planted in agricultural lands. Economic forces thus tend to have a major effect on tree management in the long run.

In this light, the current emphasis being put on planting multipurpose trees may, in the longer run, be self-defeating. Some would argue that the drive towards planting multi-purpose trees may be defeated by progressive commercialisation. Emphasis on the highest-valued end-use will lead to restrictions of other end-uses and on other population groups which depend on such other secondary alternative end-uses. It does point at a new series of problems and dilemma's for deciding upon the character, scope and purpose of future woody biomass interventions in woodlands as well as in agricultural lands.

In the short run, the conversion of natural forest into managed forests to increase yields, has usually resulted in the depletion of existing tree resources and in diversion of tree products from subsistence use to commercial markets. The distribution of tree benefits may thus change from those near the forests to distant end-users, intermediated by newly developing markets for tree products. Access patterns change and conflicts over resource use will multiply and intensify. At present we are apparently witnessing this major transition during which much wood resources will be lost.

There are as yet no successful cases of social forestry projects. Therefore, results, lessons from experience and the major problems encountered cannot be assessed at the present time. It may be expected however, that a number of the problems and issues discussed in this paper and especially in this section, will also crop up in *social forestry* projects.

Fuelwood Plantations for Urban Woodfuel Markets

The experience with proposals for urban fuel wood plantations makes for similar depressing reading (O'Keefe & Munslow, 1988, 1989). At first glance, urban fuelwood plantations wood appear to be an attractive economic proposition, notably because of the reduction in transport costs. However, the economic considerations are more complex. They include the opportunity cost in devoting land to forestry (high in peri-urban areas), real production costs compared with other fuels per unit of delivered energy, the unit cost of wood from plantations compared with wood brought as a 'free good' from natural woodland or farms and the costs dependent on species selection within the urban fuel wood plantation.

As Foley (1988) points out: it is not the immediate peri-urban area but the wider hinterland which is important. The plight of the bedraggled and depleted woodlands within the immediate city surroundings tends to distract attention from more distant and still abundant resources which are often available.

The difficulty with assuming that peri-urban plantations can meet the fuelwood needs of urban centres is that the resulting costs of production is generally far higher than consumers can afford or are willing to pay, necessitating a heavy state subsidy. As urban centres grow, the opportunity cost of the land increases as well and generally the rate of return on food production or building land will vastly exceed that of fuelwood production (Munslow et.al. 1988, 110).

The peri-urban large scale plantation as a model also compares poorly with other wood augmenting strategies. For instance, in Tanzania it was found that both smallholder woodlots and forest management and enrichment planting compared favourably to the peri urban plantation (cited in O'Keefe and Munslow, 1989, 7). The salient figures are provided in Table 10.

Table 10 Economic comparison of wood fuel production for urban markets in Tanzania (data per hectare).

	Peri-urban plantation	Smallholder woodlots	Forest management and enrichment planting
Seedlings	2500	2000	--
Rotation period (years)	26	26	20
Wood production in rotation (m3)	395	395	61*
Average annual wood produced (m3/yr)	15.2	15.2	2*
Establishment cost Tsh'000	24.9	6.7	1.4
(of which mechanization)	44%	3%	4%
Discounted costs (Tsh'000)	31.0	6.3	2.5
Discounted production (m3)	99	67	27
Discount rate used	10%	15%	10%
Break-even stumpage price (Tsh/m3)	315	95	93

*21 m3 is produced in Year 1 from thinning and firebreak clearance: production thereafter is 40 m3 for the 20 year rotation.
Discounted costs and production are for the full rotation.
Tsh = Tanzanian shillings.
Source: UNDP/World Bank, 1987.

Agronomists

Agriculturists look at the problems of rural energy shortages in a different way. To them the problem presents itself as a land use competition problem, whereby it is thought inevitable that forest land is converted to agricultural land to meet food requirements of a growing population. In addition, they blame small farmers and the rural poor for faulty agricultural practices.

The historical evidence is clear. Much of the dense forests that covered Western Europe was cleared for farming or was logged during the Middle Ages. But the rampant clearing, for instance, of mountain slopes in the Alps and the Pyrenees produced a severe ecological backlash. Alpine torrents and landslides were chronic threats by the end of the 18th century, prompting reforestation and forest protection despite growing population pressures. Similar environmental backlashes occurred in parts of Germany, France, England and in the Netherlands in the 18th and 19th century. Today, about one quarter of Western and Central Europe is forested and the forest area, much of it intensively managed, is stable -- or at least was stable until air pollution and acid rains recently began to damage the forests on a large scale (Eckholm et. al. 1984, 20). In the late 1980s the incidence of acid rains has increased further, while also the damage of uncontrolled tourism development in some winter sport areas through skiing is increasingly realised.

The magnitude of the contemporary conversion of forest land for agricultural purposes is large. For instance, one estimate suggests that between 1950 and 1983, land clearance for agricultural production was responsible for 70 percent of the permanent destruction of forests in Africa (Spears, 1986, cited in Munslow, et.al.1988, 11). But such figures have to be treated with considerable caution. With regard to land clearing by farmers there is little that can be said in quantitative terms. As Timberlake (1985) points out: little good information has been compiled on what is taking place, aside from numerous, but mostly unpublished field reports by foresters and others. Further, most of the published data refer to forests and do not include the cutting of trees on farmlands and woodlands. In India, of the total forest area officially recorded as deforested for different purposes between 1951/2 and 1975/6, as much as 60 percent was for agricultural purposes (cited in Agarwal, 1986. 31).

It is evident that there can be substantial time lags and delayed behavioral responses in dealing effectively with natural resource declines by remedial policies. The challenge at the present time and age, and for developing countries, is whether such time lags can be drastically shortened, or, even better, whether initial damages can be contained through better policies for natural resource development.

Much of the current interest in reafforestation is precisely geared to shorten these response lags. For instance, Indonesia's transmigration policy, aiming to move millions from crowded Java and Bali to the so-called outer-islands, involved transplantation of people to former forest lands, with sometimes disastrous effects. The latest $ 500 million World Bank loan for transmigration is largely for rehabilitation of areas where forest colonization has gone wrong (Eckholm, 1984, 22).

But the links between forest clearing and agricultural expansion under the impact of population growth is not all that simple as might have been surmised from the above. Different types of agriculture have different effects on forest land. Shifting cultivation systems require large amounts of territory. A shortening of the crop rotation, due to population pressure, leads to reduced or even elimination of the tree fallow, and thus to inadequate regrowth of woody materials. Low productivity agriculture is land extensive.

Intensification of agricultural production would lead to increased yields to feed a growing population, while requiring less land. This would reduce pressures on remaining woodlands. But intensified land-use practices on marginal soils lead to many problems, notably soil erosion. Higgins et.al. (1983) estimated that if soil erosion continued at its 1983 rate, loss in rain-fed cropland in the developing world would range from 9.7 percent to 35.6 percent, leading to an overall 28.9 percent decrease in crop production by the year 2000 (See Table 11).

Table 11 Projected effects of unchecked soil erosion on productivity (1983-2000)

	Decrease in area of productivity (%)	Decrease in rain-fed crop rain-fed cropland (%)
Africa	16.5	29.4
South-West Asia	20.0	35.1
South-East Asia	35.6	38.6
South America	9.7	22.6
Central America	29.7	44.5
GLOBAL AVERAGE	17.7	28.9

Source: Higgins et al., 1982

Unfortunately, most of the successful agricultural innovations of the last few decades pertain to crop innovations on well watered lands and requiring costly external inputs in the form of fertilizer and pesticides. These are not available for the poorer strata of the population such as small farmers, shifting cultivators and the landless and in areas where communications are poor. For many areas in the drier parts of Asia and Africa few technologies have been developed to meet difficult soil conditions and highly variable rainfall patterns. Where technology has been found requiring external inputs, their costs are an impediment to risk averse farmers facing the hazards of their natural environment.

