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IN

EASTERN AFRICA

Eastern Africa Environmental Trends Project
Program for International Development
Clark University
Worcester, Massachusetts 01610
U.S.A.

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FUELWOOD AND ENERGY

IN

EASTERN AFRICA

An Assessment of the Environmental Impact of Energy Uses

A Draft Report Prepared

on behalf of AID Contract # AID/afr-G-1356

Eastern Africa Environmental Trends Project
Program for International Development
Clark University
Worcester, Massachusetts 01610
U.S.A.

Our civilization... is founded on coal, more completely than one realizes until one stops to think about it. The machines that keep us alive, and the machines that make the machines are all directly or indirectly dependent upon coal.... Practically everything we do, from eating an ice to crossing the Atlantic, and from baking a loaf to writing a novel, involves the use of coal, directly or indirectly. For all the arts of peace coal is needed; if war breaks out it is needed all the more. In time of revolution the miner must go on working or the revolution must stop, for revolution as much as reaction needs coal.... In order that Hitler may march the goosestep, that the Pope may denounce Bolshevism, that the cricket crowds may assemble at Lords, that the Nancy poets may scratch one another's backs, coal has to be forthcoming.

- George Orwell, from
<u>The Road to Wigan Pier</u>

FOREWORD

This study on energy and environment in eastern and southern Africa arises out of two years' work involving Clark University with local institutions in Sudan, Ethiopia, Kenya, Tanzania, Zambia, Malawi, and Botswana. Collaborative relationships among these institutions have provided a setting to analyze the impact of development activities on the environment and to devise ways that environmentally sound projects can be planned, implemented, and evaluated.

This report is one of three. Discussions among the several cooperating institutions have identified three environmental issues which are of critical concern for the participating countries and which can be addressed through project activities. The three issues are:

(1.) The relationship between food production and climate; past, present, and future

(2.) The environmental consequences of the use of charcoal and wood to meet energy requirements in rural and urban areas

(3.) Environment and health

Assessments of food production and health will be available shortly.

The present version of this firewood document has been prepared in July and August, 1978. It is a draft. Philip O'Keefe, visiting professor of geography and international development at Clark University, has led a research team in an examination of existing literature and research studies on charcoal and wood consumption. He is the principal author. This appraisal is being circulated to interested parties in the several participating African nations as well as to specialists in the United States and Europe. Their responses and suggestions will be incorporated into a final version of this report which will be distributed some time in November or December, 1978.

The analysis is prepared primarily for planners and development officers in host Government ministries and donor organizations. It assesses the current energy situation in selected countries in eastern and southern Africa and sketches out the implications of a range of alternative responses. The executive summary suggests that the problem of firewood is critical to the well-being of high percentages of the people living in these countries, both now and in the immediate future.

Leonard Berry
Richard Ford
Co-Directors
Program for International
Development
Clark University
22 August, 1978

EXECUTIVE SUMMARY

This report considers the global energy situation with particular attention to the impacts of that global energy system upon eastern Africa. The results suggest that the energy demand for much of the eastern African population will be met by increased use, both absolutely and relatively, of forest resources. Such a scenario which would produce increasing deforestation will have negative environmental impacts. Conservation forestry projects in such instances will be merely palliative; there is an urgency to develop productive forestry projects to meet rising demand for woodfuel products. Recommendations from the report suggest that procedures for monitoring deforestation be enhanced, surveys of fuel consumption be undertaken and appropriate woodfuel technologies be adopted so that rapid design of productive forestry projects can proceed.

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SECTION ONE: GLOBAL ENERGY SCENARIO

1.1 The history of the industrial world indicates that, as economic development progresses, energy consumption per capita rises. Underdevelopment and low energy use go hand in hand. At the two extremes lies, on one hand, the U.S.A. with an annual per capita consumption of over 20,000 pounds of coal equivalent, and on the other, Nepal with less than 20 pounds of coal equivalent consumption per head per year (Odell, 1970). Though one cannot talk of low energy use as causing underdevelopment, hindrances to energy supply make economic advance difficult.

1.2 In the mid-nineteenth century, the development of technology in America had not yet reached a point where the energy sources required to fuel it involved much more than prairie windmills, water wheels, and wood. Until 1865, wood served as the energy source, providing between 80 and 90 per cent of America's energy requirements (Clark, 1975). The energy transition to fossil fuels, especially coal, occurred in the developed countries as industrialization began. Until the 1950's, economists frequently argued that a coal-base was a necessary condition for industrial growth although, of late, increasing substitution of oil and

natural gas is accepted.

1.3 In most African nations, industrialization and development planning is a more recent phenomenon and the high energy growth rates date back only to the late 1950's. These rates reflect not only the growth of the economies concerned in terms of total output of goods and services but also the increasingly energy intensive character of their development, with a consequent coefficient of energy use approaching 2.0 i.e. each percentage point rise in economic activity brings about a 2 per cent rise in energy use. This coefficient may be compared with figures of 0.7 and 0.85 for the United States and Western Europe respectively during the same period. The lower coefficients reflect the lesser significance of additional inputs of energy in the development processes of the industrialized nations. One should, however, be aware that the high percentage rates of growth in energy consumption for underdeveloped nations reflect initial low energy consumption.

1.4 Primary energy consumption in the underdeveloped countries during 1972 constituted approximately 15% of the non-Communist world commercial energy consumption. As these countries industrialize, given the energy-economic growth relationship, their share of total world energy consumption will rise relatively faster

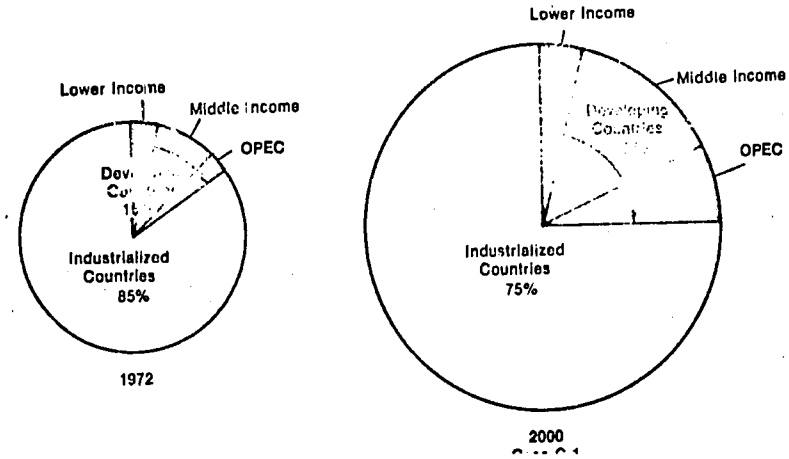
than that of the industrialized world. Estimates of the global supply-demand integrations indicate that underdeveloped countries could consume as much as 25% of total world commercial energy by the year 2000 (Waes, 1977). Figure 1 illustrates this projected share.

1.5 An important factor in the analysis of energy consumption in the underdeveloped world is the present and future growth rate of the population. The energy problems facing underdeveloped economies are more severe because of their current high population growth rates and because their projected 2.4 - 2.7 per cent average annual population growth is substantially higher than the 0.7 - 0.9 per cent population growth projection for the developed world (UN, 1977).

1.6 This projected population increase will not be evenly distributed throughout the underdeveloped countries. The population will increasingly be located in urban areas. Major cities in underdeveloped countries have achieved their size much more rapidly than comparable urban areas in the developed countries. Consequently, there is less correlation between urban growth rates and economic development than in the developed world. There is distorted rural-urban linkage which encourages urban primacy, i.e. the predominance of one single city

Figure 1

Projected Shares of the World's Energy Consumption



Source: Waes, 1977.

in the country. Isolated primate cities lend themselves to poor economic linkages such as can be guaged from the high levels of unemployment and underemployment in many developing nation urban areas. Such centers are foci for energy demand but, as personal disposable income is frequently low for many urban dwellers in these cities, the energy requirements are frequently met from "non-commercial sources (Hance, 1970).

1.7 From 1960-1972, underdeveloped countries more than doubled their consumption of commercial energy and increased their demand for electric power by more than 250 per cent. Yet in 1972, only 25% of this commercial energy demand was in the lower income countries i.e. less than $200 per capita p.a. (Waes, 1977). In these lower income countries, per capita income elasticity of energy demand is about 40 per cent higher than the corresponding total income elasticity. In other words, the industrialization process that raises the per capita income also results in a gradual reduction in the growth rate of energy consumption with respect to growth in real income. Estimates of percentage decrease in the income elasticity of energy for the lower income countries suggests a figure of between 8 and 13 per cent by the year 2000. (Waes, 1977). Similar estimates of energy consumption, to 2000, indicate that lower income countries will increase their energy consumption by 3 or 4 times

the 1972 level if rates of economic growth, between 4 and 5 per cent per year, are achieved. Figure 2 contains a breakdown, by sector share, of this final energy demand. This demand, essentially for transport and industry, will largely be met from oil.

Figure 2

Underdeveloped Countries Sector Share of Final Energy Demand: 1972-2000*

	1972	1985	2000
Transport	34%	35%	34%
Industrial	42%	42%	41%
Domestic/Commercial	18%	16%	17%
Non-Energy	6%	7%	8%

* Excluding processing losses

Source: Waes, 1977

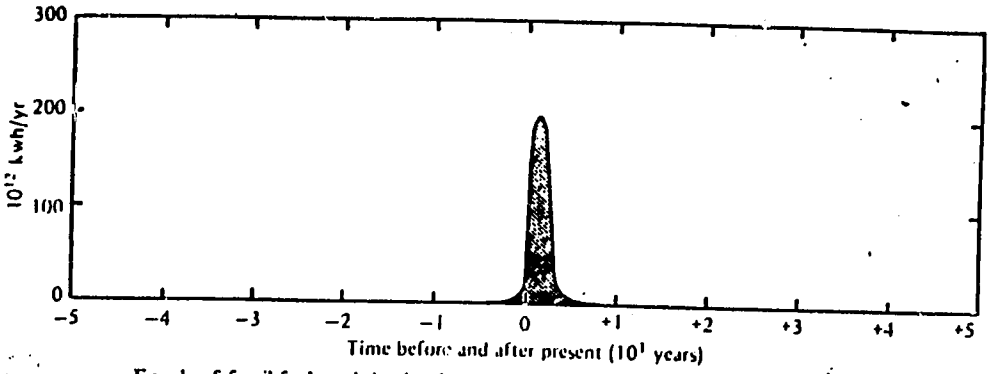
1.8 It is highly probable that higher energy prices will encourage the exploration and production of fuels in many underdeveloped countries where such activities were previously regarded as uneconomic. This is particularly true for oil, natural gas, and coal -- the non-renewable fossil fuels -- for continued price increases will retard economic growth so long as the negative balance of payments, caused especially

by energy imports, continues to deteriorate. Without higher export earnings, stable prices and continued finance assistance, most underdeveloped countries will not be able to generate current account surpluses, a position which retards rapid capital formation (Leontief, 1977).

1.9 It is difficult to predict the total amount of unused, recoverable fossil fuel resources. However, it is important to note the brevity of the period of extensive fossil fuel utilization in the longer span of human history. The historical epoch of the exploitation of fossil fuels is shown graphically in Figure 3, plotted 5,000 years either side of present. On such a time scale the epoch of fossil fuels can only be a temporary yet important phase that has witnessed the proliferation of industrialized societies.

The estimation of fossil fuel resources (Figure 4) is based on the knowledge of general geological conditions associated with the fossil fuel resource and on detailed knowledge of the distribution and extent of a resource within a given geological area. Coal resources are comparatively easy to estimate but oil and natural gas, erratic in distribution, are found only through intensive exploration. In addition to coal, oil, and natural gas, there are two other sources

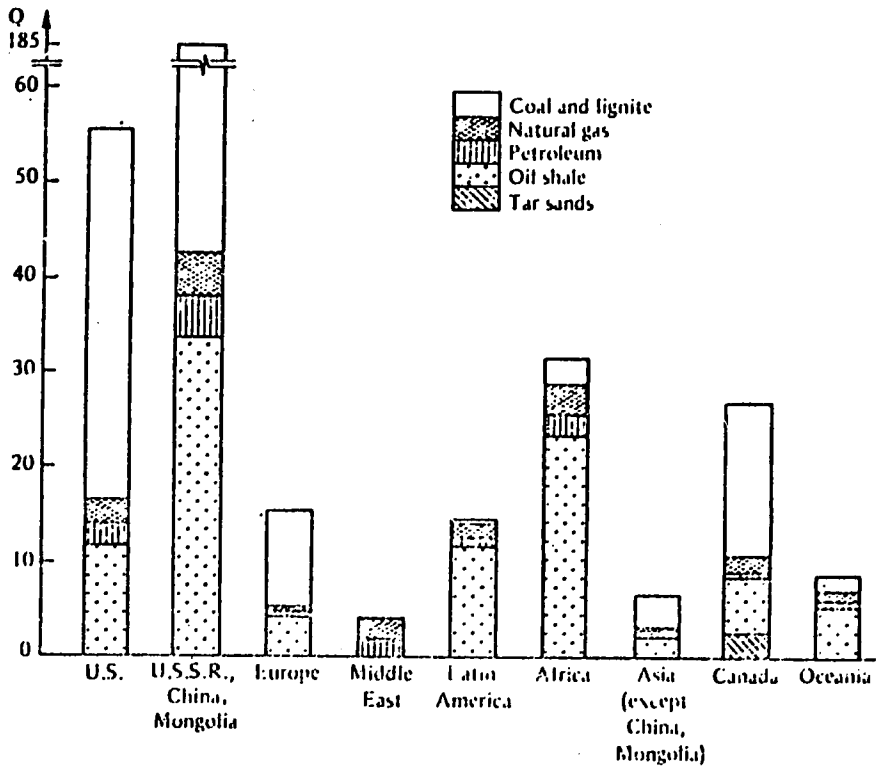
Figure 3



Epoch of fossil-fuel exploitation in perspective of human history from 5,000 years in the past to 5000 years in the future (modified from Hubbert, 1962, Figure 54).

Source: Ruedisili, 1975.

Figure 4



Remaining recoverable energy resources by region. [From R. H. Williams and K. Fenton, "World Energy Resources: Distribution, Utilization, and Long-Term Availability." (See ref. 12.)]

Source: Ruedisili, 1975.

of organic carbon compounds which are potential fuel sources: tar sands and oil shales. The processes for energy extraction from these geological formations are not commercially viable. Figure 4 illustrates the remaining global recoverable energy resources by region. Even is the underdeveloped countries wished to transfer their energy consumption to indigenous fossil-fuel resources, the extent of these resources is comparatively small.

1.10 Figure 5 provides further information on the historical pattern of energy use by major regions. All areas, except Communist Asia, experienced sharp decreases between 1925 and 1968 in the use of solid fuel from 96 per cent to 37 per cent over the period and increased its use of liquid fuel from 3 per cent to 54 per cent. Such a transition demands technological change, a technological change that underdeveloped countries necessarily followed.

1.11 Within underdeveloped countries, much energy demand was met from non-commercial sources. Information, however, is more readily available for commercial rather than non-commercial sources. Darmstadter summarizes the importance of non-commercial fuel in the underdeveloped countries:

> According to rough estimates by the United Nations, as recently as the early 1950's

Figure 5

World Energy Consumption, 1925 and 1968

	Percentage of Region's Total Energy Consumption				Percentage of World Consumption of Each Type			
	Solid Fuels		Liquid Fuels		Solid Fuels		Liquid Fuels	
Region	1925	1968	1925	1968	1925	1968	1925	1968
Africa	92.0	55.0	8.0	41.0	1.0	2.0	0.6	2.0
Latin America	38.0	6.0	57.0	71.0	0.8	0.7	7.0	6.0
Asia*	83.0	30.0	14.0	62.0	4.1	7.0	4.0	12.0
North America	74.0	23.0	19.0	43.0	45.4	22.0	72.0	38.0
W. Europe	96.0	37.0	3.0	54.0	40.4	20.1	8.5	25.0
E. Europe	83.0	53.0	15.0	28.0	5.4	32.9	0.2	14.8
Oceania	93.0	49.0	7.0	49.0	1.2	1.5	0.5	1.3
Comm. Asia	94.0	92.0	6.0	7.0	1.8	13.2	0.7	0.9

Source: Darmstadter, 1971.

> non-commercial energy (in terms of heat content) was more important than commercial categories in Africa and Asia and nearly as important in South America. In a more recent (though geographically less specific) estimate of the relative importance of the role of non-commercial fuels, the United Nations Economic Commission for Europe finds that although the non-commercial sources of world energy are slowly declining in importance (representing in 1967 perhaps 4 per cent of the world-wide total compared with 15 per cent in the non-Communist world total in the 1950's) in some countries as much as 30 or even 50 per cent of the total supply of inanimate energy may still be derived from non-commercial fuels.
>
> - Darmstadter, 1971.

Figure 6 gives the United Nations' estimates for non-commercial energy as a percentage of total energy as of 1950.

Figure 6

Non-Commercial Energy as % of Total Energy

Consumption	%
Africa	51
Central America	35
South America	45
Asia	58
North America	3
Europe	7
Oceania	13
Non-Communist World	15

Source: UN, 1950.

1.12 Data for country profiles does not, at the moment, exist. Makhijani (1975) has attempted to summarize the position of non-commercial fuel in India.

> About 120 million tons of wood, 50 million tons of dry dung and 30 million tons of "vegetable wastes" were burned each year, largely in villages, but also in the towns ... if the energy taken in by draft animals is included the per capita consumption of non-commercial energy is about 12 million BTU per year (about half of which is burned directly as fuel) compared to the commercial energy use of 6 million BTU per year (about ¼ of which is held to generate electricity).
>
> - Makhijani, 1975.

The Indian Government calculated the importance of non-commercial energy as somewhat lower suggesting that non-commercial energy was 59 per cent of total energy consumption in 1960, 48 per cent in 1970 and was expected to remain a significant, though decreasing, percentage of total energy production (Indian

Government; Report of the Fuel Policy Committee, 1974). In a country with few fossil-fuel resources, a rapidly growing population and a per capita income of less than $120 per annum, the contribution to energy demand of non-commercial sources is critical.

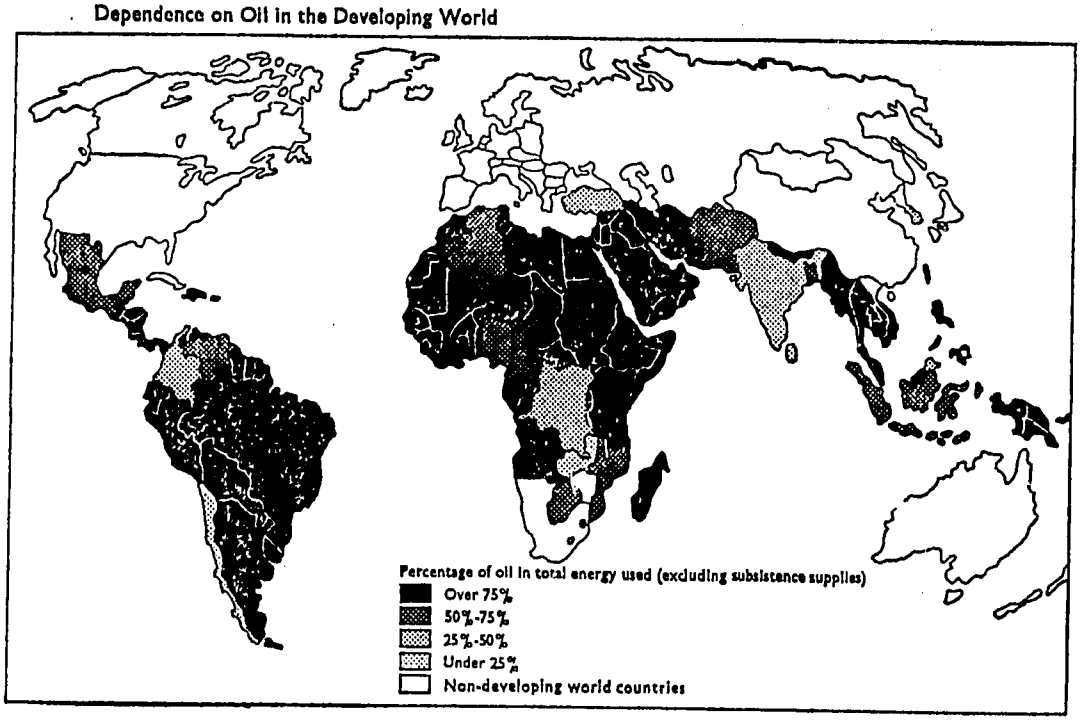
The World Bank estimates that firewood accounted for two-thirds of the total Indian non-commercial fuel consumption, vegetable wastes accounted for 20 per cent and cow dung for about 15 per cent (IBRD, 1974). With increased industrialization and urban growth, commercial fuel will account for a larger percentage of total energy consumption yet the significance of an absolute increase in non-commercial fuel use should not be ignored. The World Bank reports that over 130 million tons of firewood were consumed in India during 1974. Over 90 per cent of this is unrecorded and comes from local collection. Of the 22 million tons originating from state-controlled logging operations, over 13 million tons were used for firewood.

1.13 Such a cameo provides useful insights into the current prospects of many underdeveloped countries. Figure 7 maps the dependence on oil as a source of energy in the underdeveloped countries. Some countries are, of course, oil producing nations but those areas that are not, and do not possess large deposits of

fossil fuel have to rely on forest production to meet substantial proportions of their energy demands. Sudano-Sahelian African and the Indian subcontinent are the two largest such zones. Figure 8 shows data for per capita GNP and energy consumption for some selected countries in these zones.

Figure 7

Dependence on Oil in the Developing World



Source: Odell, 1974.

FIGURE 8

PER CAPITA GNP AND ENERGY CONSUMPTION

Country	GNP/pc. (U.S. $)	Energy Consumption pc. (kg CE)	Proportion of Total Energy Supplied by Firewood
India	110	274	30.3%
Nepal	80	259	95.8%
Malawi	80	376	89.1%
Tanzania	110	1042	96.0%
Uganda	130	531	90.2%
Kenya	150	447	66.9%
Zambia	400	900	43.4%

1.14 FAO estimates exist for the production of round wood and firewood on a global scale. Global estimates indicate that, on the average, half of the global production of wood is for firewood. The developed countries use only 8 per cent of their wood production for this purpose but the underdeveloped world uses over 80 per cent for fuel. Regional differences, for example between North America (4 per cent) and Africa (86 per cent) are even more striking (Figure 9). On a world scale, total wood production is growing at a far greater rate than the production of wood for fuel, the latter growing at only 0.86% per annum compared with 1.57%. It is also striking that the amount of wood used for fuel in the developed countries is diminishing very rapidly; almost 6 per cent per annum. The underdeveloped countries, on the other hand, are increasing their wood fuel production at a rate of 1.8 per cent each year, slower than the rate of growth for round wood (2.4 per cent) but still substantial (Pearson, 1978).

Figure 9

Round Wood and Fuel Wood Production, by Region, 1973

	Round Wood Production[a] 1973 (1000 m²)	Percentage Round Wood Produced[b] for Fuel 1973	Per Annum Growth 1963–1973	
			Round Wood Production	Fuel Wood Production
World	2,500.5	46	1.57	0.86
Developed	807.1	8	0.93	−5.95
Developing	1,029.3	81	2.38	1.81
Centrally planned	664.0	38	1.21	0.61
Africa	309.3	86	2.15	1.85
Latin America	278.4	81	1.77[c]	1.48
Middle East and Asia	691.3	71	2.41	1.81
North America	479.9	4	1.68	−6.34
Europe	331.8	17	0.41	−3.68
USSR	383.0	22	0.69	−1.06
Oceania	26.8	22	1.45	−2.04

Source. United Nations Food and Agriculture Organization, *1973 Yearbook of Forest Products* (Rome, 1974).

[a] Includes coniferous and nonconiferous "wood in the rough."

[b] Includes "wood in the rough to be used as fuel for purposes such as cooking, heating, or power production." FAO's estimates for fuel wood use are considered by many to be considerably understated.

[c] Excludes Central America.

1.15 If demand for non-commercial fuel (i.e. organic) is to increase, then it is of paramount importance to be able to assess the organic productivity of the globe. Since different plant species have different percentages of water, dry weight measurement must be utilized. Furthermore, a distinction must be made between the total synthetic product of a plant community and the proportion of this total product which ultimately produces bulk increase in the plant species.

This latter concept of Net Primary Reduction (NPP) of ecosystems is defined as the dry weight gain per unit area of natural vegetation per unit time, usually stated as $9/m^2/day$ or $mt/km^2/year$ (Westtake, 1963).

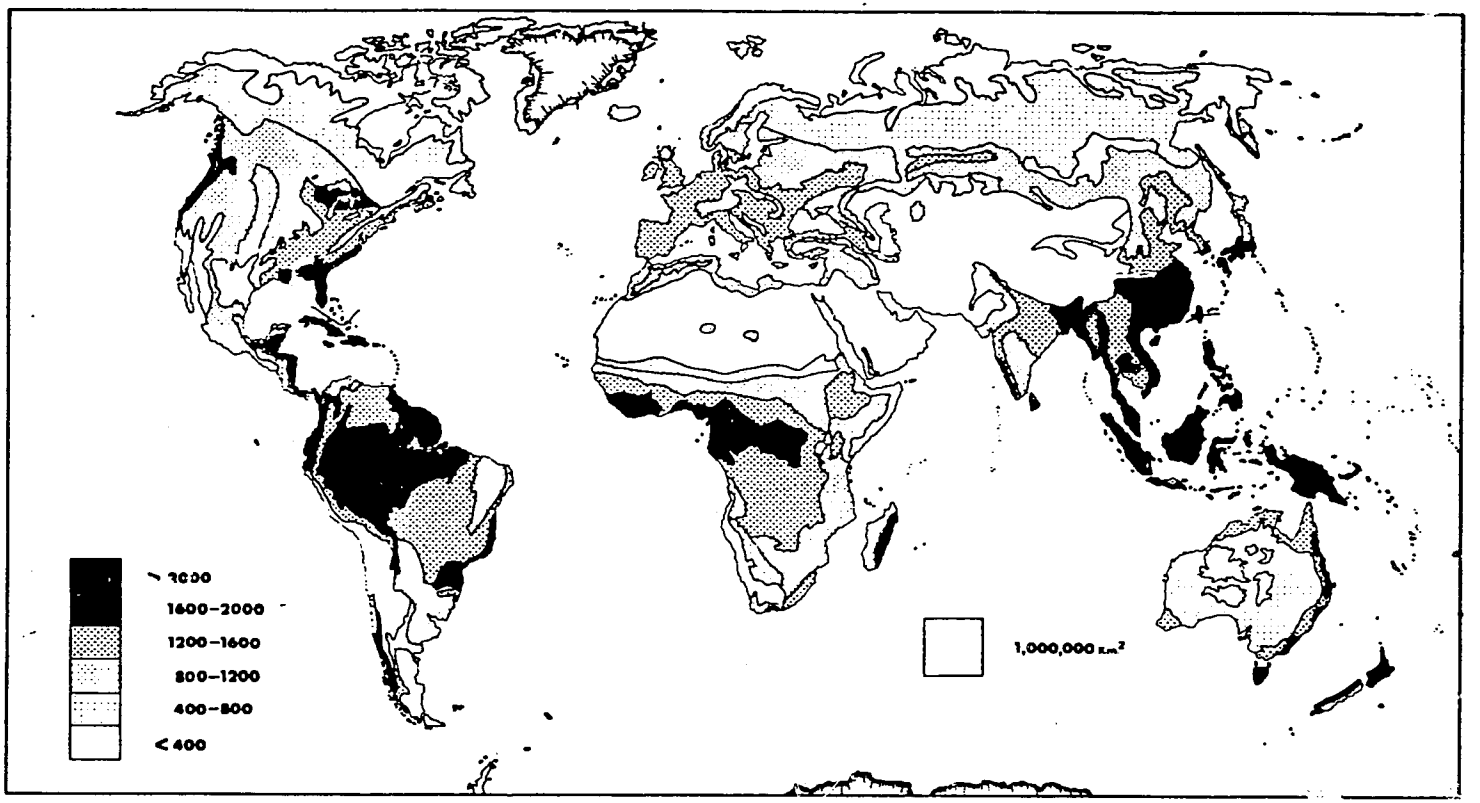
The total land area of the earth, excluding the ice caps, is 128.2 million square kilometers ($128.2 \times 10^6 km^2$). Of the 128.2 million km^2, 47 per cent can be classified as "forest" and 15 per cent as "treed grassland." In other words, 62 per cent of the earth's surface is capable of supporting tree cover. Yet this Net Primary Production estimate, mapped in Figure 10, can be challenged for:

(A) Even if land areas are capable of producing such levels of dry organic matter, there is no guarantee that it will be available for human exploitation. In a study of total NPP, from a forest site, it was concluded that 65 per cent of the above-ground production was unavailable to, or rejected by, most commercial lumbering organizations (Duvigneand, 1970). Although estimates would probably be lower for underdeveloped countries, it is readily apparent that NPP estimates do not equate feasible available energy sources from organic matter. Moreover, the areas of

low average potential NPP frequently coincide with the zones of oil dependency, especially Sudano-Sahelian Africa and the subcontinent of Asia (Figure 7). Potential NPP boundaries transcend those of nation states but energy budgets are drawn up within nation states.

(B) Natural vegetation cover is so modified by human occupance of the earth's surface that it is more realistic to cultivate landscapes than natural vegetation cover. Certain types of economic activity, such as pastoralism, require forest removal. Such forest removal frequently reduces the mineral content of the soil, lowering potential levels of forest production and, consequently lowering the estimates of potential Net Primary Production. Yet it is not realistic to suggest the curtailment of pastoralist activity so that vegetation may return to a pristine condition when the very purpose of considering organic productivity is to provide energy for groups in underdeveloped countries such as pastoralists.

Figure 10



4·2 The average potential NPP of terrestrial areas (in mt/km²)

Source: Eyne, 1978.

Potential organic material that could bridge energy gaps is not available. Estimates that exist suggest a continuing depletion in the potential productivity in cropland and pasture (Figure 11), a process that exacerbates critical energy shortfalls in underdeveloped countries (Eyre, 1978).

Figure 11

.4 The depletion of productivity in cropland and pasture (data from FAO, 1970)

	Cropland		Pasture and Meadow		
Region*	Area ($10^6 km^2$)	Depletion (10^9mt)†	Area ($10^6 km^2$)	Depletion (10^9mt)†	Total depletion (10^9mt)
Europe (without USSR)	1·5	0·75	1·9	1·52	2·27
USSR	2·3	1·15	3·7	2·96	4·11
Canada and USA	2·2	1·10	2·8	2·24	3·34
China and Japan	1·2	0·60	1·8	1·44	2·04
	7·2	3·60	10·2	8·16	11·76
Tropical and sub-tropical Asia	3·4	3·82	2·7	3·24	7·06
Latin America	1·2	1·35	5·0	6·00	7·35
Africa	2·0	2·25	8·4	10·08	12·33
	6·6	7·42	16·1	19·32	26·74
World total	13·8	11·02	26·3	27·48	38·50*

* Because of difficulty in assessing the Australian entry for "pasture", Oceania has been omitted. The world total is therefore a conservative one: it would probably be shown to be some two or three billion mt higher if Oceania could have been assessed on the same basis and included.

† The following assumptions have been made in this attempt to quantify depletion:

(a) that the mean NPP of all the original wild vegetation was 1,000 mt/km²/ year in middle latitudes, and 1,500 in tropical regions;

(b) that the productivity of all pasture land has been depleted to one fifth its original NPP;

(c) that the productivity of all mid-latitude cropland has been depleted to a half, and all tropical cropland to a quarter its original NPP.

1.16 It is beneficial at this juncture to summarize the argument to date. Although there is a clear relationship between economic development and energy consumption, typed as energy-use stages, this relationship is complex rather than linear. At the present time, global energy resources are disproportionately consumed -- the developed countries have access to, and will continue to use, a disproportionate share of energy resources. This scenario is necessarily bleak for the underdeveloped countries as their population, particularly urban population, continues to expand. The conditions of poverty, especially in the underdeveloped rural areas, require that a large proportion of personal disposable income will be spent on energy requirements. At a national scale, heavy reliance will continue to be placed upon oil imports, especially as industrial and transport networks expand, and, although exploration for fossil fuel resources will increase as oil prices rise, energy shortfall will exist. On current evidence, the bulk of the remaining recoverable fossil fuel resources do not seem to be located in the underdeveloped countries.

It is not surprising, therefore, that organic material (wood, farm residues, and charcoal) will continue to play an important role in meeting the energy

needs of the rural poor. Non-commercial energy use will increase in the future. Available evidence suggests that 50 per cent of current wood production is for energy and expansion of this production will probably be at the expense of alternative productive strategies for a given land area. Furthermore, there is evidence that suggests a continuing depletion of the potential organic productivity of the earth's surface.

1.17 In considering the present and projected energy shortfalls, it is necessary to raise the question of technical innovation. Given the existing technology, is it possible to bridge this energy gap? Such a question can be considered in both a qualitative and quantitative manner. The qualitative appraisal would point to the history of failure that marks attempts to transfer technology from developed to underdeveloped countries. Existing nuclear, hydro-electric, geothermal, and even appropriate technologies are transferred with difficulty. But, the complex arguments about qualitative change need not even be considered at the moment -- the quantitative problem is immense. Lovins (1975) demonstrates the magnitude of the problem, showing massive world dependence on fossil fuels. He calculates, with our present production rate and estimates of energy production rate increase, that even with

the building of:

> one huge (1 GW = 1,000 MW (e) = 10^9 w(e)) nuclear power station per day for the rest of this century, then when we had finished, more than half our primary energy would still come from fossil fuels which would be consumed about twice as fast as now.

1.18 The implications of such a situation are clear. Faced with energy shortfalls, low fossil fuel reserves, and an inability to find a technological fix to bridge such shortfalls, underdeveloped countries will increasingly rely on expanded production and consumption of organic materials to meet their energy shortfall, especially in rural areas -- Section Two examines the specific energy problems of several African states as they relate to this global background.

SECTION TWO: THE EASTERN AFRICAN REALITY

2.1 This section considers available energy resources within Africa, especially eastern Africa. Particular attention will be paid to the energy budgets of Sudan, Ethiopia, Kenya, Tanzania and Zambia. Figure 12 contains a breakdown of energy consumption and gross domestic production per capita for these states. The correlation between energy consumption and economic development is, again, apparent. Figure 13 indicates the total commercial energy consumption in coal equivalent kilograms per capita. The energy consumption disparities between the developed and underdeveloped world are apparent. Of the eastern African states, only Zambia has recorded commercial energy consumption that exceeds the average consumption of the underdeveloped countries.

FIGURE 12

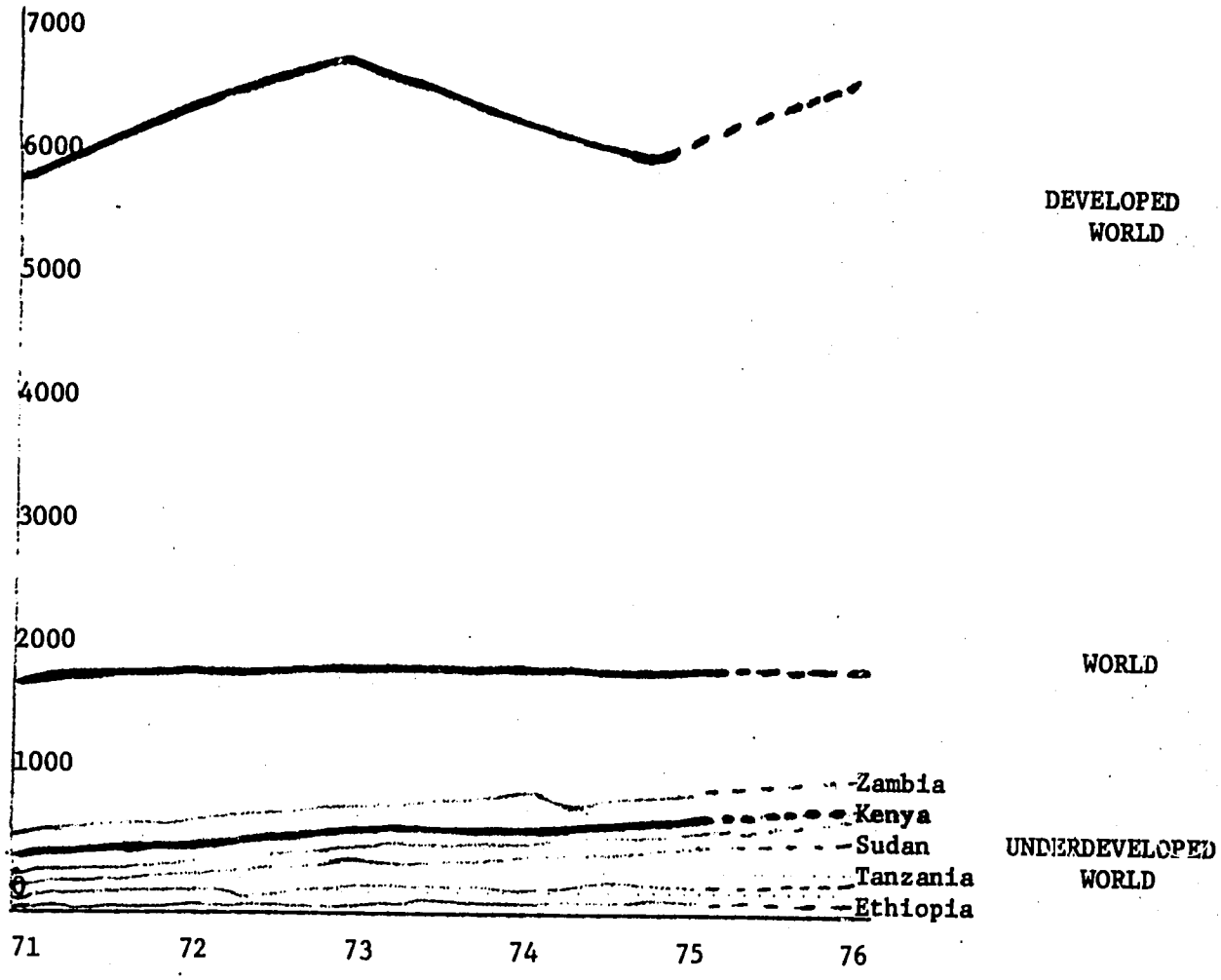
ENERGY CONSUMPTION AND GROSS DOMESTIC PRODUCT IN AFRICA, 1970

Country	Per Capita Energy Consumption (kg. coal equivalent)	Per Capita Gross Domestic Production ($)
Zambia	540	417
Kenya	153	140
Sudan	115	112
Tanzania	71	97
Ethiopia	32	65

Source: UN Statistical Yearbook, 1971.

FIGURE 13

TOTAL COMMERCIAL ENERGY



Coal Equivalent: Kilograms Per Capita

Source: UN 1977

2.2 Eastern Africa's percentage share of known world commercial energy reserves is miniscule. The nations include 2.2 per cent of the world's population but contain little crude petroleum or natural gas, and only 1.3 per cent of the known coal reserves. There is no uranium oxide and only 0.4 per cent of the thorium oxides are found in the area. In contrast, 7.3 per cent of the world's hydro-electric potential exists in East Africa (Clarke, 1975).

2.3 Africa contains 14 per cent of world coal reserves, with 80 per cent of these reserves in South Africa. In eastern Africa, small coal fields exist in the Ruhuhu River, Kuira-Songwe and Ufipa areas of Tanzania as well as Ngadabwe, Zambia.
Zambia provides an interesting example of the complexities of energy resource utilization. Clarke (1975) gives the following account:

> With a well developed copper mining and processing industry, Zambia's per capita power consumption is second highest in all African states, and coal traditionally imported from the Wankie coalfield of Rhodesia was consumed in large quantities by African standards. An initial threat to Zambia's coal supplies came in 1963, with the breakup of the Central African Federation which had embraced Rhodesia, Zambia and Malawi, while the unilateral declaration of independence by Rhodesia in 1965, and the consequent royalty,

> albeit temporary, on coal to Zambia, placed Zambia in a vulnerable position. Alternative fuels could provide no immediate solution while any imported coal would have involved severe transport problems. Zambia had little alternative but to start exploiting her own coal reserves, low quality and inaccessible though they were.... While this coal mining could hardly be justified on strictly economic grounds, although it does save Zambia 2 million a year in foreign exchange, it gives the country a greater measure of independence from unreliable external sources, has meant the provision of new routes into hitherto inaccessible areas, and provides much needed employment.
>
> (pff. 400)

In 1973, Zambia produced 940,000 tons of coal and Tanzania 3,000 tons. With the independence of Mozambique, a country with estimated reserves of 100 million tons, more coal is likely to be available to the eastern African countries.

2.4 Coal production, however, has several environmental impacts. Deep mining often produces significant leaking of sulphuric acid from the exposure of coal beams to groundwater. Surface or strip mining, which is considerably safer for miners, may cause destruction of large areas of surface terrain. Coal consumption leads to major pollution problems and, although advanced combustion technology and recycling procedures control some elements, waste disposal and general health effects remain significant. There is

increasing concern, as well, about long-term climatic effects of global increases in carbon dioxide resulting from intensified fossil fuel combustion (Howe, 1977). Yet such environmental considerations are likely to be considered secondary when energy shortfall exists.

2.5 Figure 14 illustrates the level of importation of crude petroleum in the five African nations. The 1974 decrease in Tanzanian imports reflects the opening of the pipeline. Kenya, with the largest refinery capacity, has large imports but much of this is bunkered, i.e. not for use within Kenya. Annual per capita consumption is small - Ethiopia -- 6 gallons; Tanzania -- 12 gallons; and Sudan -- 14 gallons. With the development of commercial agriculture, especially in Sudan, these consumption rates will rapidly rise.

At the present time, refinery capacity exceeds consumption but only temporarily. This situation will soon reverse. The necessity of building domestic refining capacity to meet national requirements is difficult because most of the eastern African countries have a demand for oil products of less than 2 million tons per annum, and until recently this was considered

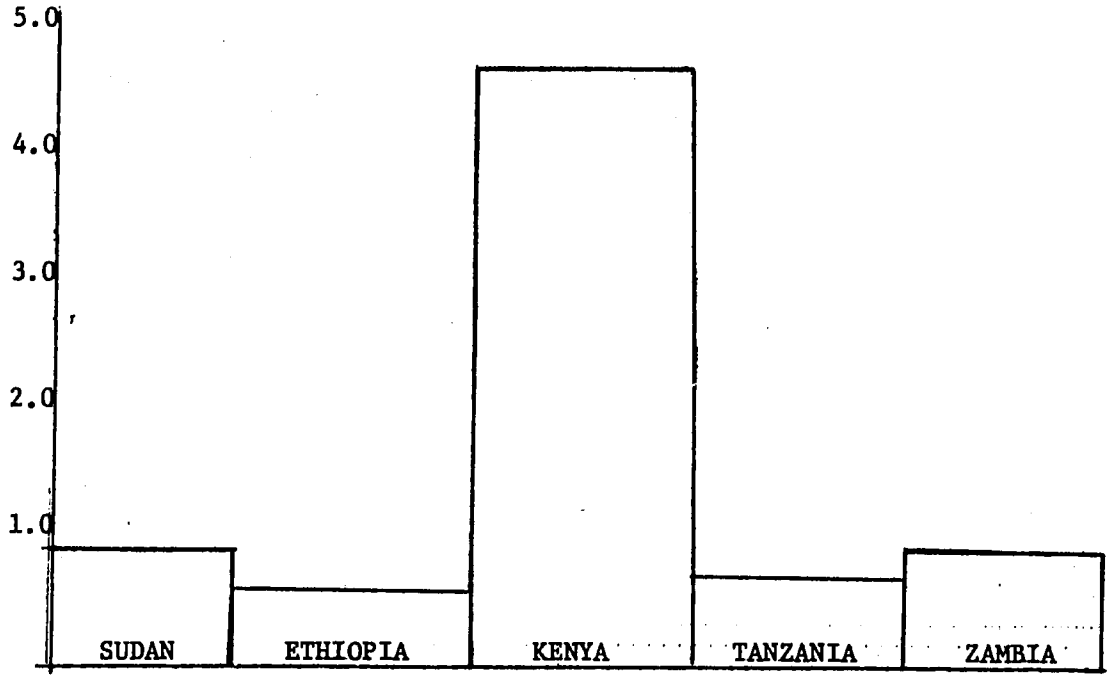
the smallest demand which would justify the construction of a refinery. The monopoly influence of the major oil companies, whose annual turnover exceeds the Gross National Product of these eastern African states, frequently means that individual states are in a poor bargaining position with the oil companies. Oil is organized internationally; it is easy, and generally safe, to handle and is relatively cheaply shipped around the world. But the pricing system ("posted price") again controlled by private corporations has been a source of conflict. For the corporations, it has remained more profitable to supply markets, such as East Africa, from the large export refineries of the Middle East and Western Europe rather than encourage indigenous refinery capacity (Odell, 1974).