The nature and focus of much agricultural R&D contributes to shortages of biomass directly. The development of dwarf or short-stem crop varieties reflect a desire to reduce the nutrient requirements of the 'support structure' to the benefit of the grains or the cubs. This leads to reduced volumes of crop wastes as fuel.

Agriculturists have traditionally been weary of trees and shrubs as potential sources of agricultural pests. Crop wastes, such as cotton stalks had to be burned in the fields to destroy remaining sources of cotton pests. In a number of countries, such as in Sudan, such cotton stalks are nowadays collected as fuelwood and transported over large distances to urban fuel markets. Agronomists and researchers have often stressed the negative effects of roots, water and shade competition on agricultural yields, and they have tended to neglect the positive effects of shelter belts on wind erosion.

Changes in broader land-use practices can threaten woody vegetation in many ways. For instance, tree cover is removed in order to eradicate tsetse fly. The establishment of dams for electric power and for irrigated agriculture usually means that also large amounts of forest area are submerged in the dam lakes. In addition, forest dwellers will be driven out and this will lead to further encroachment on other forested areas. Shifts towards mono-cropping and mechanization also militate against tree growing, as trees get in the way of tractor operation. Serial tenure patterns, where animals are allowed to roam freely on farmers' lands after the harvest, make the protection of privately planted trees difficult. The more so if cattle are kept by different ethnic groups from those who occupy the agricultural land. Even if not of different ethnic origin, different individuals may have different stakes in the land, some as farmers and others predominantly as livestock keepers. Practices such as burning associated with pasture management also impede the growing of trees. Urbanization, and improvements of trunk roads and feeder roads have also the effect of making wooded land more accessible.

However, all this land use competition need not necessarily lead to aggregate shortages of fuelwood materials. Foley (1988, 67) argues that in almost any system of agricultural production in the developing world, the supply of general biomass will tend to be at least 5–10 times greater than that of the food produced. The implication is that food and non-food biomass are jointly produced and it would therefore be meaningless to treat them as if they were separate products. Thus, wherever people are able to grow enough food to feed themselves, there will be enough biomass fuel available for cooking purposes. There does not appear to be any record of a society, which could grow sufficient food to feed itself, collapsing because it could not cook it.

There will be switches, though, between fuel types, where food and biomass/fuel are joint products. When there is no scarcity of wood resources, people use top quality firewood, the supply of which is relatively small. As this becomes scarce, they switch to lower quality wood the volume of which is greater. Later, when this lower quality firewood is becoming harder to obtain, they switch to the use of twigs and bushes; again, the supply of these is more plentiful than that of wood. Finally, they shift to the use of general biomass, the supply of which is again greater. There is thus a 'pyramid paradox' of fuel availability, with top quality at the top and other, lower forms of biomass towards the broad bottom of the pyramid (Foley, 1988, ibid.). Empirical studies are clearly required to establish whether this 'biomass pyramid' has wider applicability in different settings.

Agroforestry, an Integrated Approach

INTRODUCTION

In recent years, there is a growing discussion to the need that agriculturalists and foresters should be working closer together in solving rural land use problems. Their roles in responding to different population needs, such as food and energy for people and fodder for livestock, brings them increasingly into contacts and they begin to transgress their original, and narrower concerns.

While most scientists tend to think that agroforestry is merely a strategy whereby agronomists and foresters decide to work together, others feel that the implications of agroforestry are so far-reaching, and touches upon so many different technical, institutional and socio-economic issues, that a new scientific discipline may emerge over time.

Increased interest in agroforestry coincided with the upsurge of public interest in integrated rural development, in the rural poor and in rural energy, and thus in fuel wood.

What can realistically be expected of agroforestry in the medium term? For the immediate future not much as shall be explained, an explanation based on the historical evolution of prevailing land-use institutions and the historically determined approach to knowledge acquisition along disciplinary lines.

HISTORICAL BACKGROUND

The history of agroforestry as a field of applied agricultural science and as a focus for systematic development efforts is very short. Modern agroforestry was institutionalized through the creation of the International Council for Research in Agroforestry (ICRAF) as late as 1977. (Lundgren, 1987). In reality, many different agroforestry systems have been in existence for centuries, but they tended not to have been the subject for systematic and sustained research on their characteristics. King (1987, 5) notes:

> *'It cannot be overemphasized that for more than a hundred years, in the period 1856 to the mid-1970s, little or no thought appears to have been given, in the practice of the [agroforestry] system, to the farm, to the farmer, and to his agricultural outputs.... Systems were designed and implemented solely for the forester.... Nowhere were the positive soil-conservation aspects of the system mentioned, let alone emphasized'.... Research was designed to ensure that little or no damage occurred to the tree species; that the rates of growth of the forest- tree species were not unduly inhibited by competition from the agricultural crop; that the optimum time and sequence of planting of either the tree or agricultural crop be ascertained in order to ensure the survival and rapid growth of the tree crop; that forest species that were capable of withstanding competition from agricultural species be identified; and that the optimum planting-out spacing for the subsequent growth of the tree crop be ascertained'.*

Among the first tasks of ICRAF was to initiate a world-wide inventory of agroforestry systems (see Table 12). Although a great variety of combination systems were found to be practised, or rather the existence of a wide range of practices were formally recognized, the identification has not in all cases established how and why the various trees, crops and or livestock interrelate. Scientific knowledge is still grossly incomplete, and the ability of agroforestry as a science disseminating its findings through extension methods is still limited for lack of proven extension messages (ICRAF, 1987, Wiersum (ed), 1988).

Agroforestry, as an integrated approach to land use, was seen as having a number of advantages, though it also has disadvantages, compared to the consecutive or simultaneous use of land for agriculture and forestry in different land use units. See Table 13.

Table 12 Some Examples of Prominent Agroforestry Systems and Practices in the Developing Countries (Nair, 1984)

SYSTEMS AND PRACTICES IN DIFFERENT GEOGRAPHIC REGIONS

Prominent Systems	S.E. Asia	S. Asia	Mediterranean & Middle East	Eastern, Central & Humid West Africa	Arid & Semi-Arid West Africa	American Tropics
Agro-silviculture	1. Commercial trees among crops 2. Fruit/shade trees along crops 3. Live fences 4. Shelterbelts 5. Taungya 6. Shifting cultivation systems 7. Intercropping in plantation crops (rubber, oil palm, coconut)	1. Taungya 2. Plantation crops + arable crops 3. Commercial trees and fruit trees with crops 4. Live fences + shelterbelts 5. Various trees on farmlands for productive functions 6. Various forms of shifting cultivation 7. Medicinal plants + agri. species	1. Olive + cereals (on terraces, "banquettes", "cuvettes", etc. 2. Poplars along irrigation canals 3. Trees for sand dune reclamation 4. "Huertas" - small plots, irrigated crops + fruit trees 5. Aromatic, medicinal and fruit trees with crops	1. Taungya 2. Cacao/food crops/ forest complex 3. Plantation crops (oil palm/rubber) and root crops complex 4. Coffee + banana 5. Mixed perennial crops 6. Gum arabic + millet 7. Shifting cultivation/bush fallow systems	1. Use of trees on farmlands for protective role (windbreaks, dune fixation) 2. Productive + protective role of trees on farms (A. albida/ Leucaena + agric. crop systems	1. Trees in perennial cash crops (coffee, cacao, tea) 2. Trees for organic matter and mulch with annual crops 3. Tree live fences 4. Windbreaks and shelterbelts 5. Trees as support for climbing commercial crops 6. Taungya 7. Shifting cultivation systems
Silvo-pastoral	1. Pasture in forest plantation 2. Pasture in secondary forests 3. Commercial trees in pastures 4. Fruit/shade trees in pasture 5. Fodder trees 6. Coconut + pasture	1. Pasture under trees 2. Plantation crops + cattle grazing 3. Fodder trees + shrubs 4. Fruit trees + commercial trees in pastures	1. Oak forest + grazing 2. Pig breeding + forestry 3. Rangeland improvement	1. Gum arabic + livestock 2. Plantation crops (coconut/cashew) + pasture	1. Nomadic/semi-nomadic/trans-human 2. Sedentary livestock grazing systems/browsing systems 3. Fodder tree/shrub systems	1. Trees in pasture 2. Pasture in natural regeneration forest 3. Trees lopped for fodder 4. Trees used for browsing
Agro-silvo-pastoral	1. Crops + grazing in plantations 2. Agri tree crops + grazing in forest plantation 3. Multipurpose trees with crops/animals 4. Integrated forming systems with agric. plantation crops (rubber, coconut, oil palm)	1. Plantation crops + arable crops + livestock 2. Agric. tree crops + grazing in forest	Rangeland management	1. Coconuts/other plantation crops + food crops + grazing 2. Coffee + banana + dairying 3. Horticultural complex systems	1. Forestry dominating (forest lands) 2. Agriculture dominating (crop lands) 3. Livestock dominating (rangelands)	1. Agric. plantation crops (coconut, rubber, fruit trees) with crops and pastures
Home gardens	Various forms of multispecies combination	1. Multistorey plant canopies in humid regions 2. Arid/semi-arid systems	Mainly in large cities	Various forms	Various forms	Various forms
Others	1. Silviculture in mangrove forests 2. Agri-silvi-fishery 3. Trees on bunds in fish breeding ponds 4. Swidden farming 5. Fuelwood agro-forestry	1. Mixed perennial 2. Irrigation systems 3. Various site-specific systems 4. Fuelwood systems	1. New system in Morocco (spice plantation for erosion control) 2. Apiculture + forestry 3. Fruit trees in deserts 4. Mushroom cultivation in forest	1. Pastoral systems with corral farming (highland/ lowland interactive systems) 2. Mixed perennial cropping	1. Oasis 2. Irrigation systems 3. Various site-specific systems	Mixed perennial

Source: P.R. Nair, Soil productivity aspects of agroforestry, ICRAF, Species for Energy Production, National Academy of Sciences, Washington, D.C., 1984.

Table 13 Agroforestry: Advantages and Disadvantages (Budowski, 1984)

advantages	*disadvantages*
Biological:	
• Better use of ecological space; captures more solar energy • Temperature extremes are reduced • More biomass returns to the soil • Recycling of nutrients is more efficient • Trees improve soil structure by producing stable aggregates and by avoiding hard "pans" • Fewer weeds because less light reaches the ground and there is the possible suppressive effect of leaf litter mulch • Leaf mulch reduces water evaporation from soil, adds organic matter and reduces tillage needs • Most leguminous trees fix nitrogen by the action of specialized bacteria in the plant roots • Erosion is prevented up to a point by the binding effect of tree roots • Greater diversity of fauna owing to a larger number of ecological niches; some will be predators of harmful insects or rodents	• Competition for light between trees and other plants may lower crop yields • Competition for space between trees and other plants may handicap both • Trees compete for nutrients, store them in branches and stems, and so make them inaccessible to crops • Loss of nutrients when wood, fruit, seeds, etc. are harvested and "exported" from the area • Trees keep part of rainfall in their crowns; stemflow can adversely redistribute rainfall • Greater diversity of fauna owing to a larger number of ecological niches; some will be crop pests
Economic and Social:	
• Direct economic benefits in form of firewood, posts, poles, timber, fruit, fodder, etc. (although not all at once) • Where commercial markets exist, trees constitute "standing capital" to pay for emergencies • Crop diversity reduces risks of irregular rainfall, pest outbreaks, market fluctuations, uncertain supply of external inputs • Greater benefits from crops may offset investments required to establish trees • Trees usually reduce weeding costs • Greater flexibility to spread work loads during the year	• Yields of crops per unit area may be lower than for monocultures • Even if combined value of trees and agricultural crops is higher, it may take several years for the trees to acquire economic value • Likely to be more labour-intensive than growing either trees or agricultural crops separately • Time-lag from planting to economic benefits of trees may be longer than people can afford by comparison with other cash crops

In general terms, it is expected that the socio-economic returns for agro-forestry would be greater than the financial returns for two reasons: saving in labour costs, and ecological and environmental benefits. Should these expectations be confirmed through agronomic and forestry research, interesting further questions would arise about appropriate mechanisms, instruments and policies which would bring private financial returns on agroforestry operations closer in line with socio-economic priorities.

Some technical research successes are reported, for instance in Zambia, where the application of the ICRAF developed Methodology of Agroforestry Diagnosis and Design Method was applied experimentally, and led to a ten-fold increase of carrying capacity of the land (Munslow, et.al.1988, 84). On the other hand, Kessler and Wiersum (1990, 121) draw rather pessimistic conclusions for its applicability in the much drier Sahel. They note that a number of ecological advantages ascribed to trees have less potential in the Sahel. Nowhere in the Sahel have agricultural yield increases been realised from planting trees. The soil improving influence of trees appears to be the result of redistributive processes rather than enrichment processes. In the humid tropics, leached nutrients can be used by tree roots. In drier areas, the potential for agroforestry will diminish, and competitive processes will dominate.

The unsatisfactory state of affairs in the agricultural and forestry professions to link up in integrated agroforestry research can be explained by the historical origin of the institutions dealing with land, already touched upon in connection with the origin of colonial forest legislation.

The basic institutional structures established to deal with the use of land in virtually all the countries of the world today originate from temperate Europe and North America. There, in the late 19th and early 20th centuries, the modernization of agriculture and forestry, which was necessitated by and depended upon the rapid industrialization, led to the gradual emergence of government and private institutions to support the land users. Crop production and industrial wood production, which were carried out on separate types of land, required different professional skills, had different aims, and very often were managed by different owners (farmers versus governments or private companies). It was entirely rational, therefore, that agricultural and forestry institutions developed independently of each other.

As a result of these separate institutional developments, there are today different laws and policies governing agricultural and forest land use; there are separate training, education and research institutions; advice to land users is provided through separate extension services; agriculture and forestry normally fall under different ministries or, if they are under the same ministry, under different departments. All policies and disciplinary R & D efforts are aimed at maximizing, in a sustainable way, the output of products per unit of land, for either tree or non-tree crops. Commercially oriented mono-cropping dominates the use of land and has been seen as very successful as markets for agricultural and forest products.

When the European colonial powers established their administrations in Africa and elsewhere in tropical and sub-tropical regions, the institutional structures, policies and aims related to land use and development used in the home countries were simply copied in the colonies. This applied also to those countries which were not colonies, e.g. in Latin America, where governments chose to adopt the industrialized countries' institutional structure in land use. The model has been continued after independence in all tropical countries and the post-war institutional organizations that were set up to assist the emerging nations in improving and rationalizing the use of their land resources are all oriented on conventional-discipline lines (ibid, 1987 44-45).

These land use support institutions are inappropriate for many developing countries. With few exceptions, subsistence or near-subsistence farming systems are mixed in the sense that the farmer produces not only the bulk food crop from the land but also specialized food crops (vegetables, fruits, spices, etc.),animals meat, milk or draught power, and, very often, trees and shrubs for fuel, fodder, medicine and building materials. Cash incomes can come from surpluses produced in any one of these commodities at any one particular time. The subsistence land user's strategy and aims are to use his labour and land resources to optimize, with minimum risk, the production of various products and services required to satisfy all his basic needs. Mono-disciplinary production approaches are single activity oriented and are thus unsuitable for meeting optimization strategies across many commodities, services and labour allocations, as obtaining in diverse rural conditions.