2.6 Known natural gas oil resources in eastern Africa are small although the recent discovery of oil in Sudan will increase exploration in the sedimentary basins. Increasing oil imports, especially during periods of inflation, cause increasing rigidity of import structures and tendencies towards chronic balance of payment problems. Thus there is a countervailing tendency to search for indigenous resources.

FIGURE 14a

REFINERY CAPACITY

(Million Metric Tons)

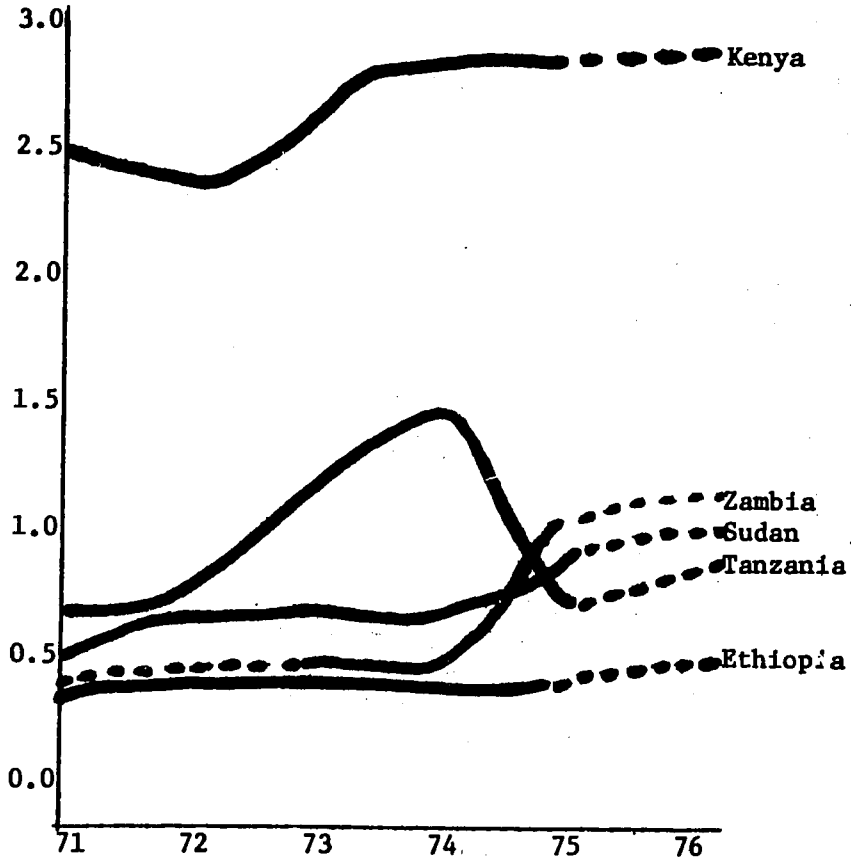


Source: UN 1977

FIGURE 14b

IMPORT OF CRUDE PETROLEUM

(Million Metric Tons)



Source: UN 1977

Control of exploration is, however, not solely in the hands of the national governments. Little bilateral aid is available for oil exploration even though oil and natural gas are elusive commodities requiring large initial capital outlays. The reasoning behind such decisions is that private funds are available so there is no capital bottleneck. Yet the history of oil and natural gas exploration and development indicates that private corporations agree to undertake such activity to limit competition or when a clear indication is given that indigenous resources will have priority over imports (Odell, 1974). Such a history bodes ill for the future of oil and natural gas exploration in eastern Africa.

2.7 The World Bank estimates that only 4 per cent of African rural population is served by electricity (IBRD, 1975). Since these estimates were made before the price escalation of fossil fuels which provide 45 per cent of the electricity, it is improbable that there will be rapid rural electrification. Discussion of electrification occurs despite the non-existence of data. Most development plans emphasize the expansion of national grids but talk of "sub-economic areas," that is, areas with sparse populations, so that the benefit-cost ratio of transmission is small. As a result, electrification development focuses on industrial-urban areas where there

is a guaranteed market. Figure 15 shows graphically the installed capacity of the industrial and public generating plants. The steep rate of increase in Zambia's installed capacity occured when the Kariba dam came on line.

Appendix B contains details of the electricity sectors of Ethiopia, Botswana, Zambia, Kenya and Tanzania. In summary, it is apparent that:

(A) The rate of increase in sales is rapid;

(B) The demand is met by either importing oil or coal or transmitting electricity, i.e. as country is energy self-reliant;

and, (C) The national grid systems do not serve the rural areas.

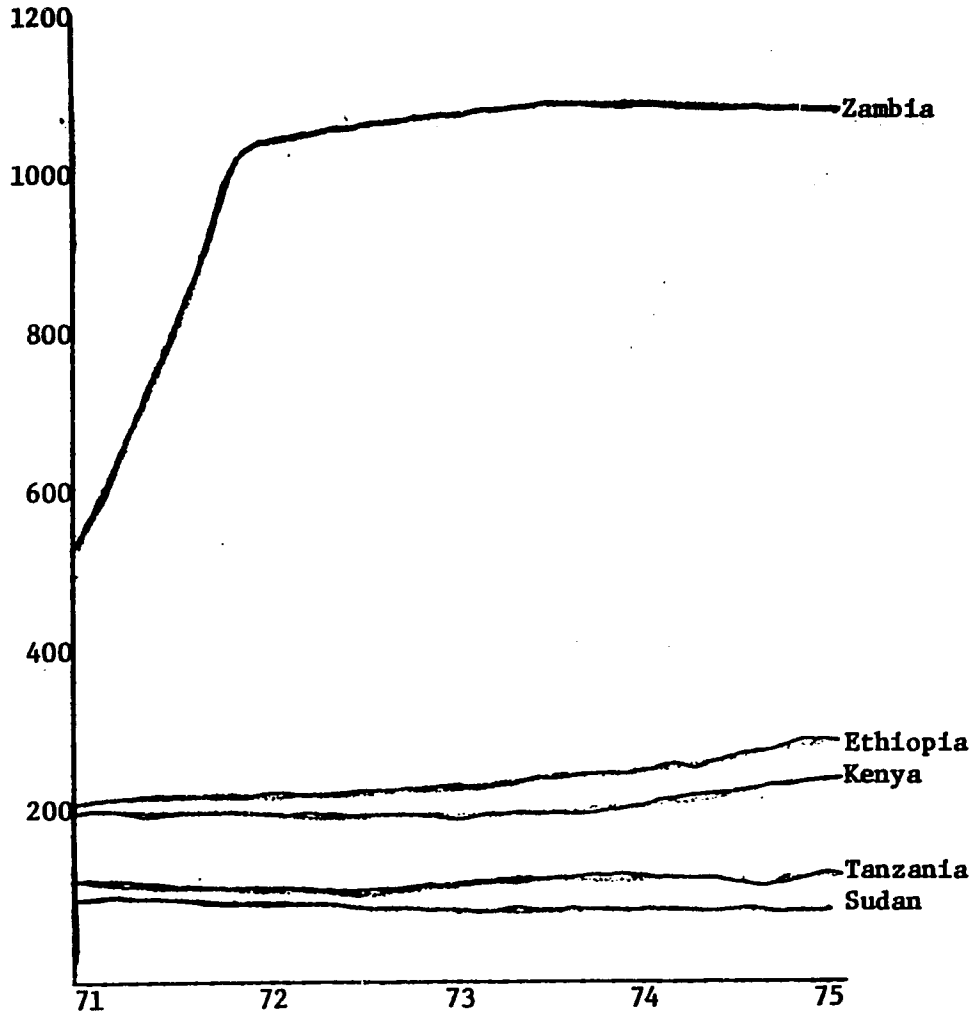
2.8 The plateau character of Africa gives the continent the greatest hydro-electric potential in the world. Yet, great as is this overall endowment, the distribution is uneven. Zaire alone has one-third of the African total and 11 per cent of the world total on one small stretch of the Congo! Elsewhere numerous small rivers such as the Tana (Kenya), Pangain (Tanzania) and Awash (Ethiopia) have great importance locally. The Zambezi-Kafue system will eventually provide 5 per cent of the African total electricity production.

FIGURE 15

INSTALLED CAPACITY

INDUSTRIAL AND PUBLIC GENERATING PLANTS

(Thousand Kilowatts)



Source: UN 1977

African demand for electric power is increasing at 10 per cent per annum (Clark, 1975), as a result of industrialization, rapid growth of urban areas, and rising per capita incomes. While such schemes as the Kainji (960 MW) attract great attention, much of the increased production is from a large number of smaller HEP stations such as Koka and Tisissat (Ethiopia, 45 and 11.5 MW respectively), Hale (Tanzania, 21 MW) and Sennar (Sudan, 15 MW).

For the smaller, dispersed markets in East Africa, the HEP plant does not provide the cheapest electricity, especially if other fuel exists. As a rough rule, for every dollar invested in the hydro-electric station, an additional $150 must be invested in transmission network and $5 in machinery that will use the electricity. Installation costs of HEP stations are two or three times the cost of conventional thermal units although running costs are lower (Howe, 1977).

2.9 Geothermal energy is a potential resource in East Africa, especially along the Rift Valley. Geothermal exploration has taken place in Tanzania, Kenya and Ethiopia but no decisions have been made to begin commercial exploitation.

Such exploitation requires the disposal of

large quantities of hot water containing pollutants including hydrogen sulphide, amonia, hydrofluoric acid, and compounds of mercury, selerium and arsenic. In the physical environment of eastern Africa, such disposal would be difficult (i.e. along the Rift Valley). Moreover, the costs associated with bringing such a resource on line are similar to those associated with hydro-electric power (see Section 2.8) (Howe, 1977).

2.10 Africa possesses nearly 14 per cent of the world's reserve of uranium oxide. Yet the prospects for nuclear power in East Africa are negligible. First, there is much debate within nuclear exporting countries about the benefits of nuclear power. Second, nuclear installation and production requires complex technology. Third, and most important, nuclear reactors are the most expensive conventional power sources and are most unlikely to be a major source of energy in the foreseeable future.

2.11 The summary of existing commercial sources of energy in East Africa enables one to draw the following conclusions:

(A) In comparative terms, the fossil fuel resources of eastern Africa are comparatively poor;

(B) In comparative terms, the non-fossil fuel resources of eastern Africa are comparatively poor;

(C) It is comparatively expensive to bring on line, non-fossil fuel production and, therefore, fossil fuel technologies are preferred. Consequently, there is a serious dependency relationship, reflected in negative balance of payments, in most economies since fossil fuel is imported.

(D) The poverty of energy resource base means that other material, chiefly organic material, becomes the major energy source available to the majority of the population.

2.12 Figure 16 provides estimates of fuelwood production in eastern Africa. There is inverse condition between level of economic development and level of fuelwood production, i.e. the poorest countries use the most wood. In fact, Kenya has a small exporting trade chiefly for charcoal to the Middle East.

It is not surprising that wood is the most frequent energy source in rural areas. Traditionally it was a free good, i.e. access was by customary right, and is a technology well known to the population. Moreover, as the economies of East Africa have become

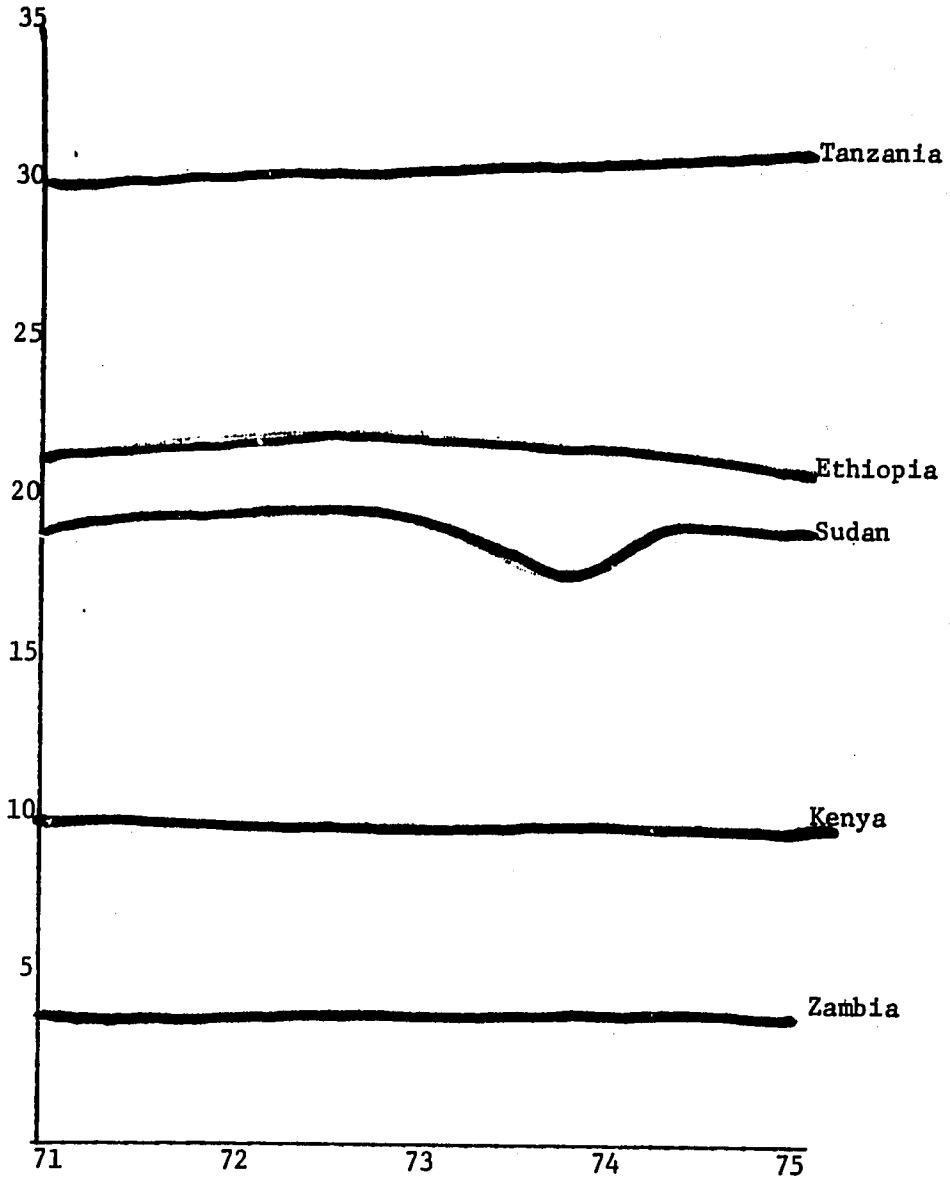
increasingly monetarized, there is evidence that, even in remote rural areas, over 50 per cent of the population buy their supplies (Digernes, 1977). To discuss organic fuel as "non-commercial" is misleading. For example, over 6,000 families are involved in supplying organic fuel, chiefly wood and charcoal, to Maputo, Mozambique. Few conventional energy providing activities would have such high levels of employment -- a factor important when considering the economic impact of energy type.

Figure 17 gives the average market price for fuel and power in East Africa in 1970. The comparative cheapness of wood indicates that this will continue to be the most accessible form of energy for the population. Even when wood resources per se are declining, current price differentials would suggest that charcoal will be preferred to fuel oil. Electricity per unit is 977 per cent more expensive than wood. Furthermore, expensive complex machinery is required to utilize electricity compared with the cheaper, simpler devices for wood -- contrast an electric stove and an open fire. Poverty means that, because of the comparative cost advantage in both energy type and energy converter, wood will be increasingly used in an absolute sense.

FIGURE 16

FUEL WOOD PRODUCTION

(Million Cubic Meters)



Source: UN 1977

FIGURE 17

Average market price of fuel and power (U.S. $) *in East Africa in* 1970

Fuel	Retail price	Cost per tonne CE
Wood	7/tonne air dry 20% m.c.	13·80
Charcoal	23/tonne	22·35
Fuel oil	0·21/gallon (43/tonne)	30·28
Paraffin	0·43/gallon (86/tonne)	57·06
Electricity	0·02/unit	134·86
Butane	7/15 kg cylinder	300·00

Source: Earl, 1975

2.13 The economics of the situation suggest that closer attention be paid to the potential productivity of natural vegetation (see section 1.15). Figure 18 lists mean net potential production for major vegetation types in eastern Africa. Savanna vegetation which covers much of eastern Africa is comparatively low on potential productivity. Consequently, the natural regenerative productivity is low. Appendix C(i) contains estimates of forest cover for the eastern African countries.

2.14 Again, however, consideration of natural vegetation as a regenerative resource is unrealistic. Reafforestation introduces secondary vegetation which has a lower biomass per unit area. It is therefore impossible to predict, with the current state of knowledge about vegetation succession, the productivity of a given area in a linear fashion. Appendix C(ii) contains examples of forest succession.

2.15 An alternative approach to assessing energy requirements would be to base the calculation on the factors influencing the energy budget of a particular region. Thus the calculation can be based on growth rates (Figure 19). The five critical growth rates are:

(A) Natural Increase of population (see section 1.5)

(B) Rate of Growth of Personal Income

FIGURE 18

NET POTENTIAL PRODUCTIVITY OF NATURAL VEGETATION*

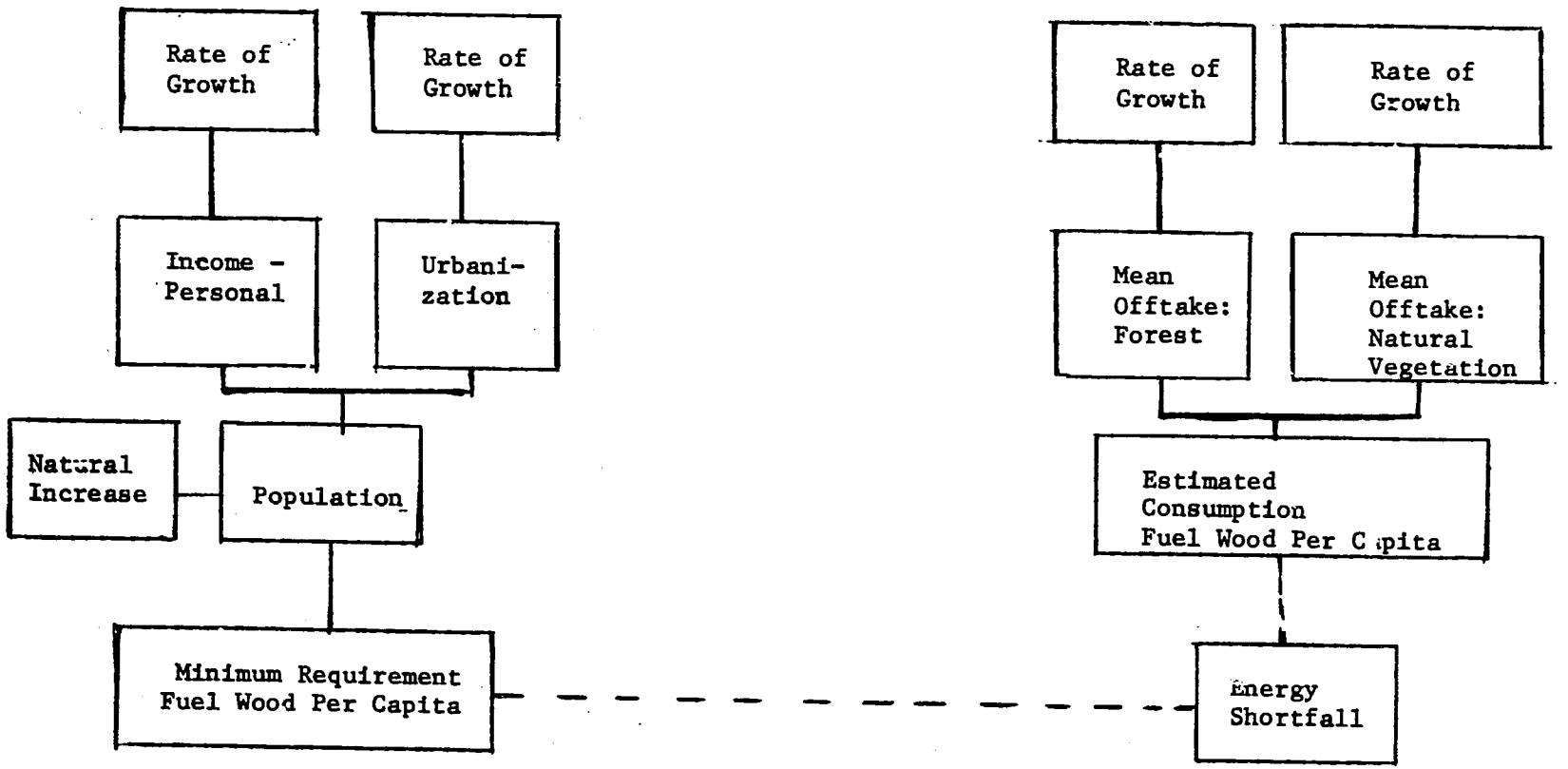
Vegetation Type	MGAN NPP (m.t./km^2/yr.)
Tropical Rain Green Forest	1500
Tropical Microphyllous Forest	1000
Tropical Savanna	750

Source: After Olson (1970) and Eyre (1978)

*Mountain complexes are excluded from this tabulation, e.g. Mount Kenya, because of the rapid variation in vegetation type with altitude.

FIGURE 19

MAJOR FACTORS IN CALCULATING FUEL WOOD ENERGY REQUIREMENTS - YEARLY BUDGET



(see section 1.7)

(C) Rate of Growth in Urbanization (see section 1.6)

(D) Rate of Growth in Forest Areas (see section 1.14)

and (E) Rate of Growth of Natural Vegetation (see section 1.15)

A, B, and C determine minimum requirements; D and E allow the calculation of annual consumption. It therefore becomes possible to estimate energy shortfall and, within certain limits, to project future requirements.

2.16 Openshaw (1971) projected the requirements of Tanzania to 2,000 using such a dynamic model. The projections were based on 1970 data, but, as some 96 per cent of the forest production was for firewood, much emphasis was placed on fuel consumption. In analyzing Openshaw's projection, Earl (1975) comments,

> Growth of GNP in real terms in Tanzania has been between 5 and 5.25 per cent but per capita GNP increase has only been about 2.5 per cent per annum as a result of population increase of 2.7 per cent. The government aims in its FYP to increase GNP by 6.7 per cent (a per capita increase of 4.0 per cent) by investment in basic industry.

In Figure 20, the high figure refers to these aimed increases; the low figure refers to the actual past

FIGURE 20

TANZANIA 2000: FUEL WOOD DEMAND AND CONSUMPTION

Factors Influencing Demand	1970	2000
A) Population*1 (Millions)	13.30	29.50
B) Urban Population*2 (Millions)	0.94	7.05
C) Gross National Product (U.S.$)		
GNP $ X 10^6	1134.00	8170.00 - high
		5345.00 - low
GNP per capita	85.00	275.00 - high
		180.00 - low
Consumption Forecast		
A) Fuelwood		
Rural	26-7	35-8 - high
		29-7 - low
Urban	1-0-8	1-4 - high
		1-2 - low
Industrial	2-1	10-7 - high
		8-5 - low
Total	29-6	47-9 - high
		39-4 - low
B) Charcoal		
Rural	0-3	9-9 - high
		6-3 - low
Urban	0-5	4-7 - high
		5-6 - low
Industrial	n/a	n/a
Total	0-8	14-6 - high
		11-9 - low

Source: Openshaw 1971

*1 estimated increase 3.1% until 1980, thereafter 2.5%

*2 estimated increase 9.5% until 1974, thereafter 7%

growth rate projected into the future. Mean income elasticity of demand for fuelwood was about 0.1. Three sectors were recognized, namely:

(i) Rural household,

(ii) Urban household,

and (iii) Non-household/Industrial.

Using such a model, Openshaw estimated that Tanzania's fuelwood consumption would be double by the year 2000 with charcoal's share of the market increasing from 3 to 25 per cent of the market.

2.17 The transition from wood to charcoal is the most important process of energy substitution for the majority of the population in underdeveloped countries. Charcoal has increasingly comparative price advantage over fuelwood as access to forests becomes more limited and the source of production becomes further removed from consumption centers. It is economically feasible to burn wood only where transport costs are negligible. Current estimates suggest that in eastern Africa the comparative advantage of charcoal is apparent if the distance between production and consumption source is over 80 kilometers (Earl, 1975; Digernes, 1977). As deforestation continues around urban centers, the transition to charcoal will accelerate. Figure 21 indicates the increase in charcoal consumption trends in Uganda between 1962 and 1972. While imports have decreased, home produced charcoal has jumped from 200 tons (1962-1962) to 63,656 tons (1971-1972).

FIGURE 21

Charcoal consumption [redacted]–Uganda

Year	Home produced tonnes	Number of men on production†	Imported tonnes
1962–3	200	15	22 000
1963–4	700	49	25 000
1964–5	1200	84	27 000
1965–6	3024	140	29 000
1966–7	6000	270	29 500
1967–8	10 000	550	30 000
1968–9	21 500	1400	30 000
1969–70	48 820	3200	21 000
1970–1	58 535	3660	17 000
1971–2	63 656	3890	17 000

Source: Annual report of the Uganda Forest Department † Estimated.

Quoted in Earl (1975)

2.18 As planners begin to realize that fuelwood and charcoal will be increasingly important to the eastern African economies, attention is increasingly focused on renewable resources and alternative technologies. Much has been written recently about the feasibility of such technologies. Available information is summarized in Appendix D. The four major types of alternative technologies for renewable resources are:

(A) Solar Energy,

(B) Bioconversion,

(C) Water Energy,

and (D) Wind Energy.

The National Academy of Sciences (1976), having considered these technologies, offered the following "fundamental and inescapable conclusions" (p. 11):

1. A variety of energy sources and technologies is indeed available as alternatives to conventional power systems;

2. With the exception of a few devices (e.g. homemade windmills, solar dryers) there are no cheap alternative technologies of significance for either industrialized or developing nations, and there will not be any in the near future;

3. It is not enough that an energy source be available; the technology to put it to use must also be available. The benefits of any one of the suggested alternatives for producing energy could be multiplied many times if even a small amount of capital were invested (a) in developing a technology needed to use the energy and (b) in ensuring that technology is properly integrated into the economy and culture.

and again, (p.4):

> In short, the devloping countries, like the rest of the world, seem condemned to a continuing struggle with increasingly high relative prices for energy from conventional sources. The "energy crisis" will continue to be, in essence, a fossil fuel crisis (specifically, an oil crisis).

2.19 More recently, attention has been focused on an appropriate rather than alternative technologies, i.e; appropriate to the political economy of the rural poor in eastern Africa. Discussion has centered upon more efficient woodfuel use, through the redesigning of stone technology and added insulation, but, more importantly, given the transition from firewood to charcoal, on charcoal converters (Appendix E). Although such activity is worthy of support, it must be emphasized that this is a technology committed to use woodfuel, albeit less wastefully, in an area where forest resources are dwindling.

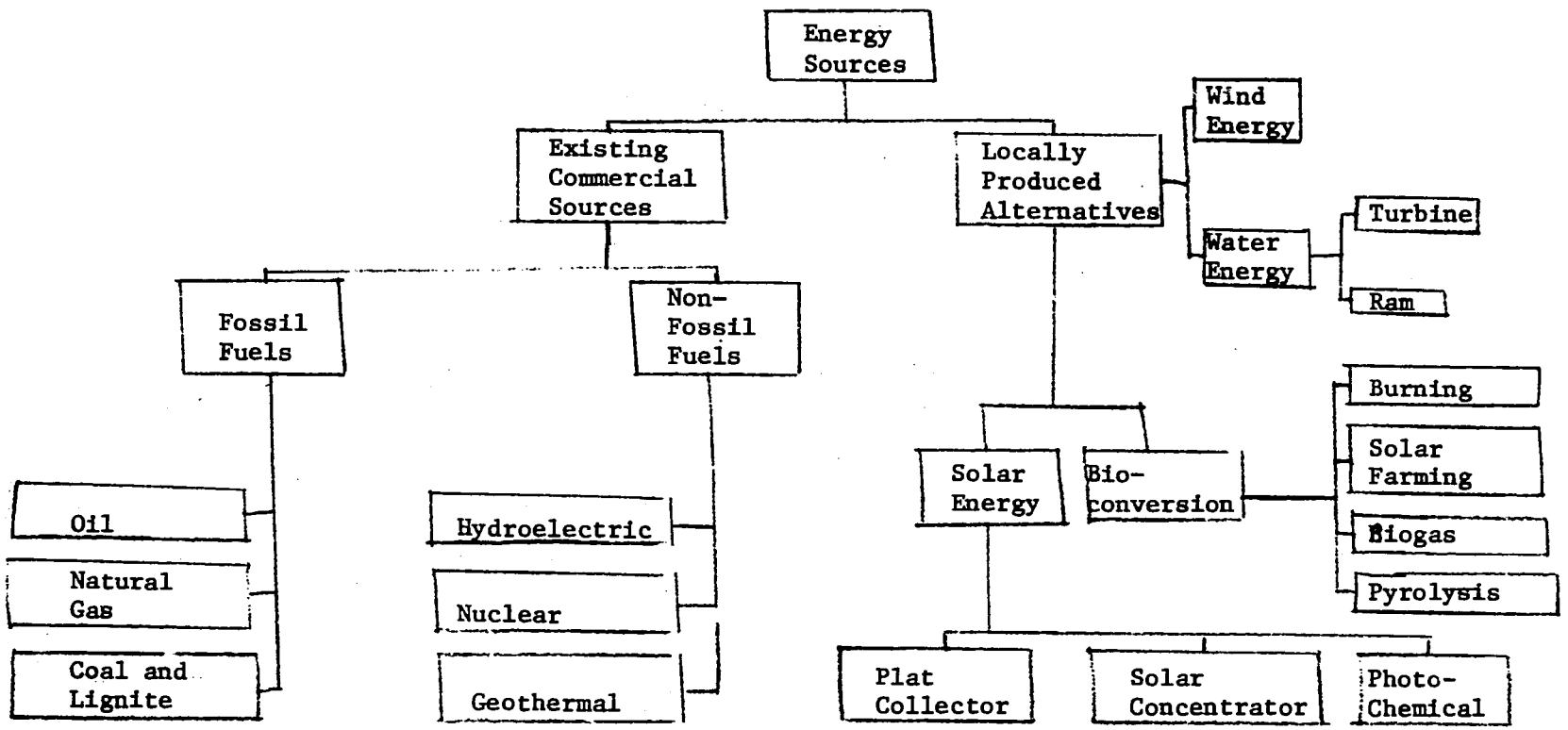
2.20 Discussing energy supply and demand is abstract and meaningless. Undoubtedly energy supplies exist, and are frequently used profligately in areas outside eastern Africa. Commercial resources, however, within eastern Africa are limited. Undoubtedly, too, demand exists for energy within eastern Africa. But this supply and demand, a traffic in commodities, is hindered by the poverty of the population. The energy crisis,

like the food crisis, is rooted in the causes of poverty. It is not surprising, therefore, that the present and future solutions to the eastern African energy crisis will be rooted in subsistence solutions, especially fuelwood.

Figure 22 outlines energy sources other than forest products. Existing commercial sources either have to be largely imported (fossil fuels) or are largely potential sources (non-fossil fuels). Technology for locally produced alternatives is not easily and cheaply available. Furthermore, all of the energy sources require specialized technology for individual family consumption, and added price beyond the cost of energy. One authority (Earl, 1975) would go as far as to suggest that the transition from wood to other fuels, especially fossil fuel, has, because of under-development, completely levelled off.

The energy scenario for eastern Africa is summarized in Figure 23(a). The current increase in woodfuel use will diminish resources. A temporary phase of increased dung and crop residue utilization will likely occur, because the labor required in making such briquettes is less than that required for charcoal. Such energy practice is, however, more common to Asia than eastern Africa. Dung and crop residue are also

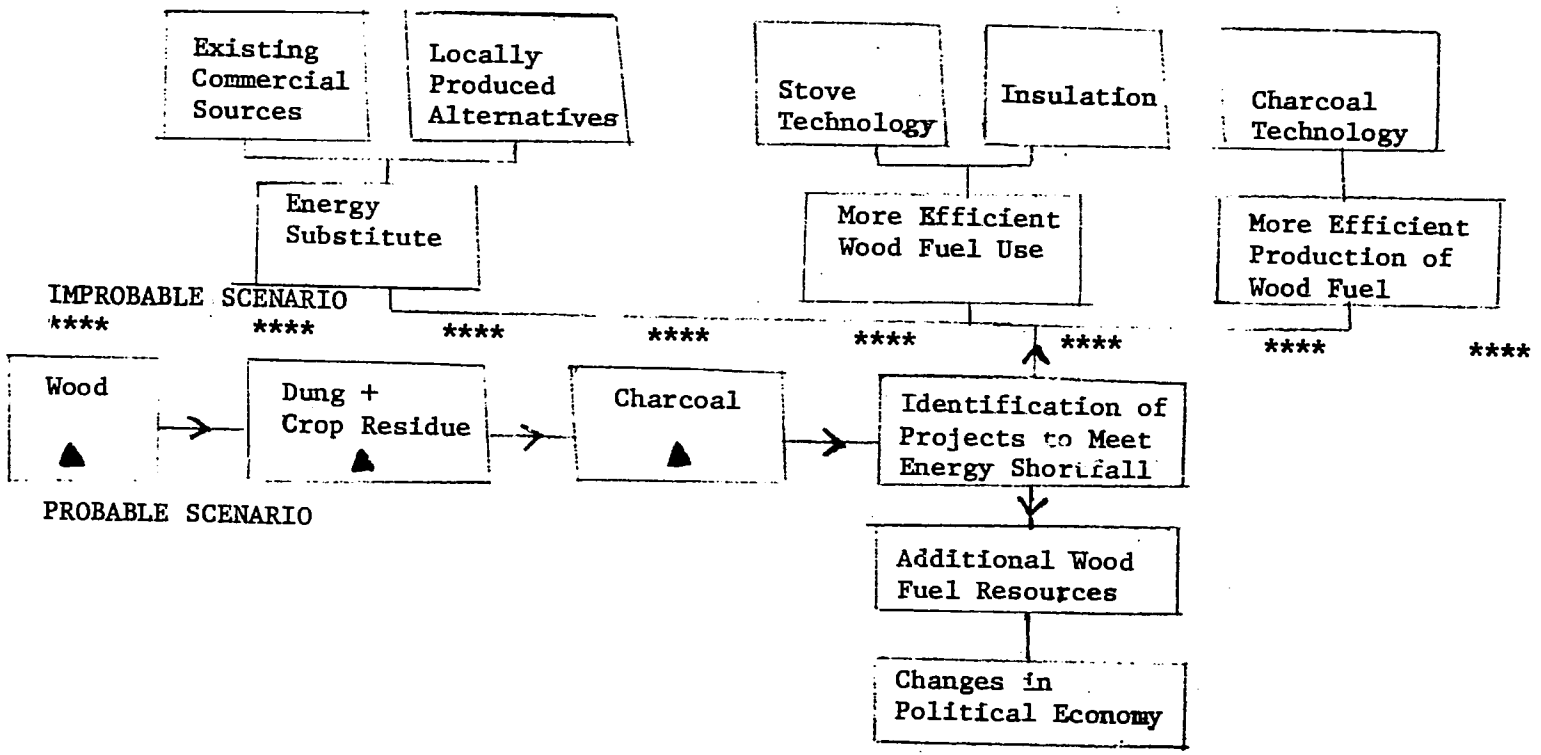
FIGURE 22



ENERGY SOURCES OTHER THAN FOREST

FIGURE 23a

EAST AFRICAN ENERGY SCENARIO



needed to complete the nitrogen cycle, a necessity for agricultural production, so that their use as a fuel has a high opportunity cost. Charcoal will rapidly rise to the fore, but, by that time, the extent of deforestation will be apparent. Demands for projects to meet the energy shortfall will increase. Yet energy substitution is not feasible in a situation of poverty. Thus the poverty of rural farmers will impede more efficient use of woodfuel and the more efficient production of woodfuel. Instead there will be a drive to establish additional woodfuel resources, a drive that can only be successful if there are changes in the region's basic organizational and structural modes of production.

And to understand the nature of those changes, it is necessary to analyze in depth the current woodfuel practice in eastern Africa and to draw the theoretical threads closer.

SECTION THREE:
EMPIRICAL EVIDENCE AND THEORETICAL CONSIDERATIONS UPON THE FOREST AS A RESOURCE

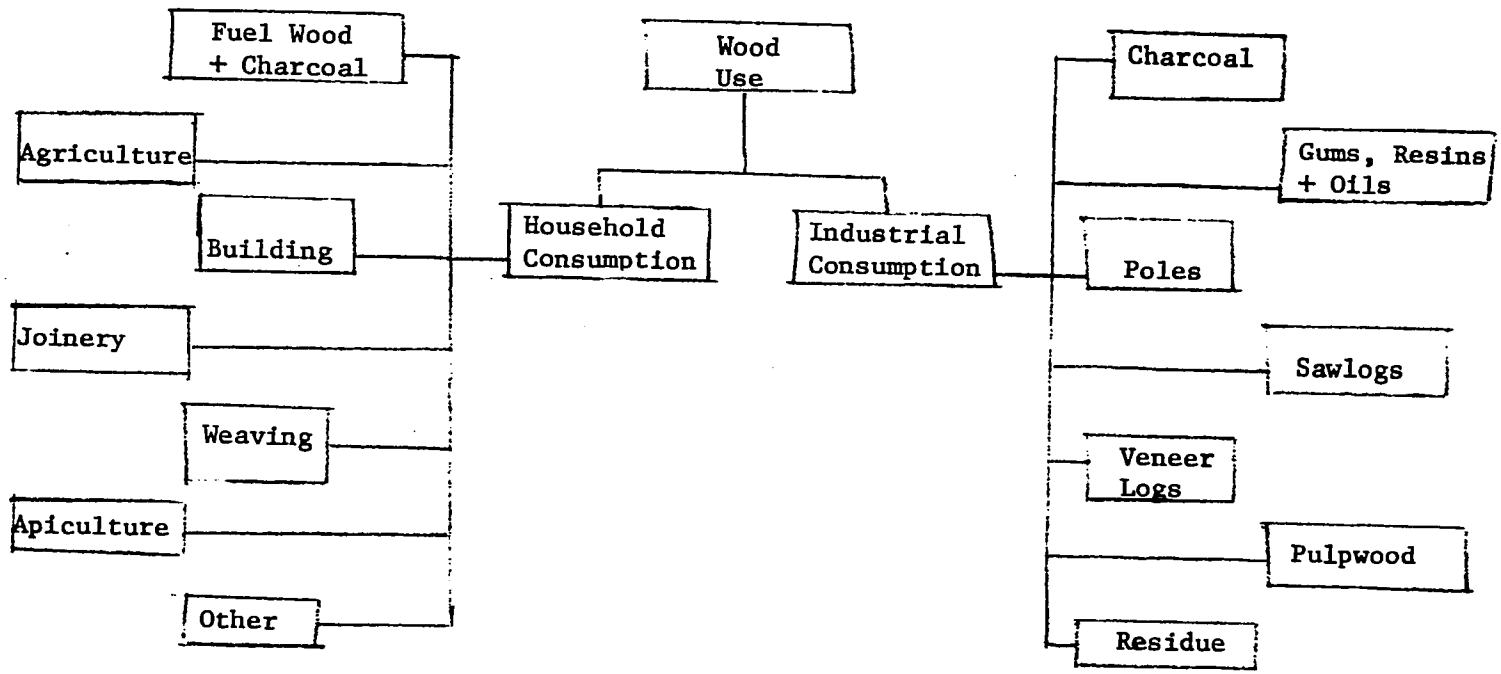
3.1 Fuel, in the form of firewood or charcoal, is the forest product in the greatest demand in the savanna, the broad vegetation zone covering much of eastern Africa. In many parts of these regions, it is not only the cheapest fuel per ton available but also the cheapest per unit of heat. Regular supplies, however, are uneven in quality, and, without properly organized management, forests rapidly become depleted. The consumption of forest products is not merely limited to household fuel. Figure 23(b) outlines the broad divisions of the consumption of wood products. Although some industrial uses of charcoal are declining with parallel decline in the traditional quilting and pottery trades, other industrial uses are increasing. The expanded use of man-made fibers (e.g. rayon) produced from forest products is likely to have a continually increasing impact on forest resources. Some authorities also suggest that the move from woodfuel to other fossil fuels is much more rapid in the industrial sector than in household consumption (Earl, 1975).

For both urban and rural households, forest products are a fuel source. More importantly, for rural dwellers, the forest provides a range of economic opportunity.

3.2 The income on peasant modes of production emphasizes that off-farm income is as important as on-farm income for the survival of the economy. Savanna forests supply fodder for cattle, nuts and seeds, edible products, including palm oil and fruit, gum arabic, resin and turpentine, gum, tannin, honey, edible fungi, medicinal plants, tasar silk, and animal protein, amongst other things. Traditionally, peasant production integrated access to these forest resources as well as access to energy products from the forest, allowing the availability and regeneration of the forest resources to continue. Before the colonization of eastern Africa, peasant modes of production, in many senses, closed systems. The imperial impact which precipitated the move to a monetary economy, the abandonment of extended ethnic groups as the principal legislators, the move from customary to statutory legislative framework, and the increasing emphasis on individual property rights are the critical transitions that illuminate the current woodfuel crisis.

FIGURE 23b

CONSUMPTION OF WOOD PRODUCTS



3.3 Traditionally, firewood was regarded as a "free good." In areas such as eastern Africa, where it was plentiful and accessible, the notion of firewood scarcity was inapplicable (Brokensha, D., and Riley, B., 1978). Similarly, land, although not scarce but rationed, was treated as a "free good." Access to fuelwood, or forests generally, depended upon customary rights to the land.

No one could sell land rights allocated to them. Lands which were not used by an individual reverted to common ownership to be reallocated by the group leadership. Under such a system, the right to land, and the mutual obligations and reciprocal managements surrounding it, not only formed the basis for an individual's economic and social security but the very basis of rural production. The result of this fuid access to land afforded by customary tenure is that income distribution and class differentiation was less marked.

The impact of modernization, especially the move to statutory, private land holding patterns, destroyed this system of tenure, including access to forest resources. Whether forest areas are owned by private individuals or are state controlled, so long as peasant producers do not have usufruct rights to forest produce, their economic livlihood is at risk. The

virtual non-existence of financial and credit institutions which could facilitate land purchases by peasants, the lack of alternative employment opportunities that would reduce pressure on the on-farm income, and the certainty of the agricultural output combine to produce a negative effect upon rural livlihood patterns.

3.4 Wisner (1977) indicated that access to forests was an adaptive strategy for coping with drought in eastern Kenya. However, the growth of private, commercial tea holdings and the expansion of game parks restricted the access of peasant producers to their traditional non-farm sources of income, the forest resources. Yet, as Hunt (1977) indicates, for areas with such degrees of poverty, it is important that all possibilities for increasing income from non-farm sources be increased.

Brokensha and Riley (1978) offer similar evidence for Kenya, arguing that land adjudication, introduced into Mbere in 1970, gave individual title to land and consequently restricted access to forest products. By September, 1977:

> land adjudication had resulted already in so much litigation and so many bitter quarrels that practically all rights of others over land had been stopped; it became common to see fences and MBWA KALI (fierce dog) signs.*

* See : Wisner (1977), op. cit. p.239.