According to Lundgren (ibid, 1987 46) there is no institution today which has both the mandate and the competence to identify solutions to land-use problems based on an interdisciplinary analysis of interactive constraints and potentials within land-use systems, and the power to assign resources in a way that will cut across institutional boundaries in order to implement such solutions. Lundgren asserts that virtually all recent policy and planning documents from international institutions, even if they pay lip service to the need for multidisciplinarity, integrated approaches and holistic views, end up making conventional recommendations such as increased use of fertilizers, irrigation and genetically improved crop varieties, increased tree planting, etc. None contain any critical analysis of the adequacy of existing institutions for addressing the totality of the problems and for contributing to their solution.

AGROFORESTRY APPROACHES

There are basically two approaches which agroforestry is currently taking. The one attempts to show how agriculture and forestry can be combined, and the second one derives from the study of what are called the 'home gardens' (Terra, 1953; SAMAKA, 1973).

The Taungya System

The taungya system was widely used as a means of reforestation (FAO, 1985, 35). It originally started in Burma in the mid-1880s, where it was introduced as a means of controlling shifting cultivators and of growing teak on a large scale. In this system, farmers planted seedlings along with food crops in cleared plots. After a few years, during which farmers weeded and cultivated the seedlings as they farmed, the trees began to shade the land, and farmers moved to another part of the forest where the cycle was repeated. Taungya soon spread to India, East Africa and elsewhere, because it is a relatively inexpensive means of planting and weeding, and because it permits the multiple use, and regular attending of forested lands.

However, raising food crops in combination with trees is frequently more labour intensive after the first year, than traditional systems of shifting cultivation which taungya replaced. For these reasons, successful taungya plantations have tended to be associated with areas which are characterized by under-employment, low living standards and shortages of agricultural lands (King, 1968, and 1987). In these conditions the system has been used to save public expense in planting and weeding of plantations while temporarily providing landless labourers with an opportunity to obtain employment and produce their own agricultural crops. These conditions imply that the approach has been more successful in densely populated areas of Asia. Its chances of success tend to be less in Africa where often labour shortages in agriculture have been documented.

Among taungya's drawbacks are that it may be exploitative of the landless poor. When it uses their labour without providing any long-term access to land, it does little to stabilize already insecure systems of land tenure. Fears that taungya workers will mobilize political support to obtain permanent tenure rights to agricultural production sometimes inhibits more widespread use of the system, as it leads to systematic encroachment into designated forest land and possibly a gradual disappearance of tree cover in favour of agricultural crops. Sometimes, projects fail due to sabotage of the seedlings by workers, to reduce tree growth and to thereby extend the period during which they can crop farm. In turn, this calls for intensive supervision by the forest department staff, including the penalty of denial of a 'next round' in the shifting frontier when farmers are seen to have damaged the seedlings. Antagonistic tensions, resulting from these conflicting interests in the project between the workers and the forest department staff may be widespread, such as in Indonesia.

From this historical basis, ICRAF is now studying and advocating agroforestry practices which guarantee more permanent land use to rural workers. This is technically obtained through periodic pruning of the trees so that tree growth will not shade out agricultural crops over time. But institutional issues, such as on land and tree tenure will have to be faced as well (see below).

Combinations of trees and crops are being identified which permit cross-fertilization and symbiosis between trees and crops, but not any or all combinations of crops and trees will have the desired effects of joint environmental and economic benefits. It should be born in mind that the functions of forests are not necessarily related to the forest as a stand of individual trees, but rather to more specific attributes. For instance, many environmental functions of forests are related to the entire forest as a complete and well-functioning eco-system. These functions may, therefore, only be manifested to a discernible extent in a sufficiently large, and often multi-species communities of trees, whereas wood, fodder and fruit are produced in individual trees. Moreover, many functions of trees are conditional upon proper management regimes. To enhance soil productivity, only specific combinations of crops and trees have the desired effects. The scientific knowledge about suitable combinations of crops and trees to produce desirable joint effects, is still rather limited, as was noted earlier.

In past technical research most attention has been focused on the fast-growing nitrogen-fixing trees, from the Leguminosae family. Currently, attention is shifting to other multipurpose trees such as edible forest trees, fodder trees, bamboos, palms and rattan. The problem, however, is that these trees are not yet widely familiar to foresters (Wiersum, 1985, 109). In fact, many *exotic* farm trees have been introduced in the past not by forest services, but by agricultural services. Many agriculturists were interested in trees that could provide shade or mulching materials in cash crop plantations. Examples of multipurpose trees that have been incorporated into indigenous smallholder farming systems after introduction first in agricultural estates include *Acacia, Albizzia, Gliricidia, Grevillea* and *Leucena* species. The characteristics of such trees often fulfil the requirements of farmers better than the timber production characteristics of trees favoured by foresters.

Examples of leguminous and other nitrogen-fixing woody perennials with agroforestry potential in arid and semi-arid areas are presented in Table 14 (Leach and Mearns,1988).

Home gardens
Home gardens, especially in parts of Asia, have been well known agricultural systems. A rich diversity of crops and vegetables, trees, livestock are combined on a small surface, usually around the home (Terra, 1953; SAMAKA, 1973). What such gardens lack is surface area, but compensation is found in developing multi-storey, multi-product crop layers each with their own nutrient requirement and microclimate (Oldeman, in Wiersum (ed) 1988). Their scientific study has, until recently, been neglected however, as the volume of the individual products was too small for commercial developments. They were seen as part of the 'subsistence complex' of small farmers, and farm labour was mostly seen as one form of inputs needed for commercial crop production. Only the 'farming systems' approach, itself a rather recent approach in agricultural sciences, began to place the farmer in the center of complex alternative decision structures in managing a range of agricultural and also other objectives. Home garden development, at present, tends to be promoted by non-governmental development organisations and not by the official agricultural extension services.

In some cases home gardens were and are explicitly forbidden for fear that they would distract available labour from the main crop on settlement schemes, or for fear that the main crop, and thus the economic viability of the settlement project itself, would be contaminated by pests hosting in the home garden (for Mwea, see Chambers and Moris, 1973).

Table 14 Some leguminous and Other Nitrogen-Fixing Woody Perennials with Agroforestry Potential in Arid and Semi-Arid Areas (Leach & Mearns, 1988)

	Species	Acacia albida	Acacia senegal	Acacia tortilis	Albizia lebbeck	Cajanus cajan	Cassia siamea	Cordeauxia edulis	Pithecellobium dulce	Prosopis chilensis	Prosopis cineraria
	Other Remarks	Combines well with agric. crops.	Yields gum arabic.	Wood used for livestock pens. Termite resistant.	Fast growing.	Sericulture/shellac.	Very toxic to pigs.	Subsistence food.	Presscake makes good stock feed.	High biomass yield.	Combines very well with agric. species.
Miscellaneous	Ornamental	•		•	•	•			•		
	Cultural, Ritual, Social										
	Medicinal/Drugs		•								
	Fibers		•								
	Gums		•••		•	•			•		
	Tannins (T) Dyes (D)	(T) •						(D) •	(T) •		
	Essential Oils										
	Waxes										
Services	Mulch										
	Organic Manure	••			•		••				•
	Nitrogen Fixing	•••	•	•	••	•••		•	•	•	•••
	Dune Fixing		•	••							
	Soil Conservation	••	••	••	••	••	••	•		••	••
	Live Fence								••		
	Windbreak						••		•		
Wood	Others										
	Sawn Timber				••		••		•		
	Wood for Utensils & Tools	•		••						•	•
	Building Material	•		••	•				•	••	•
	Charcoal		••	••	•						••
	Fuelwood	•	•••	•••	•••	•	•••		•	•	•••
	Bee Forage			••	••				••	•	•
Fodder	Shoots			•	•	•	•		•		•
	Fruit/Pods/Seeds	•	••	••		••	•		••	•	••
	Leaves	••	••	••	••	•	•	••	•	•	•
Food	Spices (S)/ Condiments (C)										
	Starch							••			
	Oils/Fats							••	•		
	Vegetable					••					
	Nuts/Seeds		•			••		•••		•	
	Fruits/Pods								•		

Fair • Good •• Excellent •••

Home gardens could provide a livelihood in areas where families no longer have adequate access to crop land, or where their holdings have become too small to obtain a livelihood from only a few crops. In some areas population pressures may be so intense that the home gardens themselves are threatened, such as for instance in the rice plain of northern Java. The need for expanding the sawa's (irrigated rice fields) increases under economic pressures to triple-crop rice. At the same time population pressures leads to an increasing number of houses being built on the homestead (the 'erf'), thereby reducing the space for a proper home garden. Paradoxically, food production and consumption may increase while the diet of the population deteriorates, as the complementary and supplementary nutrients from the old home garden, are in short supply.