> In other areas, people said that if they asked permission to gather (not actually cut) suitable firewood, and if they were on good terms with the owner, they would still be allowed to collect. But everyone predicted an increased rate of change, as more owners insisted on exclusive rights over their land. **

3.5 Such restrictions limit the opportunities of peasant families. Brokensha and Riley (1978) suggest that as people obtain individual land title, they restrict access to other's rights. The authors present a list of rights in decreasing order of their importance:

(i) Building a house
(ii) Planting trees
(iii) Planting annual crops
(iv) Grazing livestock
(v) Cutting firewood for sale
(vi) Cutting firewood for domestic use
(vii) Picking up fallen branches for domestic use
(viii) Placing bee hives
(ix) Crossing land

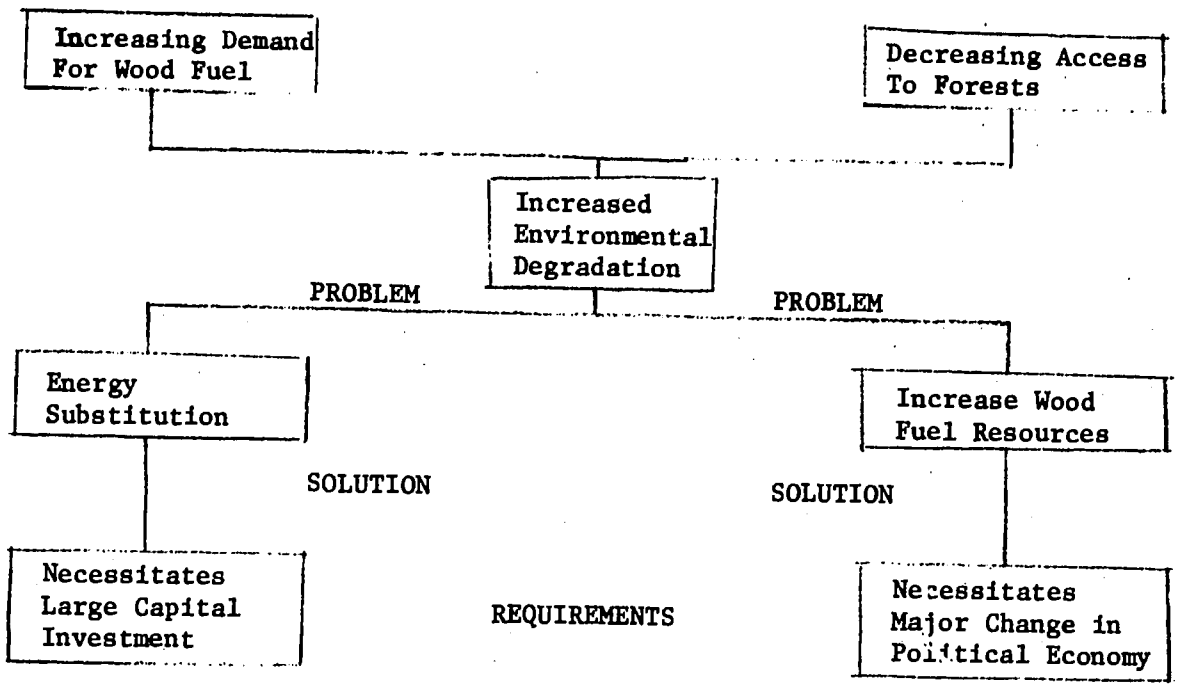
If cutting firewood for domestic use is ranked in sixth position, then the importance of the other proscribed activities can be appreciated.

3.6 Reduced access to forest resources combined with the increasing woodfuel demand (due to population growth and existing price differentials) rapidly leads to problems of environmental degradation (Figure 24). In broad outline, two solutions may be envisaged,

** (Brokensha and Riley, 1978. pp. 9-10.)

FIGURE 24

CONTRADICTIONS IN THE AFRICAN FUEL CRISIS



namely, energy substitution, or an increase in woodfuel resources. The former necessitates large capital investment (see section 2.20), while the latter requires structural changes in the organization of production, especially changes in legislation. Yet the latter scenario is a more probable strategy, given the large level of investment which energy substitution would require, and, assuming even with other forms of energy substitution, total consumption of firewood will increase by twenty per cent between 1970 and 1980 (Earl, 1975).

3.7 As wood becomes increasingly scarce, the provision of wood for the household becomes an arduous burden which usually falls upon rural women. (Evidence exists, however, that would suggest that in areas of scarcity men are beginning to help with wood collection.) Firewood that could be collected in the immediate vicinity of most households a few years ago now has to be gathered and carried a half a day's walk. It is estimated that in the poorer areas of Tanzania, for example, it now requires about 250-300 people-days of work to provide annual firewood needs of a household (Mwzara, 1977). Fleuret and Fleuret (1978) report that firewood collection in Kweinzitn , Tanzania, took an average of eleven hours per week, while Brokensha and

Riley (1978) suggest that Mbere, Kenya, is an easier site for firewood, and the average weekly collection time was six hours. Digernes (1977) reports that householders in Bara, Sudan, bought wood because none was available. Yet Openshaw (1971) argues that less than five per cent of all rural woodfuel in Tanzania was purchased. In these figures, little account is taken of between-season differences or the quality of woodfuel. Yet, it is obvious that woodfuel gathering could become a significant strain upon the economic system, especially when labor is needed for other activities, notably agriculture.

3.8 How much woodfuel is used? Per capita consumption is probably between 1½ and 2 kilograms per person per day and possibly higher, depending upon season and altitude (Rogers, 1978). Eckholm (1975) argues that if the proportion of wood consumers in the population remains constant over the next one hundred years, in Tanzania alone, wood consumption would rise from 27 million tons per year in 1975, to 370 million tons in 2075, due merely to population increase of 2.7 per cent. Fleuret and Fleuret (1978) indicate that although woodfuel per capita consumption decreases with increasing family size and with more efficient cooking techno-

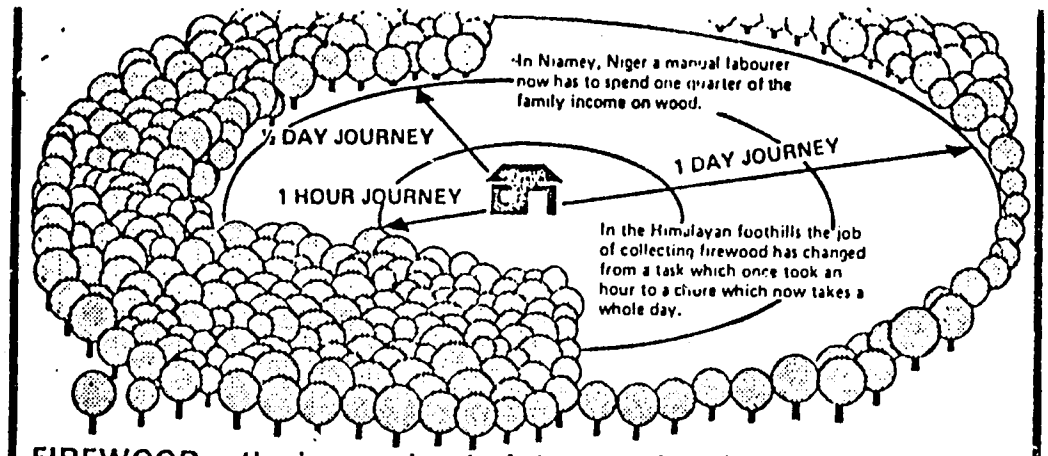
logies, a family of five requires 22.4 kilograms of woodfuel per day. To keep pace with such consumption, in the single village of Kweinzitn, the population would have to plant 1,360 trees per year!

The situation around urban areas is even more stark. Ouagadougou uses 120,000 metric tons of fuelwood per annum and devegetation is apparent within a 15-20kilometer radius of the city (Rogers, 1978). Acacia shrubs which were common around Khartoum in the mid 1950's are now only found ninety kilometers to the south (Digernes, 1977). Figure 25 graphically shows this increasing trek to find fuel. But for the urban dweller such deforestation means increased prices, a rapid transition to charcoal, and possible roughhandling at the hands of petty commodity producers who control transport networks to urban areas. Brokensha and Riley (1978) cite examples of Kenyan legislation to control export of charcoal and regulate prices in Nairobi and Mombassa. Figure 26 contains data on consumption of woodfuel and charcoal by selected countries.

3.9 Constant deforestation decreases land productivity. Rapp (1974) saw the cutting and uprooting of woody species for fuel as a direct cause of desertization:

> The woody biomass (including main roots) of the arid steppes is about 700 to 800

FIGURE 25.



FIREWOOD — the increasing trek to provide a family's fuel

Source: Rogers, 1978

> kg of dry matter per hectare. If we assume that 8 million people out of 12 million people depend on this type of fuel and that the daily consumption of firewood is 1 kg* of dry matter per person, we may conclude that about 2 million hectares of woody slopes are destroyed each year. If there were no regeneration during the rainy years, except under less than 150 mm of rainfall, when there is practically no regeneration on shallow soils. The result is man-made desert. (p. 35)

The problem with placing environmental degradation within such a broad framework as desertization is that the analysis leads nowhere. Notwithstanding the obvious environmental degradation, in terms of eastern Africa's development, it is arguable that the key issues to solving the problem of energy are in fact administrative, political, and economic and not, beyond the basic factor of the resource base, environmental. Energy crises... desertification ... are merely fragments of a continuing vicious circle of poverty.

3.10 Critical to the solution of these problems is the question of land tenure. Law expresses the value system of the dominant class in a society: within the underdeveloped countries of South Africa, new class alliances are being established (Shiuji, 1975). The characteristic feature of customary land tenure, as far as the new dominant classes are concerned, is that it

*Rapp rightly considers this an underestimation.

FIGURE 26

The pattern of consumption of wood fuels in selected countries

	Year	average use of wood fuel per capita/yr (m^3)	charcoal as a share of total wood fuel use (%)	household use as a share of total wood fuel use (%)	urban use as a share of total household use (%)
Gambia	1973	1.61	26	85	25
India	1970	0.38	..	..	..
Kenya	1960	1.00	6	98	..
Lebanon	1959-63	0.17	37	98	20
Sudan	1962	1.66	42	98	15
Tanzania	1960-61	1.14	..	97	3
	1968-69	2.29	3	93	4
Thailand	1970	1.36	46	91	12
Uganda	1959	1.53	..	92	..

Source: ARNOLD (1978)

contains insufficient responses to the demands of development.

> Development requires economic transformation mainly of the institutions of the subsistence sector. One could hardly expect to find a tool for their transformation in the very law that describes them.
>
> (Seidman, 1966)

While changes to statutory law, either individual or state, can unleash productive forces, enabling, for example, increases in agricultural production, the articulation of different production relationships upon subsistence economies hastens the destruction of those economies. Access to woodfuel is merely one aspect of this situation.

3.11 The recommendations to stop environmental degradation and to increase the supplies of fuelwood are, to date, piecemeal. For example, Kowaro (1976) suggests that in Kenya, because of the lack of forests, it is undesirable to cut trees for charcoal. His recommendations include:

(a) Increased afforestation,

(b) Quickly maturing species,

(c) Increased utilization of rapidly regenerating species,

(d) Avoid felling on steep slopes or riverbanks, and

(e) Avoid removal of total vegetation cover.

While none of these proposed activities is a "bad" action, none are necessarily "good." The objective frame of reference must be one of the integrated rural development that has an explicit time frame for forestry projects.

3.12 Once the point is reached where wood is only supplied by growing it, the time frame involved can become an important limiting factor. The rural poor, existing as they do on the margins of subsistence, cannot afford to forgo the the meeting of present needs for future needs. Present needs are likely to be imperative. Unless there is sufficient incentive at the community level to effectively offset that wish to consume forest products immediately, forestry products will fail.

With the introduction of forest projects, the gap between establishment and production can become a severe constraint. The minimum production time, even with rapidly maturing acacia species, is not likely to be less than eight years, so other activities should exist to secure the provision of sufficient "tide-over" income. Moreover, communities will require security of tenure to the land. Adequate assurances must be made that the peasant who plants the trees can also harvest them.

3.13 Considering the amount of labor through time devoted to forest production, fuelwood is underpriced. Rural producers have little price incentive to produce and protect forest reserves. It might be possible to value fuelwood indirectly in terms, for example, of the increased crop production that would result if agricultural residues were returned to the soil rather than being burnt or of the productive activities that could be undertaken if it was not necessary to spend so much time fuel gathering. Such values are not easily derived. It is especially difficult to value labor. Moreover, the equity issues, the fact that it is the poor who need wood, suggest that attempts should be made to encourage price inflation either in project appraisal or the market place.

SECTION FOUR:

CONSIDERATIONS IN PROJECT DESIGN OF FORESTRY

4.1 Forest projects are different from most agricultural development projects in two important ways:

(A) The benefits of the project are usually environmental for the push for forestry projects comes largely from the administrative sector with responsibility for conservation. Such benefits are difficult to measure in price terms and frequently do not accrue to those who planted the trees. When ecological considerations are primary, issues of equity are difficult to resolve.

(B) A long time period elapses before forest projects become a major source of income. Many peasant producers do however, have an urgent need for current income and so cannot in present circumstances afford to participate in forestry projects. Moreover, the long pay back period associated with forestry projects makes them unattractive as investment strategies.

Yet, the benefits of forestry products are undeniable.

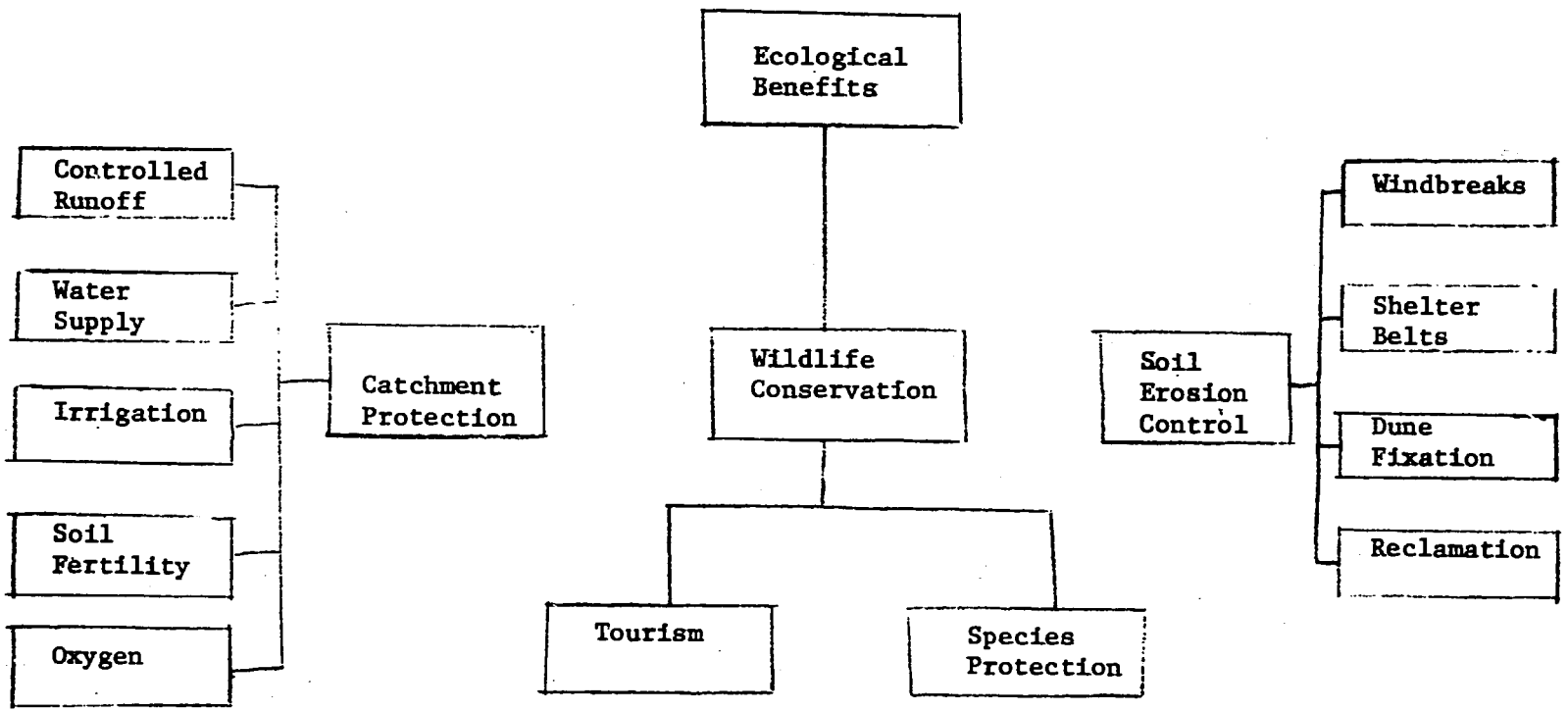
4.2 Forests in eastern Africa are fragile ecosystems. O'Keefe (1975) indicated the fragility of such systems especially if the vegetation is removed. Forests have pronounced microclimatic effects, reducing the range of daily temperature variation, retaining a layer of cool, moist air and enhancing local climate. In catchment areas, they act as porous reservoirs by retaining water in the roots and humus layers and releasing it as a sustained flow through time. Land is thus protected from erosion, minimizing river, canal and dam siltation. The absorbed water feeds streams and underground aquifers contributing to a stable hydrological cycle so necessary to agricultural production. Soil erosion is further retarded because the forest acts as a windbreak and provides important shelter belt protection enabling dune fixation and land reclamation especially in arid and semi-arid areas. As a habitat for wildlife, forests provide for specie protection (Eckholm, 1978) and the possibility of tourism. It should be noted, however, that many authorities do not regard tourism as a developmental activity (see Shiuji,

1973) particularly, as is the case in much of East Africa, if the tourist resources, e.g. game parks, restrict rights of access to indigenous ethnic groups. Figure 27 outlines the ecological benefits of forestry projects (Ibid., 1978).

4.3 The benefits of forestry to the usual populations of eastern Africa are threefold. First, forest trees provide fuel, shelter, and other goods essential to rural community needs. The fuel is low cost per unit, is produced locally and thus substitutable for costly commercial fuel or agricultural residues, prevents diversion of household labor, and assures the availability of cooked food. The building materials from forest resources are low cost per unit, produced locally and thus substituting for costly commercial materials, which allows for the maintenance and improvement of housing standards. Second, forests and forest land provide food and contribute to environmental stability necessary for continued crop and animal production. Complementary sources of food, fodder and forage are available for dry periods. Increased productivity of marginal cropland frequently results from forest products. Third,

FIGURE 27

ECOLOGICAL BENEFITS OF FORESTRY

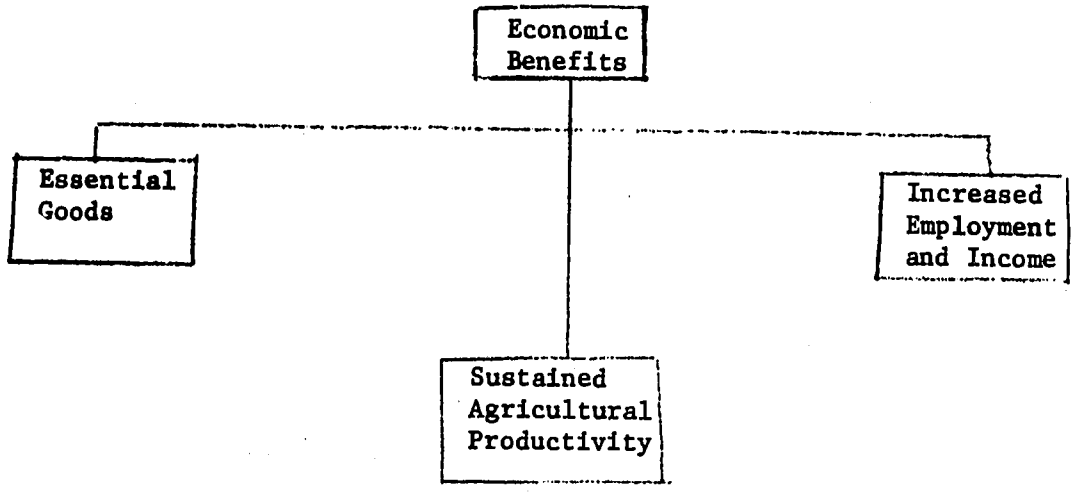


forestry and forest products can generate additional employment income to rural areas. Additional employment is provided by the project itself, diversifying the community economy. Inputs are available for local handicraft, cottage and small scale industries. Diagram 28 outlines the economic benefits of forestry projects to the community.

4.4 Depending upon location, firewood plantations, as opposed to integrated forest development programs, can vary greatly in cost. In Sudan, on already irrigated land, such plantations are estimated to cost $100 per hectare (Uhart, 1976) as opposed to $690 per hectare in the Sahel (Uhart, 1975). First year costs are $565 - $725 per hectare for planting and maintenance (Weber, 1977). The total cost of firewood from such projects is about $10 per ton. These figures are generally high suggesting a high market price per unit fuelwood. This emphasizes the earlier argument (3.13) that wood is underpriced because regeneration costs are not born by peasant producers who utilize natural forest. Local village woodlots with decentralized fuelwood production are at the opposite end of the spectrum. In these projects it is difficult

FIGURE 28

ECONOMIC BENEFITS OF FORESTRY PROJECTS



to estimate labor and firewood inputs and thus economic returns.

4.5 While the benefits and costs of projects can be qualitatively evaluated, it is difficult to use conventional techniques to quantitatively assess forestry projects. The role of forestry in rural development will vary enormously between countries depending on their ideologies and resources of government, type of the society and the locality. Several policy considerations, however, are likely to apply to most countries:

(A) Forestry development requires a commitment by government towards the rural population;

(B) Forestry development requires an integrated approach to resource development;

(C) Forestry development, if it is to succeed, requires participation of the rural population; and

(D) Forestry development is a long-term process and therefore requires a long-term commitment from government.

(Pao, 1978)

Within such broad policy frameworks, it is difficult to use conventional cost-benefit analysis for many forestry projects. With the exception of forestry infrastructive development and industrial wood processing, the evaluation of projects presents particular problems which may be classified as empirical and theoretical. Appendix F contains a summary of forest program assessment techniques.

4.6 The empirical problems associated with project evaluation of forestry development are:

(A) Projects are frequently located in densely populated areas, where people are exceedingly poor and dependent on forest resources, but where little natural forest remains and there is no tradition of reafforestation.

(B) Forest development involves long investment, and payback periods during which few benefits are available and relatively little employment is generated; this makes projection of future income hazardous.

(C) The risks of investment and the opportunity costs of forestry, in terms of alternative

land use and other investments, are high, so that individual investors are unlikely to speculate in such development.

(D) Many of the benefits of forestry accrue to society and not directly to the residents of the area or the investors.

(IBRD, 1978)

4.7 The theoretical issues associated with the project evaluation of forestry development are:

(A) Project evaluation views forestry programs in terms of self-contained projects. More importantly, inter-relationships with other projects and with other economic sectors are usually omitted from speculation.

(B) Project evaluation focusses on individual projects and is thus weak in identifying developmental effects. Assessment of societal benefits and costs beyond the project boundary, are thus poorly calculated.