Home gardens usually include a small-livestock component: pigs, ducks, chicken, fish and bees. However, little systematic knowledge exists in respect of silvo-pastoral, or agro-silvo-pastoral approaches to tree growing in integrated systems in savannah-landscapes so widely occurring in Africa. For a recent bibliographic study on the Sahel on these problems, see Van der Graaf (1991).

Other Policy Approaches

Energy specialists, foresters and agriculturists define the rural energy problem and its causes in different ways. They propose different lines of action which are, in large measure, defined by the professional and institutional environment in which they have been trained and work. Awareness of problems with rural energy, and the urge to do something quickly in response, especially when funding for new initiatives appear to be available, almost inevitably lead to a project-based approach.

Rural energy projects tended to be treated as add-ons to the range of professional activities within established institutional and policy frameworks. However, many of the project approaches discussed in this paper do not seem to have been very successful. A number of misconceptions in diagnosis, implicit assumptions and expected behavioral responses turned out to be in need of revision.

Within such a partial and project approach the range of adaptive changes in response to experience gained is, however, limited. At project level many broader issues of policy and of institutional settings cannot be dealt with effectively. They exceed the knowledge and the competence of those most directly involved in the project, through execution, planning or supervision. Policy issues, in most cases, have to be taken up at regional or national level and they often impinge on a range of other issues and other interests. Even to define new directions in policy turns out to be complex, leave alone mobilising support for adoption and implementation. When, additionally, issues are raised in respect of the basic competence and main tasks of the institution itself, policy discussions and bureaucratic self-interest seeking intermingle to a degree that stalemate results. However, both types of fundamental issues are being raised in respect of forest policy: questioning the nature of forest ownership, the role of government in management and the objectives of forest management.

Professionals with other backgrounds than those discussed so far in the paper, have joined the debate and they tend to ask questions about deforestation and its causes in yet other ways. Two approaches will be taken up here. Those who look at the root cause of deforestation and the resulting rural energy crisis from the perspective of land tenure, and those who look at the behaviour of individuals and corporations from the perspectives of the macro economic and/or sector specific, incentive systems under which actors operate.

LAND TENURE REFORM AND SOCIAL FORESTRY

To explain the root causes of deforestation some researchers seek the answer in unsatisfactory land tenure situations. The fact that many woodlands are held as "commons" is seen to provide incentives to over-exploit the resources and disincentives to maintain and improve the resource. Hence, institutional reforms are instrumental to enable improved management. To the extent that it is now increasingly recognized that agronomists and foresters should work closer with, and respond to the multiple needs of the rural population, the different land tenure regimes for forest lands as contrasted to those for agricultural lands are seen as an obstacle to effective collaboration. Land tenure reform may well be a precondition for more fruitful and constructive forms of collaboration between various professional groups working in the field with the people. Contrary to the long-term trend in agricultural lands, where ownership and/or effective control has moved in the direction of privatisation, in respect of forest land the overwhelming historical approach from the mid-19th century through political independence, has been for the state to assert ownership and to reserve most of the management roles to itself, as was pointed out in the section on forestry earlier in this paper.

To illustrate the implications of this dichotomy of land tenure regimes on the nature of the problem to be taken up in this section, the following quotation from the ESMAP (1988) seminar is given:

> *'The household energy problem of Eastern and Southern Africa can partly be overcome if the rural population would participate in tree planting....but why should they? In general the land does not belong to them, the incentives are lacking, and the return on labour and investment are not attractive in view of the very low market price for woodfuels'.*

Similar conclusions might be drawn in an Asian, and thus high population density context, where the bulk of the rural population are tenant farmers and landless labourers. The latter have no access to land, and the former might have no incentives to plant trees. People may even be actively discouraged from planting trees, in those cases where the planting of trees is a means to establish land-rights in disputed land claims. But should this conclusion be accepted?

It may be useful to pursue some of these institutional issues somewhat closer, particularly through taking up on some of the debates in India, and some very limited evidence from Kenya. The discussion is not intended to resolve the issue of land tenure in forest lands, but to illustrate some of the relevant arguments and to point at the fundamental and far-reaching implications of this debate for future possible or desirable roles for forest authorities.

The classic historical case for public ownership and public management of forests has been made on a number of grounds (Commander, 1986, 333).

(1) Forest management is associated with a wide range of externalities that impinge on the economy not just of proximate producers but also of the economy and the eco-system as a whole.
(2) Management of forests requires a level of professional training and scientific competence that lies outside the capacities of potential private owners.
(3) The time horizons for forest management and the spatial requirements for an efficient harvesting and replanting favour public investments.
(4) The ecological variety is only likely to be preserved in a context of public management.
(5) Public ownership allows for economies of scale, and
(6) Public ownership would allow for a wider and more just distribution of forest benefits.

Such claims are often taken by foresters as axiomatic truths. Having grown used to the public ownership and public management model, the assumptions and assertions of the model are rarely questioned, at least until the present time. Like in so many contemporary policy areas, non-governmental agencies have played a key role in raising fundamental issues about forestry management. In India, the activities of, for instance, the Chipko movement has been catalytic to rethink traditional forest policies and institutional arrangements. The Chipko movement was formed to protest excessive forest destruction by loggers under the auspices of the state forest service, to protest the disregard for the interests of forest dwellers, and to protest the environmental destruction contingent upon logging. The protests were led by women who form human chains, hand-in-hand, to stop the bulldozers, and such methods brought the much needed publicity necessary to present its views.

Many of the claims of the public sector forestry model crucially depend upon the quality of management. With increasing and diversifying claims on forest resources, the process of effectively balancing contrasting and conflicting claims on forest lands becomes very complex. The model also implies a notion of the state as 'guardian of the public good', where all interested parties have equal access and power to partake in policy debates about forest policy. It furthermore assumes that political leaders in effect make decisions in response to long term and not short term opportunistic considerations. Where politicians were recognized to be fickle and unpredictable, the State Forestry Bureaucracy took it upon itself to set long term policy. Finally, the model requires that adequate resources are available to effectively implement and enforce implementation of forest policies as formulated, largely by the forest resources bureaucracy itself.

Reactions to poor performance of forestry departments and the increasingly deplorable state of forest resources in India are in two directions (Saxena, 1987, 20-27). On the one hand, there are those who argue that public management should be strengthened to enable the state to live up to its mandate. On the other hand, there are those who argue that adherence to this model lies at the root of the conflicts, and that ownership, as in agricultural and other land resources, should be transferred to the private sector, perhaps through lease holds (Commander, 1986). If the latter, there are again conflicting views about two options: to allocate land to individuals or corporations to practice farm forestry, or to allocate land to communities to again practice *social forestry* for the benefit of their joint membership. Many such forest-dweller communities have been forest dependent for centuries, but their rights have been diminished over time by state policy.

There exists, perhaps, a viable alternative to state-managed forest lands in the form of farm forestry on private land, without leading to the seemingly automatic change-over in favour of agricultural production and the destruction of the forests (Blair, 1986, Saxena, 1987, 30-34).

There is by now growing evidence that tree growing on agricultural lands can persist despite population pressures. In India, farm forestry appears to be the most successful component of *social forestry* approaches (Arnold, 1987; Commander, 1986; Blair, 1986; Saxena, 1987), while also in Kenya extreme population pressure on agricultural lands, in Kakamega, goes hand in hand with extensive tree growing on private lands in the area (Dewees, 1989).

A major difference between the two cases is that in Kenya the phenomenon seems to be prevalent among very small farmers. In India it seems that predominantly the larger farmers turn to farm forestry, but Blair (1986, 1320) shows for Maharashtra (India) that there may be considerable scope for farm forestry for small farmers, where also sizeable numbers of small land-holders are classified as poor.

Others have pointed out that small communities of forest dwellers have proven over long periods that they are capable of managing and using, in a sustainable manner, forest resources on which they depend for their livelihood (Singh, 1986; Saxena, 1987; Ballabh and Singh, 1989). Thus, the popular assumption that 'common properties' inevitably are doomed to disappear (Hardin, 1968) need not hold. In fact, management regimes for common natural resources has received much academic and increasingly also policy interest. It has led to better definition of conceptual and operational concepts in common pool matters (BOSTID, 1986; Bromley and Cernea, 1989; Van de Laar, 1990a).

Searching for explanations to the phenomenon that also small farmers turn to tree planting, one comes to the conclusion that when landholdings become too small for making a living in agriculture, off-farm employment and incomes have to be sought. Labour constraints then inhibit that much time can be devoted to pursue agricultural activities on the little holding that is left, and farmers adapt by growing trees as a 'crop' which requires few inputs and little maintenance.

It grows well on agricultural lands, and its products do have good sale value in the market. In the short run, fuelwood, fruits and fodder is produced and, with time, valuable poles and even timber can be obtained. If resources are not needed in the medium term, the tree(s) need not be cut. They can grow to greater stem diameter, and thus fetch high incomes from full timber at a later stage. Pricing policies could also play a role in farmer decision making favouring trees over crops. Where agricultural products are subject to a ceiling price, and forest products are not, farmers may turn to trees rather than crops. Trees can therefore be an important and flexible source of savings and income when needed (Chambers and Leach, 1989). Tree growing is a safe investment, and certainly superior to other forms of monetary savings in rural areas where financial markets are poorly developed.

In light of these findings which indicate that there may exist a viable alternative to state forestry, the debate about the future of public forest lands in India but perhaps also elsewhere, and the appropriate role of the forest department may be reopened.

Those who favour continued state authority, stress that, while having the legal responsibility for forest lands, they have been starved of resources to do a good job at managing state forests in national trust. Consequently, they tend to argue that no institutional changes are necessary, but that more resources would enable them to serve the national needs better.

The counter argument, for India (Commander, 1986), but possibly also valid elsewhere, is that state forest services have an established record of inefficiency and corruption, and that strengthening them would be paramount to license increased inefficiency and corruption. The forestry department, it is argued, is increasingly unable to simultaneously balance the competing land use claims of the rapidly growing population, and the broadened array of end-uses for wood due to widening demand and the diversification of the production structure. Privatization of forest lands is advocated as a strategy which will enable improved performance of forest resources for a multiplicity of end-uses.

Commander (1986) favours a middle ground to outright farm forestry on public land in India. He is in favour of long, conditional leases. On the one hand, to allow for an inter-generational time horizon necessary for tree growing, while at the same time building-in some safeguards for the type of forest cover to be maintained, the density of planting and felling cycles.

In practice, as a result of historical developments, it is the forest department which has benefitted most from the greater interest in reforestation over the last decade, by attracting and controlling most of the additional funding which was forthcoming. This is unsatisfactory. Some argue (Saxena, 1987) that the present strategy of giving the entire responsibility of afforestation and all additional resources to the forest department, also for tree planting on lands, like civil/soyam and panchayat, over which it has little *de jure* control needs to be reviewed. It would seem more appropriate if the panchayats and farmers are more directly involved in plantation, and that available financial resources for afforestation should be broader channelled. Panchayats and farmers, alongside with the forest department should concentrate on those wastelands over which they have better control, because they are adjacent to farm lands.

By implication, the area directly under the Forest Department would be substantially reduced, and the scope for different land use and population distribution policies might be widened. Such a rethinking process might also open new perspectives in many other countries as well. Despite extremely high population densities the percentage of the total land area claimed by the Forest Act is enormous, even in densely populated Java in Indonesia (Poffenberger, 1990, map on p 30).

It is, of course, far too early to already draw conclusions about desirable futures for forest lands from the very few examples of apparently successful farm forestry experiments reported in the literature. In respect to Africa it has been observed that 'one of the greatest problems faced in spreading the word about the possibilities for improved bio-mass management is our ignorance of the cultural and gender issues at a domestic level. A central problem in many societies within the region and beyond is that women have the responsibility for fuelwood collection but are often not permitted under custom and tradition to plant trees. Conversely, fuelwood collection is a women's responsibility, so it is of no interest to men, yet it is frequently the men who exercise the sole right to plant trees' (Munslow, 1988).

The origin of such taboos on tree planting by women seems to be that land ownership disputes were in the past resolved by adjudicating on the basis of male tree planting on the land, in a social context where possession of capital assets was confined to men. One possible way to overcome this conflict in Kakamega is to redefine fast-growing fuelsticks and fodder trees from 'tree' to 'crop'. (Munslow, et.al. 1988 88).

Even without going so far as to suggest major changes in land use policies for designated forest lands, there is a need to study a much wider range of land use models involving tree growing, and the merits of alternative management models.

To position the place of the state-owned and state-managed forestry land model within the broader framework of institutional land use options, Figure 4 will be helpful. Using ownership of the land and management responsibility for the land as the two main variables, the table provides an overview of the range of possible combinations for discussions of institutional forest policy options.

As is clear from the presentation in Figure 4, in many of the systems outside the standard model of state management on public lands (nr 16 in the scheme), the role of the forester will be more advisory rather than executive. But classical foresters' tradition has little of an extension capability. Hence in many current *social forestry* systems considerable energy is spent in attempting to develop extension capability in forest services. The key issue is whether in the non-forest lands scope can be found for intensification of tree management, to compensate for the loss of 'designated' forest areas, on which much of the whole debate about deforestation trends tends to concentrate at the present time.

Regardless of the ultimate merits of public versus private ownership of forest land, the problem of the desirability of contemplating changes in ownership status is complicated by even discussing or suggesting changes. Discussions about changes in land use rights, by themselves, act as a source of forest degeneration, in addition to the reality that various more 'stable' forms of 'ownership' in practice tend not to be enforceable effectively. Transitional phases in tenure status induce a degeneration of forest resources into open access resources, because such changes are accompanied by considerable uncertainty, whether changes will be implemented or not at all.

For instance, in Ghana usufruct rights over forest resources were originally those of customary law. In the early 1970s, as an outgrowth of political conflict, all rights over natural resources were stripped from the traditional communities and assumed by the national government. As a result, Ghanaian forests are now even more subject to the 'tragedy of the commons' than they were when property rights were vested in tribal groups, which had some incentive to maintain the resource. The transfer of all rights to the national government has meant that access to the remaining forest is virtually unchecked (Repetto,1988, 82). Similarly, in Pakistan deforestation accelerated enormously when the principality of the Wali of Swat was nationally integrated in 1969, accompanied by a transfer of responsibility to regulate forest use from the community to the Pakistan Forest Department.

Also the form in which land tenure changes are effectuated can lead to excessive deforestation. Where the granting of land title from designated state forest land to individuals is made dependent upon the land being cleared for agriculture, this will induce spoilage of large tracts of forest land to expand land title claims. (Southgate and Runge, 1990, for a discussion in the context of Ecuador, and other countries in Latin America).