(C) The benefits and costs selected belong to a narrow range of easily available, quantifiable data, and comparable variables. Furthermore, impacts are divided into benefits and

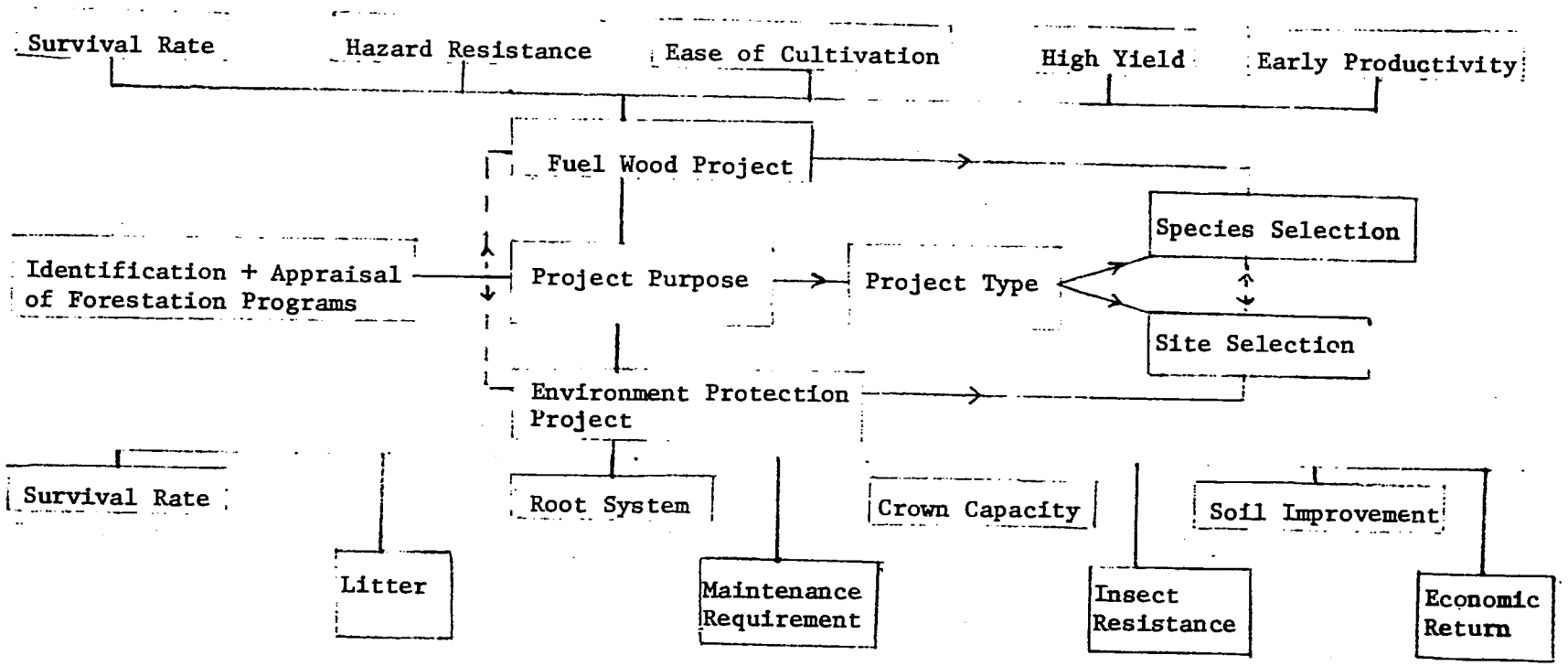
costs not by their actual effects on their relationships between people and their environment but by predesigned categories within an accounting framework.

(D) Evaluative criteria follow strictly monetary principles of maximizing some function of benefits and costs. Such criteria do not adequately cope with the complexities of forestry projects. In particular, the range of forest projects requires different evaluative measures.

4.8 Diagram 29 indicates the two major project purposes, namely, environmental protection, and fuelwood availability. The two purposes reflect the dominant responsibilities of administrations responsible for forestry conservation and production, respectively. Although these projects are obviously related, in that conservation has an economic face and production an ecological one, administrations tend to devise separate projects as befits their bureaucratic brief. One of the few examples of integrated approaches, i.e., integrating conservation and production, to forestry by government

FIGURE 29

SCHEMATIC OF MAJOR FORESTATION PROGRAMS



is the United States Forestry Service which Clawson (1977) has described as an "oligopoly." Perhaps something in the nature of "oligopolistic" power is needed to run successfull forestry programs that run counter to the norms of current commercial assessment.

Ecological factors will be paramount in considering environment projects, thus site selection will be a prime consideration. Topography, climate, soil, plant indicators and biotic factors will determine the selection of tree species. Species will be chosen for survival rate, litter, root system, crown capacity, insect resistance, soil improvement capability, maintenance requirements and economic return. Environmental protection projects will focus on site selection but within rural communities site selection will frequently be limited as the best sites are reserved for agriculture.

In contrast, productive fuelwood projects will be specifically concerned with economic returns. Attention to the survival rate and hazard resistance to the crop will be important; ease of cultivation, particularly an accurate assessment of labor input, will be a major criterion of assessment. High yielding, early maturing species will be considered most suitable because of the

necessity of earliest possible cash returns. Diagram 30 outlines a schematic of factors influencing fuelwood quality. Appendix H contains more detailed descriptions of these factors.

The duality of the schematics, environmental protection vs. fuelwood projects, brings forth site and species selection criteria respectively. Yet this becomes a false duality when one considers that site and species are closely related. The duality merely reflects the organization of administrative priorities and responsibilities, conservation and production, and thus the concerns that will be uppermost in financing forestry programs.

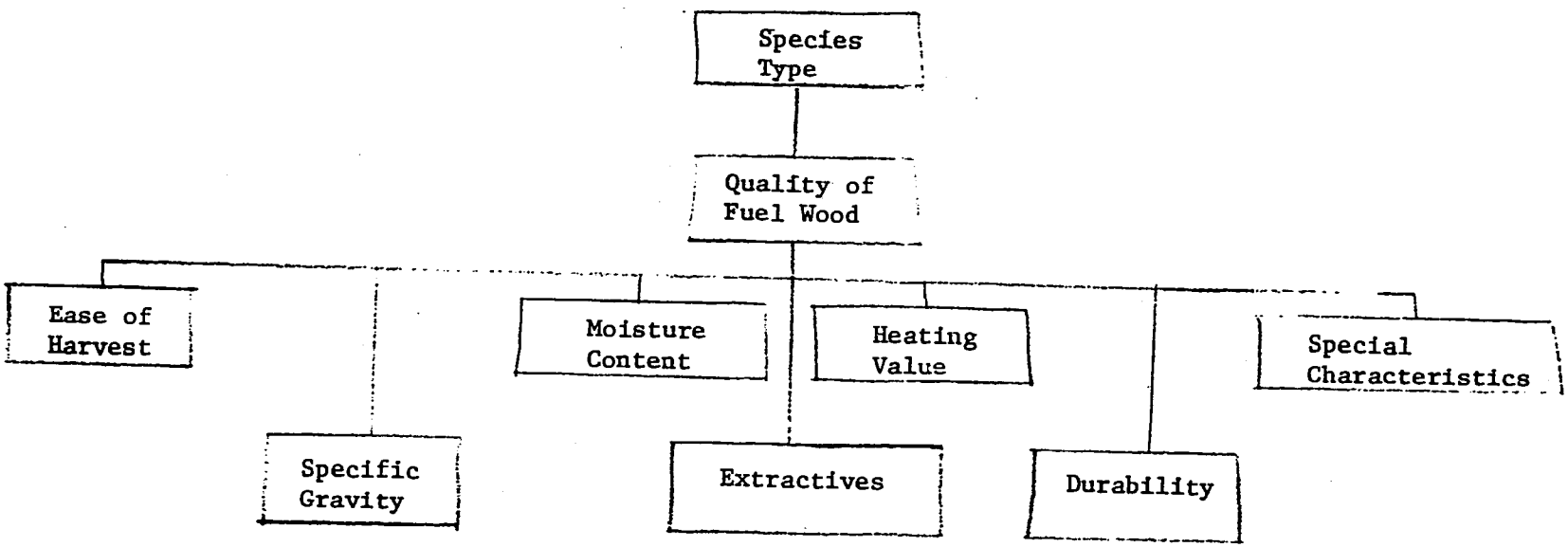
4.9 The project type (Figure 9) will determine site and species selection as well as the project purpose. Discussion on project type, like the discussion on economic evaluation contained in Appendix G, depends upon who is discussing forestry development. Development agencies have focused upon:

(A) Rural Development Forestry -- usually associated with integrated development projects

(B) Natural Forest Management and Industrial Plantations -- frequently large private or

FIGURE 30

DETAILED SCHEMATIC OF FACTORS INFLUENCING FUEL WOOD QUALITY



state concerns

(C) Infrastructure and Extraction Projects -- providing a capacity for industrial plantations

(D) Industrial Projects -- focusing on the vertical integration of forest production and semi-finished commodities, e.g., plywood

and (E) Institution Building -- including training (IBRD, 1978)

In all of these projects, the role of the fuelwood user is negligible. In assessing forestry project type, it is suggested that the production system of the project be the major focus. Five project types can be delineated:

(A) Multiple Product Forestry -- where the eco-system yields more than one product

(B) Arboriculture -- the highly skilled, intensive cultivation of trees, individually or in small plantations

(C) Agro-Silviculture -- where land is used to produce both trees and crops

(D) Silvo-Pasture -- where controlled growing of vegetation takes place during part of the rotation

and (E) Small-Sacle Forestry -- in which silviculture is dictated by local demand and the

local availability of suitable land.

Figure 31 presents the variation in project type and the relationship between project type and aspects of site and species selection.

4.10 At the Second Expert Consultation on Forestry for Community Development held on June 21-22, 1977, four case studies of forestry projects from East Africa were presented (FAO, 1977). These case studies are contained in Appendix H. Four major conclusions emerge from a consideration of these projects:

(A) In all cases, government supports the development of forestry projects in integrated rural development

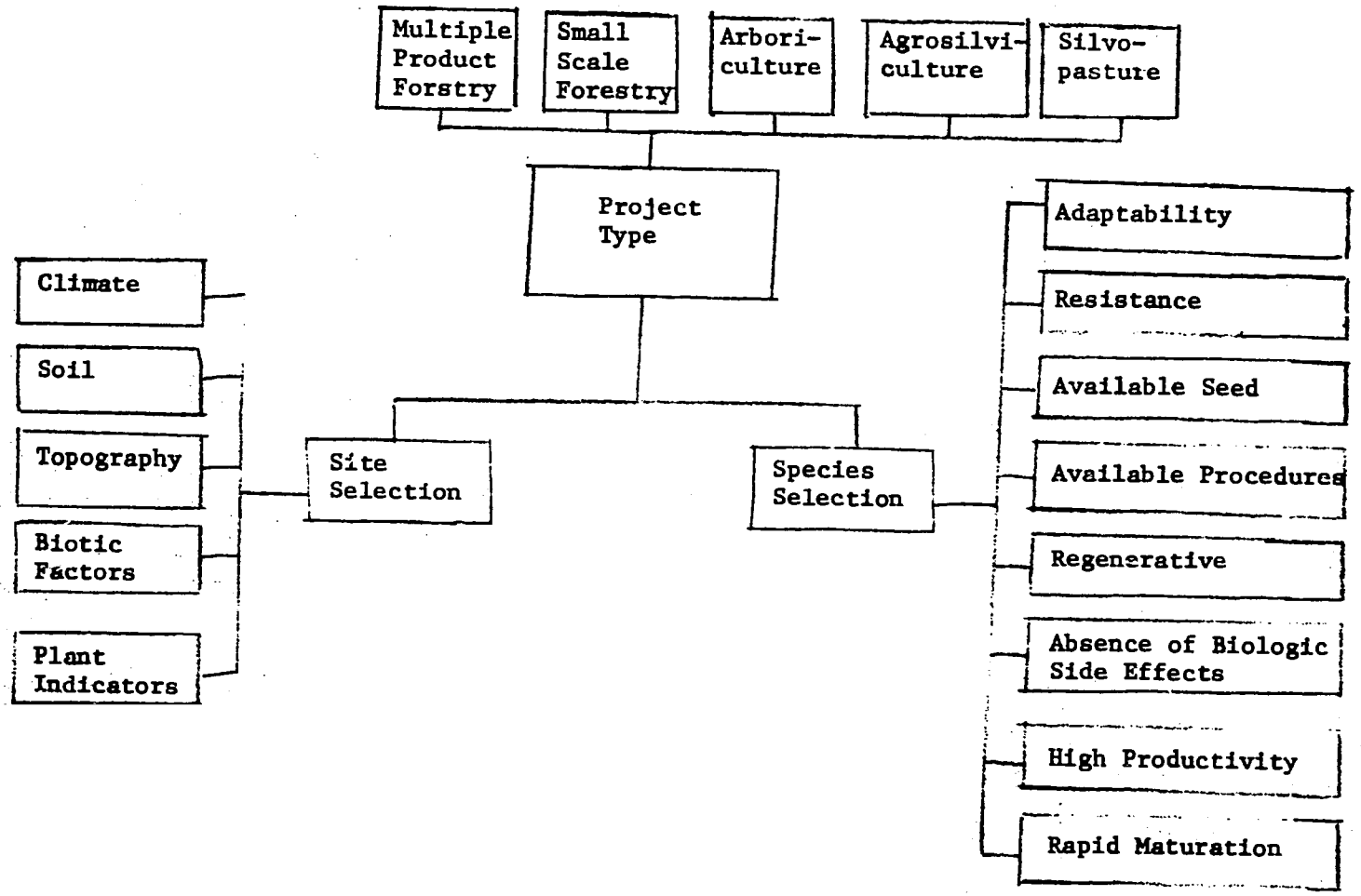
(B) Initial surveys of production systems and land use capability are essential to successful project development (see 4.11)

(C) Critical to project success is an understanding of the local labor budget and system of land legislation

(D) Technical problems exist or even arise after project initiation so that the institutional and educational aspects of forestry

FIGURE 31

SITE AND SPECIES SELECTION BY PROJECT TYPE



project implementation must be carefully considered (see 4.13)

Although few such projects exist, the very fact that there are any at all is an encouraging sign for the future.

4.11 Surveys of production systems and land capability are essential for project success. However, before a decision is taken to inititate such a survey, government support for the program -- not merely the survey -- must be evidenced. The local community must be willing to participate in such a survey, and, for the success of the survey, inter-agency coordination must exist at a working level.

The production systems survey should consider the socio-economic characteristics of the community, including socio-demographic profiles, land tenancy, capital investment, labor, budgets, working capital, agricultural practices and other economic activities so that the net value of production can be calculated. A household sample (? 10 per cent) should be taken to clarify the nature of family budgets. Such data will enable existing and potential demand for forest products to be assessed, expecially the potential <u>effective</u> demand, i.e., the future demand

for products not yet available given certain scenarios about future changes in income and lifestyle (O'Keefe, 1974). Land capability surveys should include:

(A) Inventory of forest and related resources;

(B) Climate, hydrology and water resources utilization;

(C) Geomorphology, soils and erosion; and

(D) Ecological zoning, wildlife, vegetation and landuse.

Young (1977) provides an excellent example of land classification and land capability surveys with particular reference to Botswana.

4.12 Ecological complexes are complex ecology. Even a forestry program designed for environmental protection may, of itself, produce environmental hazard. Environmental hazards are, of course, likely to be more common in fuelwood projects, especially large, single specie plantations.

Soil erosion can occur because of improper cropping or grazing and logging or road construction leading to degradation of water quality and sedimentation in reservoirs, rivers, and canals. Water pollution can occur

because of pesticide and fertilizer use encouraging water pollution and water-born diseases. Increasing incidence of flood or drought might occur, especially if the water table is altered by engineering works. Fire hazard, too, may increase.

Estimates of fire occurrence and strategies of risk management should be incorporated into project appraisal and project design, respectively.

4.13 If forestry is to take a place in local community development, then the local community must be included from the inception of the forestry project. Local community organizations must be able to voice their opinions and participate in decision-making about issues of land tenure, customary rights, and the state of forest land. Discussions on crop-sharing cooperatives and local credit schemes that would enhance the probability of forestry schemes should be encouraged. Only then will government be able to pass enabling legislation and regulatory provisions to stimulate successful forestry projects. Extension programs, paralleling those in agriculture, with research and technical capabilities, training, and staff are needed if adequate information is to be collected and disseminated.

4.14 Forest projects, because of their administrative origin, fall into two categories, environmental protection and fuelwood projects, which have conservation and production foci respectively. Although the technical details of project requirements can be evaluated, namely project type, site selection and species selection, the calculation of the benefits and costs of such projects is fraught with difficulty. It is difficult to place accurate prices on land evaluation, labor -- including time saved from traveling for woodfuel -- and ecological benefits without entering into serious discussion of equity. The long payback periods and the uncertainty associated with such projects means that accurate forecasting is difficult and private investors, even governments, are unwilling to commit capital resources to forestry development. Yet if fuel crisis is to be avoided in eastern Africa, governments must give strong backing to the development of the forestry sector, backing which includes adequate surveys and extension services but, most important of all, guarantees the rural poor access to the products of the forest through recognizing their statutory rights as producers.

It must be accepted that the decision be made in a non-economic manner -- this is not to suggest that the forestry projects be accepted if they are financially unsound but rather that as other non-economic parameters are taken by economists, such as employment or income distribution goals, the task of conserving the environment and providing energy needs also to receive priority.

SECTION FIVE: SUMMARY AND RECOMMENDATIONS

5.1 The current energy shortfalls that impact globally have a differential impact between the developed and underdeveloped countries. No technological fix is currently available that would rapidly transform the energy budget of the world. For the next two generations, the world will essentially be a fossil fuel economy. In underdeveloped countries, where increasing population and increasing urbanization are raising the levels of fuel demand, use of woodfuel resource will increase absolutely. At the present time, woodfuel is the cheapest and most readily avail-available form of energy to the poor. Damage to eco-systems will result unless careful planning accommodates this increased demand for woodfuel.

5.2 Growing demand for woodfuel occurs as access to forest resources decreases for the majority of the underdeveloped populations. Subsistence producers who rely on "free" access to the forest are thus further impoverished. Ecological degradation occurs but the solution to environmental impact lies within redefinition of the socio-economic framework in association with engineering or forestry schemes. People need energy; people need wood. Planning must focus on both wood production and ecological conservation.

5.3 Project design of forestry development is fraught with difficulty. Problems are particularly acute because although selection options for project type, species, and site can be outlined, the determining factor in forestry projects is project purpose, i.e. conservation or production orientations. While emphasis should be placed upon production projects, capital to finance such projects is frequently scarce because of the high opportunity cost of such projects in the face of capital shortage. Without such projects, however, the energy crisis, especially in underdeveloped rural and peri-urban areas, will escalate. Only with sincere commitment from government to development in rural areas will forestry projects be speedily implemented, thereby easing the impending energy crisis among the poor.

5.4 The commitment to the devlopment of productive forestry projects will probably focus upon small scale programs if the rural and peri-urban poor are to benefit. It is therefore necessary to link forestry projects with other elements of factor supply in integrated development projects. Neither technological development nor manufacturing can, of themselves, produce a beneficial energy program. Moreover, in energy programs requiring high technology, the availability of foreign exchange is critical. Capital shortage restricts such projects. Therefore, the most

feasible option seems to be village woodlots.

5.5 At this juncture, it would be naive to list specific policy recommendations. Instead this report makes suggestions which could provide groundwork for the development of more specific recommendations. In particular, it suggests ways in which to answer three questions:

(A) WHERE is the fuel crisis?

(B) WHAT INFORMATION IS NEEDED to alleviate the fuel crisis?

(C) WHAT APPROPRIATE TECHNOLOGIES can be developed to alleviate the fuel crisis?

5.7 The impact of deforestation is primarily recorded in the daily struggle of peasant producers to find sufficient fuel. This deforestation is, however, readily observable in the landscape. An interlinked monitoring system which joins together a small, selective global monitoring system with local, national, and regional (internation) monitoring activities would enable existing areas, and probable areas of deforestation, to be identified (for a more complete discussion of monitoring see Berry and Ford, 1977).

5.8 No present organization is currently globally responsible for monitoring the combination of factors

that contribute to environmental degradation, in a more broad sense, to desertification. Such responsibility could be assumed by the United Nations Environment Program (UNEP) as part of its Global Environment Monitoring System (GEMS) providing technical advice, data coordination and dissemination, identification of gaps in existing knowledge, and stimulating experimental work on ways to improve the monitoring system.

5.9 Soil erosion is a particularly important element to monitor as it directly relates to the degree of deforestation. Soil erosion can be measured on small sample plots, through gross measurement of stream sedimentation and through deposition levels in lakes and artificial bodies of water. Hydrological data coverage is not comprehensive in the areas most prone to deforestation and soil erosion and needs to be improved.

5.10 An example of the effectiveness of a global monitoring system can be seen in Diagram 32 which shows part of an ERTS-I satellite image of semi-arid land with degradation perimeter around Dodoma, central Tanzania. The white circle of 40 kilometer radius

Diagram 32

Figure 7.1. Part of an ERTS-1 satellite image (Dec. 25, 1972, channel 5) of semi-arid land with degradation perimeter in the surroundings of Dodoma (D), central Tanzania. Black patches = woodland.

Source: Rapp, et al, 1976.

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These detailed surveys should also consider cooking patterns and technologies so that detailed trend analysis of firewood consumption can be made. The following paragraphs suggest topics that need to be considered in these surveys. The checklist is that suggested by FAO (1977).

(i) Socio-economic survey at the community level:

(A) Socio-demographic characteristics:

(a.) Population: origin, total number and number of households, sex, age groups, migrations (tables and graphs);
(b.) economic activities, unemployment, sub-employment;
(c.) villages, road and telegraphic connections (map with human settlements and road network);
(d.) the family, the clan, the council, political parties;
(e.) the religion, traditions, attitudes to change;
(f.) habitat, housing, water-supply, fuel sources, etc.;
(g.) social amenities and services, transport, communications, power, medical care (including shops, craftsmanship, ceremonies, leisure, folklore, clubs, associations, cooperatives, credit unions).

(B) Tenancy

(a.) Land ownership, rights and regulations (exploitation units to be indicated on map);
(b.) ownership distribution-size groupings;
(c.) values and land market;

(d.) share-cropping, communal land use, State land leasing/permit systems.