		Control/ownership of land and trees			
		individual farmer	extended family	communal	state
Responsibility over tree management	individual farmer	1	2	3	4
	extended family	5	6	7	8
	communal	9	10	11	12
	state	13	14	15	16

Management Systems	Characteristics of different Community Forestry Systems
Farm forestry	1. Private tree growing on communal lands. 2. Private tree growing on family lands. 3. Privately managed tree farming, plantings around houses. 4. Public land allocation schemes for private tree growing.
Family forestry	5. Family tree growing on cummunal lands. 6. Family tree growing on family lands. 7. Family tree growing on private lands. 8. Public land allocated for family forestry activities.
Communal forestry	9. Communal tree growing on community lands. 10. Communal tree growing on family lands. 11. Tree growing on private lands organised by community institutions. 12. Public land allocated for communal forestry activities.
Publicly-managed forestry for local community develop-ment	13. Public plantings on communal land. 14. Public plantings on family lands. 15. Public plantings on private lands. 16. Publicly-managed schemes on public lands with social or environmental objectives.

Figure 4 Community Forestry Systems (Laban, 1989)

An implication to be drawn from discussions about desirable futures for forest lands is that it could lead to a shifting balance in assigning main responsibility for different segments of the wood-materials market to different actors. Private farmers would gradually take over the role to meet commercial needs for wood products such as building poles, small timber and for paper and pulp, with the role of the state will be reduced to safe guarding the environmental and watershed protection, and advising other land users on how to incorporate tree growing on their holdings. In practice, the production of timber has in many instances already been entrusted to private corporations under more or less unsatisfactory logging arrangements (see below), and more diversified divestitures of powers and responsibility away from the Forestry Department could be contemplated.

There is however a snag. It is unlikely that the private sector would supply the woodfuel needs of the poor. Wood fuel is low priority wood use and the poor have too little cash income anyway to purchase it. A new task for the public sector could then be to assume greater responsibility for meeting the fuelwood needs of the poor. The tendency for past and also still current 'social forestry' projects to be targeted as providing fuelwood for the poor is also in need of revision (Blair, 1986). As argued before, one should not apply 'double tying' to such projects by specifying target groups as well as end-uses of biomass projects.

Revision of Forest Codes may be needed, not only in India and elsewhere in Asia, but also in many parts of Africa. Elbow and Rochegude (1989, 19) note that many officials of Sahelian forest services and ministries have come to express the view that it is not clear that any amount of materials and manpower needed would be adequate to enforce a centralized management system which is so little inviting of popular participation.

Resistance to change the Forest Department's role can be expected, the more so as the forest department in a number of countries is held responsible to generate part if not all its operational expenses. With income from timber concessions diminishing, they would have to rely on general government resources to fulfil the remaining tasks more effectively than they are currently able to do.

FISCAL INCENTIVES AND PRICING STRUCTURES

In the last few years yet other approaches to analyze deforestation, its causes and consequences, have been developed. They do not focus on land tenure, rural energy needs, commercialization and commoditization of woodfuel markets, agricultural land needs and on the poor people living on the forest fringes. Instead these authors draw attention to the macro, regional and sectoral policy environment, through the incentives provided to especially large corporations as prime movers of forest frontier development or destruction. It is an approach pioneered by the World Resources Institute (Repetto, 1988), which carried out a survey of the major timber producing countries. Noteworthy are also the contributions of Mahar (1989) and Binswanger (1989) in respect of the Amazon area in Brazil. Similar analysis is applied to Ecuador (Southgate and Runge, 1990). The approach and analysis may have wider applications in other countries and situations.

These authors point at the manner in which the Brazilian government over the last 25 years has attempted to develop Amazona, which has been rarely designed and carried out with due regard for the environmental consequences. Problems started with the decision to build the trans-Amazonian highway. Generous investment incentives were given to investors to engage in environmentally questionable livestock projects. Settlement projects were set up in such a way that poor settlers found themselves at the cutting edge of a moving frontier. Lack of institutional support for successful agriculture encourages extensive and environmentally harmful patterns of resource use through shifting cultivation practices in new areas of which too little was known about soil characteristics and potentials (Mahar, 1989).

Projects in Amazona would be economically nonviable, except for (a) the tax shelters, (b) the rules of public land allocation, (c) the progressive land tax containing provisions that encourage the conversion of forest to crop land or pasture, (d) tax credit schemes aimed towards corporate livestock ranches which subsidizes inefficient livestock ranches on cleared forests and (e) the availability of subsidized credit for approved ranches (Binswanger, 1989).

Repetto (1988) calls attention to inappropriate policies in respect of royalties and related charges on private concession holders in public timber lands. Their studies are based on a large sample of relevant, forest rich, developing countries. Such policies have been deficient in two ways. First, charges have been much less than the stumpage value of the timber (See for an authoritative review of forest revenue systems in developing countries: Gray, 1983). [A standing tree's stumpage value is its implicit market worth, estimated by subtracting from the market value of the wood products that can be derived from it all the costs of harvesting, transporting to mill, and processing.] This policy has not only lost potential government revenue, but has also created enormous pressures from business and political interests to obtain timber concessions for the large 'resource rents' they offer to concession holders. This rent-seeking syndrome has led to over-rapid, wasteful exploitation, including the harvest of timber in critical watersheds and other ecologically vulnerable sites.

Second, in the developing countries, the structure of royalties has, usually in combination with inappropriate selection systems, exacerbated loggers' proclivities for high-grading forest stands and needlessly damaging remaining trees.

In this perspective policy reforms in respect of raising royalties sharply and modification of defective royalty structures could contribute in a major way to reducing wasteful deforestation.

However, most governments have generally proved reluctant to enact royalty reform. A number of countries have embarked upon a forest products based industrialisation drive and use the low royalty rate as an incentive to prospective investors.

Of the countries studied, only Sabah in 1978 and Liberia in 1979 have increased royalty levels sharply. China attempts to control by administrative means. In Malaysia, the Philippines, Indonesia, Ivory Coast, Ghana Gabon and elsewhere, royalties continue well below true stumpage values. In the United States, royalties are bid up competitively to approximate true values. However, timber with negative stumpage values is routinely harvested because government absorbs substantial logging costs. The simplest remedy would be to require only minimally acceptable bid prices, high enough for the government to recover its full cost of growing and marketing timber.

Concessions' policies also requires changes in the duration of concessions and in the level of area license fees. Prior to the Second World War, many tropical timber concessions were granted for up to a century. Newly independent governments have generally reduced the periods to 5 to 10 years. Given long growing cycles logging firms hardly have a financial incentive in maintaining forest productivity. Instead they repeatedly reenter logged-over areas before concessions expire, compounding damages from the initial harvest (Repetto, 1988, 32-33).

The country case studies by Repetto (1988) produce some startling pieces of information on deforestation trends. For instance, between 1988 and 1998, 8 million hectares of virgin forest will be logged, an area equal to 12.5 percent of Indonesia's remaining productive forests and more than 53 hectares for each new job created. Annual deforestation in Indonesia has increased to 700,000 hectares in 1985, by far the highest in Southeast Asia. China is acutely short of forest resources; although ranking sixth in the world in total area, China's forest area amounts to only 0.12 hectares per capita -- 18 percent of world average. Since 1975, the disappearance rate of West Africa's productive closed forest has been the world's highest.

CONCLUDING REMARK

The discussion in this paper has shown the widening range of the contemporary debate about rural energy problems. The complexities of the issues are gradually being understood, but solutions become increasingly difficult to design. Competing aims and goals for development strategies in the past led to spill-over effects affecting the natural environment. The buffers of the natural environment to accommodate unrepresented interests and to provide a safety net for population groups which have insufficient access to the levers of power, diminish rapidly in many countries and regions.

Since this rural energy problem was proclaimed as a crisis, thus from the mid-1970s, a number of different diagnoses have been made concerning the magnitude of the problem. In a short period a number of different approaches to meet the problem have been tried. Most of these approaches rested on a narrow perspective on the nature of the problem. Little or no hard evidence existed to justify policy approaches, and policy recommendations were conceived within disciplinary traditions inappropriate to the realities of rural life in many of the developing countries. Consequently, successes to date in meeting the rural energy crisis have been limited. As different analytic perspectives shed light on a widening range of problems and issues, the search for more appropriate solutions has started in earnest only from the late 1980s.

Attention on rural energy aspects of development strategies was focused on finding rural solutions. More recently, the diagnosis is both changing and again widening in scope. For instance, Churchill (in ESMAP 1988, 22-23) states that the household energy problem in Africa is a problem whose origins and solutions will be found in urban areas. Moreover, while it is true that most rural household level energy is currently used for cooking, more intellectual and policy 'energy' is required to focus on providing households with energy for purposes other than cooking. Both for rural and for urban households more energy is required for survival and livelihoods.

ANNEX I

The Analytical Fuelwood Gap Model

Gap models of the type described below have been widely applied, and thus have been implicitly 'legitimized' to a large extent, in energy studies. For instance, in the first half of the 1980s sixty-odd country studies were carried out under the auspices of the UNDP/World Bank Energy Sector Assessment Programme. Nearly all of them used variants of the model as described below (Leach and Mearns, 1988, p 5-8). The analytic structure of the underlying model can be represented by the following set of equations (Anderson, 1987; Allen and Barnes, 1985).

In regions where consumption begins to exceed the Marginal Annual Increment (MAI) the rate of change in the volume of the tree stocks can be represented as

$$dS/dt = (a - f)S - C$$

where S denotes stocks at time t, C the consumption rate, 'a' the MAI per unit stocks, and 'f' the net rate of felling -- the rate of removal of trees for agricultural, industrial and other activities minus the rate of planting by the forestry service and by farmers. The value 'f' is not necessarily constant but is here put as a parameter associated with S on the grounds that current planting rates are small and that the rate of land clearing declines with S.

The consumption rate is thought to increase exponentially with population growth. But as fuel wood becomes scarce, real costs and prices rise, and people turn to substitutes or otherwise reduce consumption. Hence we might write the consumption rate as $C = (A/P) \exp(pt)$, where A is a constant, P is price, and 'p' is the population growth rate. In turn the price increase might be expected to vary inversely with (among other things) the available stocks, from which

$$C = (Co/So)S \exp(pt)$$

where Co/So is the ratio of the consumption rate to stocks at
$t = 0$. This gives

$$dS/dt = S[a - f - (Co/So) \exp(pt)],$$

the solution to which, taking the case where 'f' is constant, is

$$S/So = \exp\{(a - f)t - (Co/pSo)[\exp(pt) - 1]\}.$$

The term inside the exponent includes an exponential term, showing that the rate of decline of tree stocks, under the circumstances considered, itself has an exponential element. For example, assume that there is no felling except for fuelwood and that the yields from new plantings are small ($f = 0$); that the initial consumption rate is just equal to the MAI ($Co/So = a$); that the MAI is equal to 2.5 percent of stocks ($a = 0.025$); and that the population growth is 3 percent a year. Then the annual rates of decline of stocks at 0, 10, 20, 30, 40 and 50 years are 0.0, 1.0, 2.1, 3.6, 5.8, and 8.7 percent, respectively, and the stocks decline to 19 percent of their original value over 50 years. If stocks are initially declining at, say, 2 percent a year, the decline to 19 percent takes only 30 years, and even quite modest assumptions about f reduce the time to 15 to 20 years. A graphical presentation of a similar model is presented in Figure 5.

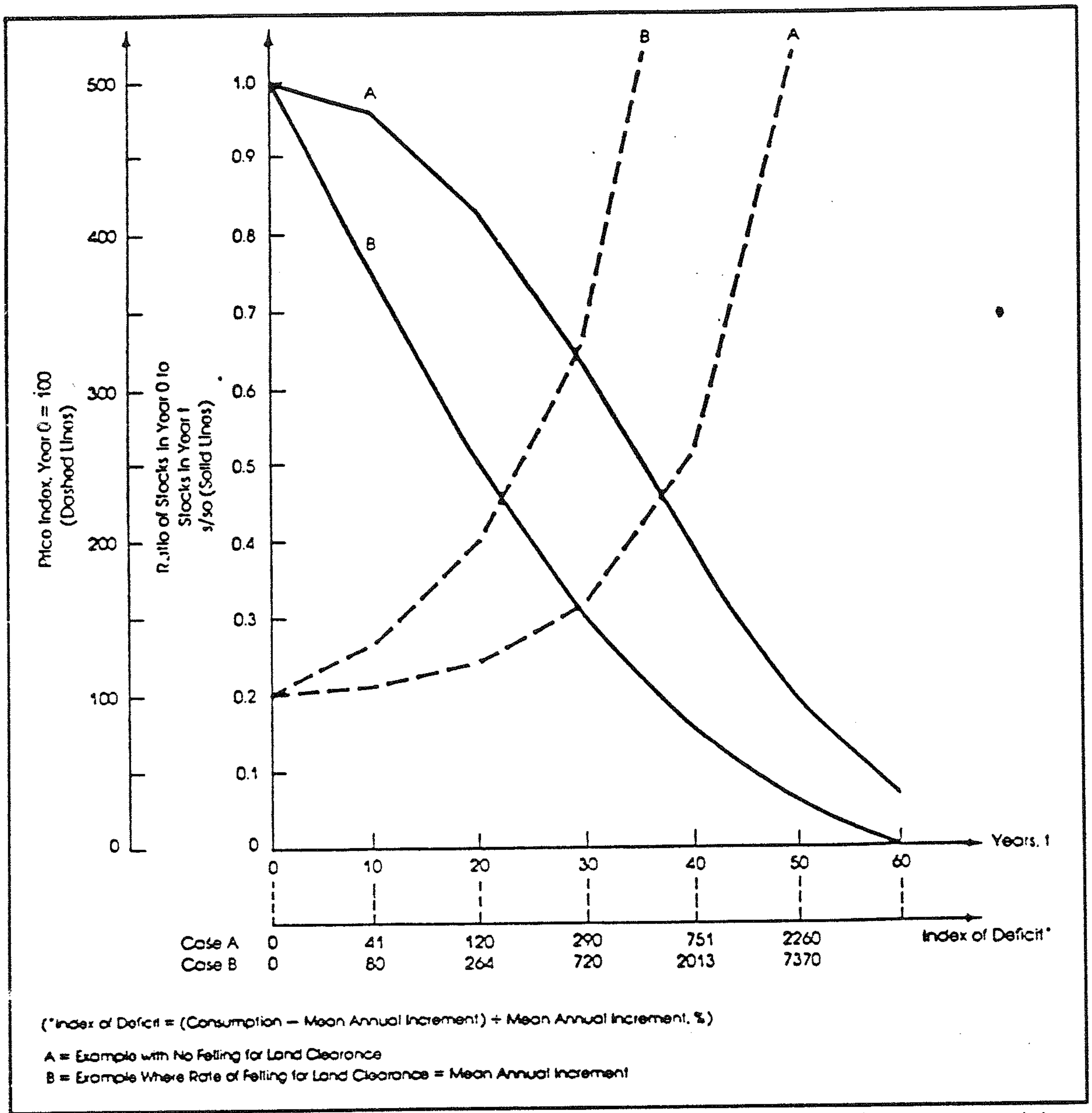


Figure 5 Decline of Tree Stocks When Rate of Consumption Exceeds the Mean Annual Increment (World Bank-26587)

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