(C) Capital investment (Values if possible to be indicated)

(a.) Housing and roads;
(b.) land clearance and reclamation, irrigation, permanent crops, agro-industrial plants, home and cottage industry;
(c.) forest lumbering and industrial enterprises;
(d.) warehouses, public and freight transportation.

(D) Exploitation units

(a.) The farm: relationship between farm and land property;
(b.) total number of farms, farm distribution (map), size groupings (graph);
(c.) types of exploitation units;
(d.) use of farm area, rotation of crops.

(E) Labor

(a.) Relationship between farm management and labor;
(b.) quantity and type of labor;
(c.) hired workers, corvee, exchanges of labor in the community;
(d.) specialization of labor by age and sex; (seasons and hours of work).

(F) Working capital (Community statistics)

(a.) Tools and equipment; production, maintenance, repair and market;
(b.) livestock: type, quantities, values;
(c.) other working capital: feedstuff, seeds, fertilizers, their quantities and market.

(G) Crops, cultural practices

(a.) Cash crops: total area, varieties, cultural practices, inputs and other

expenses, yield, production per unit and total production;

(b.) subsistence crops: total area, varieties, soil preparation, rotation, cultural practices, yields, production per unit and total for the community;

(c.) feed and fodder production: total area, grass species, cultural practices, yield;

(d.) permanent crops: total area, cultivation practices, yield, total production;

(e.) livestock breeding: types and quantity of livestock, breeding practices, inputs, production per unit and total for the community;

(f.) poultry: types, total, production;

(g.) staple diet and techniques of preparation.

(H) Forestry and forest-related activities (avoiding duplication with the pertinent survey)

(a.) Timber output: species, unitprices, production costs, markets;

(b.) wood processing industries;

(c.) other forest products: fuelwood, charcoal, etc.

(I) Other economic activities (earning values)

(a.) Fisheries, hunting;

(b.) handcrafts;

(c.) non-agricultural labour;

(d.) skilled workers and professionals.

(J) Production

(a.) Gross production (values per unit and for the community);

(b.) gross saleable production (processing, marketing, price);

(c.) products consumed by the peasant.

(K) Expenses (other than for productive activities)

(a,) Food;

(b.) housing and power;

(c.) clothing;

(d.) education;

(e.) transport, communications;

(f.) taxes and,contributions;

(g.) ceremonies;

(h.) leisure;

(i.) debts.

(ii) **Farm and household sample:**

The community level socio-economic survey should be supplemented by a farm and family level survey, comprising 30-40% of the exploitation units/ families of the project area. Again, for particular situations this outline should be adapted to secure all relevant information.

(a.) Information on local tenure, type of exploitation, surveyor, area, topography and aspect of the land, road access, membership of cooperatives or associations;

(b) information on the family (including employment, education, etc.), labour units and how they are spent, hired workers, labour distribution over the year, labour peaks, exchange of labour, wages, diet and food preparation;

(c) information on land use, indication of the production per unit and the total value as well as the value of fixed assets, livestock (by type) and their value, machinery and equipment and determining the value per ha;

(d.) information on farm production (and total value) will include: total production for each product, saleable production (stating price per unit and total value), family consumption and its value.

(e.) Information on farm expenditure, specifying (per unit and total) expenditure on seeds, fertilisers, organic manure, pesticides, machinery (including hired), trees or stumps for planting. fodder, feedstuff, litter, veterinary and drugs, servicing of livestock, restocking, operation, repair and amortization of machinery and equipment, insurance, electricity, irrigation water, processing of product, transport, repair and maintenance of buildings, roads, tracks, fences, channels, etc., adding the total value.

(f.) Information in indebtedness, stating the nature of the debt and its repayment.

(g.) Information on family expenditure, specifying food purchased, fuel, clothing, medical, education, transport and visits, house repair and maintenance, household and furnishing, social events, personal taxes, fees, etc. The total amount of debts should be indicated.

(h.) Family earnings outside farm (source of earning), indicating the annual total.

A balance of income should be finally obtained, determining:

(i) Net farm product (total value per ha and value per labor unit) as the difference between the saleable production and the farm expenditure.
(ii) Net farm income as a result of deducting from the net farm product the wages, the rent (in case of tenancy) and the repayment of farm debts.
(iii) Final balance as the differences of the net farm income (plus other income) and family expenditure and the consumption in the household of farm produce.

The balance may often show a deficit because it is normal or family expenditure to be adjusted to family income, but without allowing for the amortization of machinery, replacement of livestock, replanting of trees, all of which have to be taken into account in the questionnaire outline.

The assets will be obtained deducting the total family assets (saveable income, plus land and fixed assets belonging to the family, plus livestock, machinery and other assets), the total indebtedness being the sum of the debts on the farm and the family debts.

5.13 The data obtained from the ecological and economic surveys should be combined into a process analysis of the energy flow system that goes beyond the normal range of economic ecology by applying thermodynamic principles to the analysis of the forestry within a framework of production and reproduction in the socio-economic formation. Energy flows are a fundamental measure of quantity and the thermodynamic principles provides a unifying principle by which previously unrelated information about environmental and economic systems can be related. Appendix H contains a simple example of utilizing such an energetic approach to the economic ecology processes. Although this

system does not emphasize wood use, it is possible with the collection of adequate data to incorporate such consideration into these models.

5.14 With increased use of wood, it is important that three technologies be rapidly developed or improved, namely:

(A) wood stoves for household use;

(B) insulation methods where fire is used for warmth;

(C) more efficient charcoal converters, such as the pyrolitic conversion technique.

Monies employed in the devlopment of these technologies will enhance the efficiency of woodfuel utilization and thus reduce the rate of forest depletion.

5.15 The knowledge gained by such monitoring of environmental change, surveys of production systems, and energetics analysis needs to be complemented by investigations of current administrative capability for forestry programs, of existing experimental woodlots, and of inventions of tree species with particular emphasis on productive capabilities. Only if these steps are undertaken will sufficient analysis be available to combat successfully deforestation with the development of integrated forestry projects without which the impoverishment of the eastern African rural and peri-urban population will continue largely unabated.

APPENDIX A

ENERGY USE IN EAST AFRICA

(i) Total Commercial Energy: Coal Equivalent Kilograms Per Capita

	Sudan	Ethiopia	Kenya	Tanzania	Zambia
1971	121	31	143	71	497
1972	135	33	134	73	523
1973	133	33	148	97	539
1974	125	31	171	74	487
1975	140	29	174	70	504

Total Commercial Energy: Coal Equivalent Kilograms Per Capita (cont.)

	World	Developed	Developing
1971	1936	5993	344
1972	2000	6240	357
1973	2065	6460	379
1974	2044	6298	390
1975	2028	6094	401

Source: UN 1977

(ii) Import of Crude Petroleum: Million Metric Tons

	Sudan	Ethiopia	Kenya	Tanzania	Zambia
1971	0.650	0.513	2.541	0.944	
1972	0.780	0.637	2.499	0.819	
1973	0.790	0.680	2.716	1.415	0.659
1974	0.740	0.610	2.808	1.638	0.620
1975	1.150	0.600	2.826	0.729	1.211

Source: UN 1977

(iii) Refinery Capacity as of December, 1975: Million Metric Tons

Sudan	Ethiopia	Kenya	Tanzania	Zambia
1.200	0.740	4.300	0.850	1.100

Source: UN 1977

(iv) Installed Capacity: Industrial and Public Generating Plants

(Thousand Kilowatts)

	Sudan	Ethiopia	Kenya	Tanzania	Zambia
1971	112	224	216	142	577
1972	115	225	213	147	1027
1973	120	315	220	156	1031
1974	120	315	227	160	1031
1975	120	320	285	160	1031

Source: UN 1977

(v) Fuelwood Production in Million Cubic Meters

	Sudan	Ethiopia	Kenya	Tanzania	Zambia
1971	19.6	22.5	10.5	31.0	4.4
1972	19.6	23.0	10.65	31.5	4.55
1973	18.7	23.0	10.75	32.087	4.55
1974	20.89	23.0	10.875	32.965	4.55
1975	20.89	23.0	10.875	32.965	4.55

Source: UN 1977

APPENDIX B

ELECTRICITY IN EAST AFRICA

(i) Kenya

(a) Sales of Electricity by Type of User, 1971-1975

'ooo kWh

	1971	1972	1973	1974	1975
Domestic and staff quarters	114,405	122,991	129,141	139,039	151,258
Off peak water heating and pumping	105,497	117,941	121,282	120,670	134,551
Industrial	223,507	252,846	285,912	316,607	311,854
Commercial	186,158	204,222	223,938	239,486	263,333
Lighting and power (small consumers)	9,516	9,948	10,842	12,513	15,052
Street Lighting	9,232	9,389	10,447	10,066	10,670
Special Contracts	66,903	77,506	78,159	86,505	114,714
Total Sales	715,218	794,843	859,721	924,886	1,001,432

(b) Generation, Imports and Consumption of Electricity, 1971-1975

'000 kWh

	1971	1972	1973	1974	1975
Domestically Generated	557,262	664,171	723,271	799,641	901,203
Imported	293,356	283,168	302,379	295,975	260,774
Total Available	850,618	947,339	1,025,650	1,095,616	1,161,997
Internal Usage and Transmission and Distribution losses	135,400	152,496	165,929	170,730	160,545
Total Sales	715,218	794,843	859,721	924,886	1,001.432

(ii) Zambia: Electricity Growth Indicators, 1970-1976

Item	1971	1976	Index 1976/1971	Average rate of growth %
Installed Generation Capacity (MW):				
Hydro:				
Kariba (North)	--	600	--	--
Kafue (Stage I)	300	600	200.0	14.9
Victoria Falls	88	108	122.7	4.2
Mulungushi	20	20	100.0	--
Lusemfwa	18	18	100.0	--
Lusiwasi	6	12	200.0	14.9
Kasama/Mbala	1.95	6.75	346.1	28.1
Mansa/Lumangwe	2	9	450.0	35.1
Thermal:				
Copperbelt	130	70	--	--
Lusaka	10	10	100.0	--
Maamba	--	110	--	--
Diesel:				
Zesco (North)	3	7.9	263.3	21.3
Zesco (South)	1	2	200.0	14.9
Gas Turbine:				
Copperbelt	40	60	150.0	8.5
Zambia National Generation Total (MW)	619.95	1,633.65	263.5	21.3

(iii) Tanzania

(a) Electricity Sales By User

(Million kwh)

Year	LOCAL SALES						Power Station use and Transmission Losses	Total Units Generated
	Domestic	Commercial	Maximum(1) Demand	Light Industrial	Public Lighting	Total Sales		
1960/62	--	--	--	--	--	114.65	21.48	166.13
1963	--	--	--	--	--	162.94	22.63	185.57
1964	--	--	--	--	--	167.89	24.45	192.34
1965	--	--	--	--	--	180.05	33.19	213.24
1966	47.53	33.18	120.50	10.97	2.71	214.89	37.57	252.46
1967	49.37	34.25	141.91	11.95	2.90	240.38	41.63	282.01
1968	52.22	36.98	160.15	13.64	3.20	266.19	47.16	313.35
1969	48.15	42.45	197.66	15.06	3.46	306.78	51.54	358.32
1970	61.34	45.96	213.12	16.81	3.80	341.03	54.93	393.96
1971	63.57	48.92	237.81	17.20	4.04	371.54	54.09	425.63
1972	67.91	51.03	263.92	17.26	4.13	404.25	69.33	473.58
1973	73.40	53.40	281.80	18.30	4.50	431.40	82.50	513.90
Percentage Change 1973/72	8.38	4.64	6.77	6.03	8.96	6.72	19.00	8.51

(b) Energy: Electricity

	1964	1965	1966	1967	1968
Production (million kWh)	192.3	213.2	252.4	282.0	133.4
Local Sales (million kWh)	167.9	180.0	214.9	240.4	266.2

(iv) Ethiopia: Energy: Electricity

	1964	1965	1966	1967
Production (in kWh)	208	238	265	294

APPENDIX C

FOREST COVER AND VEGETATION SUCCESSION IN EAST AFRICA

(i) Estimates of Forest Cover

Because each nation uses its own criteria, estimates of forest cover for each East African country are difficult to compare. In addition, the nomenclature associated with the varying ecosystems is not consistently employed. Thus, what may be determined as forest in Botswana may not be so classified in Kenya.

BOTSWANA: The total land area of Botswana is approximately 58,537,000 hectares of which 962,000 were classified as forest in 1975 by FAO. This is slightly more than the FAO estimate for 1965 which is 958,000. Both figures are about 1.6% of the total land area of Botswana. However, the 1953 estimate by FAO was 97%. Another source gave a figure of 79% covered with thornbrush. The 97% figure would cover all of the Kalahari desert and the Okavango swamp. It appears that the first figures are for commercially usable forest and the later figures for land covered with some sort of natural vegetation.

MALAWI: The total land area of Malawi is 9,408,000 hectares of which 2,314,000 h or 24.6% were classified as forest by the FAO in 1975. There was no change from the 1965 to 1975 estimates. However, the FAO in 1953 gave a figure of 1,130,000 or about 12% forest cover and another source (Chapman, 1970) estimated that there were only 50,000 hectares of forest left in Malawi.

SUDAN: The total land area of the Sudan is 237,600,000 hectares and 38% of this was classified as forest. That is 91 million hectares. In 1953 there were 94 million hectares or 39.6% of forest. This is mostly Acacia forest.

KENYA: The total land area of Kenya is 56,925,000 hectares. The forest area was given as 1,935,000 or 3.4% for both 1965 and 1975. The same source for 1953 gives 1,291,000 Or 2.3% and appears to indicate a substantial increase in forest area for Kenya while most observers of the situation talk of the rapid deforestation of the country. Another source gave an estimate of approximately 1,430,000 hectares of forest which included 200,000 hectares of bamboo forest and 33,000 hectares of mangrove forest.

ETHIOPIA: The total land area of Ethiopia ia 110,100,000 hectares. The FAO statistics give a picture of a country with a constantly increasing forest area. In 1953 the area was 7,400,000

hectares, in 1965 it was 9,652,000 and in 1975 it was 8,860,000 hectares of forest. These also conflict with reports of diminishing forest resources.

TANZANIA: The situation in Tanzania is more what one would expect, with a decreasing amount of forest. In 1953, 40.0% of the total land area (88,604,000 hectares) was classified as forest, i.e., 36,340,000 hectares. The figures for 1965 and 1975 were 33,942,000 hectares or 38.3% and 31,074,000 hectares or 35.1%

ZAMBIA: The total land area of Zambia is 74,072,000 hectares. The figures for Zambia show mixed change, increasing from 1953 to 1965 and then declining from 1965 to 1975. The figures are: 1953, 37,100,000 hectares or 50.1%; 1965, 37,631,000 hectares or 50.8%; and 1975, 37,330 hectares of 50.4%.

(ii) and Vegetation Succession

DRY DECIDUOUS FOREST (Zambia)

"Baikiaea forest" is one type of dry deciduous forest. It exists mostly on Kalahari sands, which are deep, well-drained and almost sterile sands in southern Zambia and neighboring areas. This type of forest exists equally well under 700 or 1,200 mm of annual rainfall. This is a two-storied forest and may have either an open or closed canopy. The dominant tree types are "Baikiaea plurijuga" and "Pterocarpus antunasil" with "Acacia giraffe" a common species. There is a shrub layer and a dense rainy season ground cover. Not much of this forest type remains. Disturbance by burning, cultivation, and change in water table result in a regression pattern where the "Baikiaea forest" is replaced by a vegetation type called "Kalahari woodland". The Kalahari woodland is really a catanary regression from forest to grassland with five distinguishable stages. These stages are named according to their dominant plant types. They are:

1. Guibourtia woodland, a two-storied forest with thinly scattered smaller trees below an open canopy.

2. Burkea-Erthropheum woodland which has an even more open canopy and is dominated by a fire resistant species.

3. Burkea-Diplorhynchus scrub, this is a very open forest with the trees down to only 5-6 meters in height.

4. Diplorhynchus scrub, this is widely-spaced fire-damaged scrub forest.

5. Parinari suffrutex savanna, this has a carpet of grasses and suffrutex with very few widely scattered scrub trees.

MONTANE FOREST (Zambia)

These types of forests occur in areas above 1,800 meters elevation with rainfall of approximately 1,000 per year. In addition, they experience frosts of 10-20°F during several months of the year. Mist or ground level clouds are frequent. It is usually a three storied forest with the canopy at 27m or more. It is a very mixed forest with no single dominant tree type. There is an evergreen understory between 9-18m high and a shrub or subshrub layer below this. There are few grasses but climbers and epiphytes are common. Many of the larger trees are buttressed.

Montane forests are extremely susceptible to fire. The regression leads to secondary low forest, then to scrub. This is followed by a biotic grassland. Some of the grasslands contain some shrubs but many are completely grass.

APPENDIX D

ALTERNATIVE TECHNOLOGIES

(i) Solar Energy

(a) Operation: Use of the sun's rays to develop an energy source for various functions; harnessing solar power has proven to be effective means of utilizing the vast potential of the sun in a decentralized manner on the village level.

(b) Basic Systems: Passive Solar Heating -- storage of energy where sunlight strikes building and interior; system shields structure from unwanted summer heat while capturing and retaining sun's warmth during winter months;

(1.) overall fuel saving of 50%
(2.) increased comfort ensues with this type of system
(3.) pragmatic means to employ passive system and supplement energy needs with firewood or other combustible fuels
(4.) performance and durablity oftens outweighs conventional heating systems
(5.) following initial capital input for system the costs of maintenance and operation are minimal relative to alternative energy sources
(6.) major advantage to implementing this sort of system is its environmentally sound implications; it would greatly offset precarious state of fuelwood supply and moreover mitigate the serious problem of desertification on the local level

Active Solar Heating -- use solar collectors (black metal tubing or flat sheet) to capture sunlight and then transport it by means of air or water to storage area where it can later be tapped as needed.

(1.) greater potential with active system and possibility of implementing various types of solar equipment and back-up components
(2.) greater efficiency in terms of storage capabilities and power generation
(3.) certain components of system are amenable to local manufacturing

(4.) ecologically sound relative to alternative sources

(5.) significant disadvantage to widespread use of active solar systems at this time is the cost involved; technical equipment tends to be expensive, however, increased production in the near future will reduce these costs considerably; these costs should also be evaluated in respect to opportunity costs of resource scarcity and environmental effects of present systems, i.e., firewood or petroleum

(c) Solar Dryers: Operation -- low-grade heat from simple solar devices can be used to dry crops (corn, soybeans, alfalfa, prunes), to remove moisture from lumber and textiles; source now provided by prodigious amounts of propane and methane gas.

Advantages --the following:

(1.) traditional open air methods are slow and conducive to decay of harvest; simple solar collectors speed up drying process and thus minimize deterioration by rodents and rain

(2.) ecologically sound and obviously less environmental impact than using scarce firewood

(3.) limited technological skills required to operate and implement this system; more feasible potential on village level

(4.) capital input is at minimum; cost-benefit financially and environmentally certainly imply its tremendous potential as a decentralized practical operation on the local level

(d) Solar Cookers: Operation -- parabolic mirrors reflect and concentrate sunlight onto grid or pot; interest has grown since the dangers of dissertification have been realized and the potential of solar stoves and ovens are becoming more realistic with the advances of heat storage technology.

Advantages -- the following:

(1.) relatively simple technology involved with these cookers which makes it immediately feasible on the village level

(2.) materials and operation remain at a minimum cost level
(3.) reliable source of energy that will improve firewood crisis

Disadvantages -- the following:

(1.) today can only be supplementary device since specific functional time and storage of high functional heat is expensive
(2.) major drawback to solar cookers is that they require new method of meal preparation as cooking is restricted to daylight hours (reason for failures of experiments in Mexico and India)

(e) Photovoltaic Devices: Operation -- direct conversion of sunlight to electricity using visible part of solar spectrum; solar cells or semi-conductor devices convert from almost 3% to almost 30% of incident solar energy to DC electricity.

Utility -- generates electricity, provides alternative to batteries especially in remote areas; e.g., solar cells employed for transmitting educational T.V. in Nigeria in 1966; remote transmitters, drilling rigs, signal buoys

Sources and Potential -- solar cell made from silicon - generally an abundant material; presently technology of solar cells of photovoltaic systems maintains 10% solar conversion efficiency with peak power capacity ranging from 1 watt to 10's of kilowatts

Advantages -- the following:

(1.) no additional sources of energy necessary to supplement system
(2.) no moving parts and thus requires little maintenance
(3.) operates at ambient temperature, modularity
(4.) ecologically sound; non-pollutant energy and will offset the fuelwood crisis and inadequate electrical grid within villages
(5.) following initial investment low capital input costs for system's lifetime; this would serve to ameliorate the balance of payments deficit caused by the skyrocketing prices of petroleum and other natural gases

Disadvantages -- the following:

(1.) solar cell technology may require external assistance on the local level which would involve higher costs and some expatriate dependency

(2.) current costs of photovoltaic cells are expensive and definitely above the capabilities of rural budgets; in 1974 it cost 500 dollars per peak watt; however; the costs are declining as technology expands; 1977 cost per peak watt was estimated at $13.50; projected cost in 1981 is between one and two dollars

(ii) Biogas

(a) Operation: Production of methane (chemical equivalent of natural gas) from non-woody organic matter by action of aneorobic bacteria; animal dung and human excreta and other organic materials used; maintenance of temperature acidity (ph) important

(b) Use: source of fuel for irrigation; residue of process is high quality fertilizer

(c) Advantages:

(1.) labor intensive
(2.) minimal capital input / foreign exchange
(3.) community biogas plant would afford employment and increase agricultural productivity
(4.) ecologically sound

(d) Disadvantages:

(1.) not feasible at present time for widespread use
(2.) for a 'village public utility' need capital and technological education
(3.) minimal equipment needed but it would have to be imported and at present time its prices are not competetive with alternative systems

(e) Costs: ten cubic meter tank to serve 5 person family - 15-20 dollars

(iii) Photosynthetic Conversion

(a) Operation: culturing of plants as energy foodstock; solar energy stored in form of chemical energy within cellulosic plant material; energy released by drying material and burning directly

(b) Potential Fuels: ethanol, methane

(c) Utility: fuels, heating, cooking

(d) Advantages:

(1.) low cost storage
(2.) utilizing vast potential of plants and organic matter as energy source
(3.) renewable source of energy
(4.) available on the local level in terms of materials, operation and capital input
(5.) ecologically sound; recycling of organic materials; low content pollutants

(e) Disadvantages:

(1.) scope of technologically initial requirements may not be available on the local level; technology involves knowledge of energy content of plant materials, multiple cropping, annual biomass yields
(2.) costs involve various considerations; dependent upon agricultural considerations of particular village transport of plant material to generator site, handling of materials during conversion; extent of capital input relative to capacities of individual villages
(3.) significant opportunity cost of planting energy crops rather than food crops; historically the need for increasing food crops far outweighs other options, perhaps even energy production.

(iv) Pyrolitic Conversion of Agricultural and Forestry Wastes

(a) Operation: system operates by means of 'pyrolysis' - thermal degradation of organic materials, thereby producing charcoal and various forms of alcohol fuels, charoil and chargas

(b) Utility: basic cooking and heating needs along with applications for crop drying and lighting, i.e., lamps (charoil)

(c) Energy Sources: large pieces of wood from forestry wastes, and smaller materials such as sawdust, ground shells or rice straw

(d) Disadvantages:

(1.) at present, capital costs of system estimated too expensive for many rural areas. Initial

capital investment not feasible on a small scale

(2.) despite minimal technology requirements, unskilled or careless design along with amateur operators could present problems in self-sustaining operations of the system

(3.) digestion process can often be slow which leads to delays in production and possible financial losses along with problems of efficiency

(v) Hydropower

(a) Operation: Through means of water pressure the system creates energy; energy then converted within turbine into mechanical energy; electrical generator converts this into electrical energy

(b) Utility: production of electricity, mechanical tasks, - apparatus connected via belts or gears to grain mills, pumps, wood and metal-working machines

(c) Two Basic Systems: Waterwheels - no change in water pressure

Turbines - transfers kinetic energy to rotor; used for small-scale hydroelectric units; generates more power than waterwheel; HYDROLIC RAM: simple pump operated solely by flowing water; only two moving parts; HYDROLIC AIR COMPRESSOR or TROMPE: no moving parts· stores energy in form of compressed air; can be used to drive turbines which in turn can drive production machinery or electric generators. All turbines require that water be conveyed to them under pressure from source at some elevation above the turbine. The drop in elevation may result from natural conditions or artificial means such as a dam.

(d) Power Capacity: dependent upon type of system and water source; small scale hydroelectric unit capable of 5-15 kw

(e) Advantages:

(1.) use of local materials
(2.) labor intensive
(3.) minimal maintenance since no moving parts in some systems
(4.) capable of 24 hour operation
(5.) efficient means of small-scale irrigation
(6.) small-scale units serve to decentralize energy production at the local level

(f) Disadvantages:

(1.) most systems must be chosen according to appropriate geology (dam location and run off), topography (slopes, storage and evaporation), and stream flow (rainfall and watershed area); these locational factors restrict some areas from using hydroelectric power
(2.) implementation of hydropower systems require some technical expertise that might not be locally available
(3.) limited production of small-scale hydroelectric units at this time; cost per kw is therefore high and not competitive for rural areas; estimated cost of electricity at generator: 8-10¢/kw
(4.) cost-benefit for small-scale hydropower systems does not always outweigh cost-benefit analysis for development of large-scale hydro and thermal electric central generating stations and the extension of electrical power lines to the rural areas.

(vi) Wind Power

(a) Utility: Electricity, cutting wood, water plumbing, crop processing, irrigation

(b) Two Basic Systems: Windmills -- mechanical power, pumping water
Wind Turbines -- generating electricity, producing high rpm's

(c) Types:

(1.) Savonius Rotor - vertical axis
(2.) Darrieus Motor - horizontal axis
(3.) Multiblade Fanmill

(d) Power Capacity:

(1.) wind production increases with square of the propellor's size
(2.) windpower increases with cube of velocity; therefore twice as fast a wind produces eight times as much power

(e) Advantages:

(1.) low capital input
(2.) labor intensive

(3.) technology and materials available at local level
(4.) ease of maintenance
(5.) ecologically sound

(f) Advantage of Small-Scale Windmills:

(1.) more practical to mass produce them or to locally construct from available materials
(2.) capable of producing power in slower winds and thus can operate a higher percentage of the time

(g) Advantage of Small-Scale Wind Turbine:

(1.) efficient production of electricity when coupled with hydro-power as support system; thus intermediate-sized wind machines are an economical source of electricity

(h) Disadvantages:

(1.) question of acceptance amongst indigenous populations
(2.) lack of engineering expertise - needed to match operating characteristics of generator to properties of windmill and local wind conditions
(3.) requires some equipment that might not be locally accessible
(4.) depending on local wind conditions, the basic systems do not always provide a constant flow of energy; large-scale wind machines have storage problems

(i) Costs: prices are variable; must be evaluated for each system

APPENDIX E

APPROPRIATE TECHNOLOGIES

(i) Charcoal Convertors

(a) Operation: through the carbonization of wood and other vegetation a charcoal substance is yielded that contains a greater amount of energy utility; the quality of the charcoal is dependent upon the type of wood and carbonization method that is used.

(b) Utility: heating, cooking, industrial heating

(c) Sources for Charcoal: organic substances, wood (roundwood), coconut shell, bone

(d) Basic Systems: Kilns - firing wood with partial combustion

(1.) FIXED KILN: permanent site structure, depends on location of wood and cost of labor to operate on constant basis

(2.) PORTABLE KILN: practical on local level as it is relatively easy to operate and can serve the needs of a village by its flexible location; the system is also affordable compared to alternatives

Retorts - furnace or oven; heated by external source and applied to outside of container

(1.) usually a fixed structure in vicinity of stable wood or organic materials

(2.) produces gas and commercial products

(3.) retorts afford better control of the carbonization process; higher yields than the kilns; retorts, however, are more expensive per unit charcoal

(4.) average yield for approximately 4 tons of wood (dry) material is equal to 1 ton charcoal

(e) Advantages:

(1.) use of local materials

(2.) labor intensive

(3.) relative to the use of wood in raw form - charcoal production involves less transport and less labor costs

(4.) ecologically sound; utilization and refining of tropical forest and its residues promote more productive use of natural resources; charcoal serves to convert previously unmark-

etable vegetation to valuable energy source; type of charcoal is a smokeless fuel

(5.) charcoal industries will save forestry costs of thinning and improving forests; trade-off between charcoal yield and the usual quicker return on investment solely through wood preparation

(6.) potential for a viable charcoal industry that will not only develop an efficient energy for the indigenous population but may also expand sufficiently to initiate exporting charcoal on the world market or at least to surrounding countries; this chain of events would certainly increase the profitability of investing in the much needed sector of forestry

APPENDIX F

DETERMINATION OF ECONOMIC OPTIMUM IN FORESTRY PROJECTS

Over a period of more than one hundred years there has been developed an enormous volume of technical literature on this subject. Merely to list all of the reports would be a very large job, and one would almost surely miss some. A full analysis of these reports is probably impossible for any single author, and even if possible would be wholly out of keeping with the purpose and style of this report. My goal in this Appendix is much more modest. The pages which follow present only the barest minimum outline of some of the recent economic literature on this subject. They are designed primarily to give the interested reader a little flavor of the literature and some references by which he or she can follow the subject further, if interested. This discussion may perhaps be most useful to the beginning student in forestry or in environmental management or to one who wishes to know something about the subject without getting too involved.

As a useful generalization, the literature can be divided very broadly into two categories: (1) that by professional economists interested primarily in economic theory, especially in capital theory, who are generally much less well informed about forestry than about economics, and who are generally less interested in the application of their theory than in its development; and (2) that by forest economists who are generally competent foresters as well as economists, interested in application of theory to practical

forestry problems more than in the development of theory for its own sake. There is clearly no sharp line dividing these groups; some observers might classify a writer into a different group than would another observer; and some writers almost defy classification. Nevertheless, this classification is useful and is employed in this Appendix.

It is useful to start a review of recent economic literature, of the first of the foregoing two broad classes, by reference to Gaffney's work (1957). He neatly summarizes some of the basic concepts of timber harvest determination into a single table (Table I). This table and his report analyze the writings of R.D.G. Allen, Irving Fisher, Kenneth Boulding, and others, all better known as economists than as foresters. Basically, Gaffney revives the findings of Martin Faustmann, who wrote in 1849 and whose work is often the starting point for all writers on this subject. Gaffney expands and generalizes Faustmann's approach.

In the derivation of his formulas, Gaffney initially makes the assumption that all costs of timber growing are incurred at the beginning of a rotation -- "regeneration" -- in his terms; and that all income is received when the trees are cut. Later, he shows how recurrent costs and intermediate income can be worked into his basic formulas, but he does not make much use of such intermediate costs and returns. Gaffney develops several formulas, under varying assumptions, which are too detailed to be reproduced here. His expression of the Faustmann formula (in Gaffney's terminology) is as follows:

Table I. Some Concepts of Financial Maturity and Their Advocates in Relation to Two Elements of Urgency

If the Interest Rate is Equal to \ If the Site Rent is	Zero	Annual Equivalent of Periodic Net Revenue
	Financial Maturity is a Maximum of:	
Zero	Total Growth is Maximum (No avowed Advocates)	Mean Annual Net Growth (Waldrente)
Market Rate	Discounted Net Revenue is Maximum (Allen and Fisher)1/	Annualized Net Revenue (Bodenrente) (Faustmann)3/
Maximum Internal Rate	"Internal Rate of Return is maximum (Boulding)2/	Site Rent and Internal Rate of Return (present study)4/

Adapted from Chart, p. viii, Gaffney, see [4].

1/ Allen, R.G.D., Mathematical Analysis for Economists, London: MacMillan and Co., 1938. Fisher, Irving, The Theory of Interest, New York, MacMillan Co., 1930.

2/ Boulding, Kenneth, Economic Analysis, New York, Harper and Bros., Third Edition, 1955.

3/ Faustmann, Martin, Berechnung des Werthes, welchen Waldboden sowie noch nicht haubare Holzbestande fur die Waldwirtshhaft besitzen", Allg. Forst Und Jagd-Zeitung 25: 441-455, 1849. Translated into English as Martin Faustmann and the Evolution of Discounted Cash Flow, by M. Gane, Commonwealth Forestry Institute Paper No. 42, University of Oxford, 1968.

4/ Gaffney, M. Mason, Concepts of Financial Maturity of Timber and Other Assets, A.E. Information Series No. 62, Department of Agricultural Economics, North Carolina State College, Raleigh, North Carolina, December 1960.

$$t = \frac{1}{p} \ln \frac{g'}{g'-p(g-C_o)}$$

where t is the length of the timber rotation (measured in years);

p is the interest rate, measured continuously throughout the year, which compounded equals the annual interest rate (a refinement which even Gaffney admits usually makes no great difference, as contrasted with use of an interest rate);

g' is the annual increment in stumpage value;

g is the total stumpage value; and

C_o is the regeneration cost.

Gaffney discusses numerous approximations of shortcuts and some formulas advanced by other authors (including some not listed in Table I) and shows how each of these may be reasonably good, and perhaps simpler than his own approach, but always under some special circumstances but not under others. For instance, the land rent may be zero or close to it, or the supply of capital may be unlimited at a known interest rate so that the returns to some factor other than capital should be maximized, or other special circumstances may prevail.

Gaffney compares the results of his (or the Faustmann improved) formula with the results obtained by others, in a number of particular situations. Sometimes, the results are nearly the same, sometimes they are quite different, and where results differ, he naturally feels that his analysis is the more accurate. As noted, some approximations do very well in some situations, but discrepancies may be evident only when the correct formula is used as a basis of comparison. As he notes (p.89): "But Faustmann's formula is not a final

solution to the question of financial maturity. It is only a simple classic theme, if you will, for latter day composers to weave into large patterns, to vary and orchestrate with the full symphony of modern instruments".

A recent paper by Paul Samuelson (1976) deserves special mention. Samuelson reviews a number of studies, including that by Faustmann and several by some of the same authors whose work Gaffney had analyzed more than fifteen years earlier, some of which are listed as sources for Table III. All or nearly all the writers Samuelson refers to are better known as economists than as foresters. While Samuelson mentions Gaffney, he does not put much stress on his analysis, preferring to go back to the original works which Gaffney had analyzed. Samuelson goes on to develop his own solution to the problems of optimum age at which to harvest timber, in a highly elegant and fully rigorous way that bears some resemblance to Gaffney and Faustmann. He is very careful to state the four "definite assumptions" upon which his analysis rests, as follows:

> (1) knowledge of future lumber prices at which all outputs can be freely sold, and future wages of all inputs;
> (2) knowledge of future interest rates at which the enterprise can both borrow and lend in indefinite amounts; and
> (3) knowledge of technical lumber yields that emerge at future dates once certain expenditure inputs are made (plantings, sprayings, thinnings, fellings, etc.)
>
> Finally, it is assumed (4) that each kind of land suitable for forests can be bought and sold and rented in arms' length transactions between numerous competitors; or, if the government owns public lands, it rents them out at auction to the highest of numerous alternative bidders and conducts any of its own forestry

operations so as to <u>earn the same maximum rent</u> obtainable at the postulated market rate of interest. (Underlining in the original.)

To the economic analyst working on forestry problems, as to the forest owner /manager, these conditions are highly limiting. Samuelson recognizes that his assumptions are "heroic" but he defines them as necessary for a "simple" solution. On the basis of these assumptions, and by a rigorous mathematical deductive process, Samuelson comes up with a formula for deciding upon the proper timing of timber harvest, which includes input costs (which he reduces to labor costs), interest rate, and rent on land.

The first line of (6b) is the correct Faustmann-Gaffney-Hershleifer formulation. Its equivalence with the maximum-land-rent formulation of (6a) is seen from solving the last relation of (6a) for R and noting its equivalence with the second relation of (6b) except for the extraneous constant r.

$$\text{(6b)} \quad \max_T \left(Pf(T)e^{-rt} - WL\right)\left(1+e^{-rt} + (e^{-rt})^2 + \ldots\right)$$

$$= \max_T \left(Pf(T)e^{-rt} - WL\right) / (1-e^{-rt}) = \max_T (R/r)$$

$$= \left(Pf(T_\infty)e^{-rt_\infty} - WL\right) / (1-e^{-rt_\infty}) = R_\infty/r,$$

In this formula:

T = time

In the steady state, a new part of each forest is being planted at every instnat of time, an old part is being cut down at age T, and forest stands of all ages below T are represented in equal degree.

P = prices for "lumber," by which here, as elsewhere, he apparently means all wood products.

$f(T) = Q_t + T$ = quantity of "lumber" that can be cut at time T + increment of time t

... as we'll see, f(T) is short for f(s,L,T), where L is labor input at the beginning of one planting cycle

and s is the land used throughout that complex cycle.

r = interest rate
W = wages
L = quantity of labor input

and by these Samuelson apparently incudes all current inputs into the forest productive process

Samuelson agrees that if the land rent is zero, then this term can be dropped from his formula. He does not say, but presumably would agree, that if the input costs to the forest landowner were zero, then his term could also be dropped. If an owner did not seed or plant his forest land after harvest, but relied instead upon natural reseeding; if he did not fertilize, thin, or spray at any time; and if fire protection were entirely a public responsibility; then his input costs would indeed be zero or very close to it. Something not too unlike this exists for some small private forest owners. If input costs and rent are dropped out, then the cost associated with timber age is reduced to interest on the harvestable value of the stand. One can either use an assumed interest rate, or one can calculate an age of trees which maximizes returns above this interest rate, or one can calculate the age of trees at harvest which maximizes his rate of return. The results, under this particular set of conditions, should be the same.

Charles Howe, in a recent paper in the same general tradition has also dealt with this same problem, in a somewhat simpler way but stating that he is basing his analysis on those of Faustmann, Gaffney, and Samuelson (1976). He starts (p. vi) with a flat conclusion:

> "In forestry, as in fisheries, there are many levels of sustained yield. The question really concerns the socially optimal rotation (or pattern of rotations) is set, the yields are also set.

He goes on (p.14):

> For expositional purposes, let us assume that we are dealing with a fully regulated forest with an established rotation of t units of time (e.g., decades). A fraction of the forest area (1/t) might be cut and replanted during each unit of time. Letting f(t) represent the volume of timber standing on an acre of land as a function of the time since planting, the physical yield each unit of time would be:
>
> $$(1) \qquad Y(t) = \frac{N}{t} \cdot f(t)$$
>
> where N is the number of acres in the forest. This represents the simplest notion of sustained yield, a yield invariant over time (there is no implication that a forest thus "regulated" is in any sense optimal). (1) makes it clear that there exists a different sustained yield for each value of t, i.e., for each possible rotation.

Howe continued with a more complex case:

> For one acre of forest land which has just been cut and replanted, the optimal rotation problem can be stated as:
>
> $$(2) \qquad \max_{t} \left\{ (\pi_o(t) = (p \cdot f(t)e^{-rt} - k)\ (1+e^{-rt} + e^{-2rt} + \ldots) \right\}$$
>
> where π represents the present value of one acre, p the unit value of timber net of harvesting and transport costs, k for the replanting cost, and where it is assumed that the rotation will be constant forever.

One can welcome his recognition that trees standing in a forest are not logs, much less that they are not lumber, and that the woods are not the point of consumption of the wood grown. There is no recognition of costs other than replanting, nor of management practices other than selecting the length of the rotation.

When it comes to the forest economists who were more interested in solving practical forest management problems than in devel-

oping a body of theory, there is also a large body of literature. In general, these writers have not spelled out their theory in as much detail as the group I call the economic theorists nor have they relied as much on deductive reasoning, but rather they have focused their energies on the application of theory. While these writers vary greatly, of course, most of them use economic theory which is fully adequate for the problem they address, but they do not consider theory as the end product of their work.

When it comes to this group of writers, one scarcely knows where to begin. Duerr in his textbook on forest economics, especially in chapter 9, utilizes this approach to practical forest management problems (1960).

John Walker in a relatively recent study has made two major improvements over most earlier formations: his model explicitly considers markets and the effect of harvest in one period of time upon timber prices in the next period of time, and his model "can start with a timber inventory that is non-optimal. This situation is commonly encountered where forest management must begin with an overmature stand of timber." (1971)

> The situation that must exist between the last unit of wood cut at time t, and the first unit cut at time t + 1, is expressed by the following first degree difference equation:
>
> $$V_t (MR_t - MC_t)(1+i) = V_{t+1} (MR_{t+1} - MC_{t+1})$$
>
> where
>
> V_t = the volume per acre of the last (youngest) age class harvested at time t,
>
> V_{t+1} = the volume per acre of the forest (oldest) age class harvested at time t+1,

MR_t = the marginal revenue of the last unit of wood harvested at time t,

MR_{t+1} = the change in total revenue at time t+1 if a unit of wood of the first (oldest) age class is not harvested in t+1,

MC_t = the marginal cost of the last unit of wood harvested at time t,

MC_{t+1} = the change in total cost at time t+1 if a unit of wood of the first (oldest) age class is not harvested in t+1,

i = the rate of interest for equating net cash flows at times y and t+1.

William F. Hyde has developed the traditional models of economic analysis of optimum date of timber harvest a great deal further than any earlier analyst, primarily by the introduction of a number of additional factors which are highly important in actual forest management situations (1977). Specifically, his analysis is either innovative or stronger than earlier ones in the following ways: (1) by its explicit use of timber yields by site classes; (2) by showing the effects of various forest management practices, including thinning and fertilization, on timber yields, both as measured by volume of wood produced and as measured by size of trees at various stages of the growing cycle; (3) by its thorough analysis of the effects of lags in stand regeneration, on both timber yields and costs of timber production by site classes including the risks of failure in seed plantings, cultural measures such as weeding, and others; and (5) its explicit introduction of differences in "access" or costs of roads and of transport, for sites in different locations and of different topography.

Hyde's analysis is not easily summarized in this brief Appendix. Perhaps more than any other author listed, his work bridges the theoretical and practical approaches. He develops numerous formulas in the best theoretical tradition, but he also introduces a great deal of quantitative empirical data, and he draws policy conclusions of major importance. His analysis not only solves the standard problem of economic age of timber under a wide range of natural and economic conditions, but it also provides the basis for a choice of the economically optimum intensity of timber management under specified conditions, and it also provides the basis for rational economic choice in the allocation of timber land among its many possible uses (such as timber harvest versus recreation).

Forest economists in countries other than the United States have studied the same problems as discussed in this report. A full review of literature from outside of the United States is impossible for this report. One easily read and directly applicable study is by Hiley (1956). His analysis is direct, practical, and realistic. While he gives primary attention to forest plantations, including their establishment, thinning, and other management matters, his analysis is very much in the tradition of forest economics as applied to all forest management problems.

Source: Clawson (1977)

APPENDIX G

FACTORS INFLUENCING SPECIES CHOICE

(i) Ease of Harvesting: e.g., disadvantages of crooked or thorny species. Harvesting costs per m^3 are inversely related to volume per ha. Thus a more productive species will not only need less land for a given yield than a less productive species, but will also be cheaper to harvest.

(ii) Specific Gravity: For wood at a given moisture content, heating value is directly related to specific gravity. Comparisons may be made at different moisture contents, of which "oven-dry" (0%) and "air-dry" (12-20%) are those most commonly used. Although air-dry specific gravity varies by a factor of 8 between the lightest (*Ochroma*) and the heaviest (*Piratinera*) species in the world, the ratio between alternative species likely to be grown for fuelwood on the same site is unlikely to exceed 2. It should be noted that specific gravity in fast-grown short rotation crops may differ considerably from that in mature natural stands. An example is *Eucalyptus grandis*, which has an air-dry S.G. of 0.82 in natural Australian stands but only averages 0.55 in plantations in South Africa.

(iii) Moisture Content: (m.c.) Freshly felled wood usually has a m.c. of between 50% and over 100%. A given volume of average density (S.G. 0.5) if dried from the "green" (100% m.c.) to the air-dry (20% m.c.) , loses 40% of its weight and gains 16% in heating

value (the 16% would be needed to evaporate the additional moisture if burnt green). The gain in heating value is less important than the saving in weight, an important factor if much handling or long transportation hauls are involved.

The m.c. of green wood tends to be higher in the lighter wood, in which there are plenty of air spaces, than in the denser woods. As a general rule, therefore, a species which would be preferred for its higher S.G. air-dry, is likely to be even more superior if used green.

(iv) Extractives: The higher the percentage of extractives (oleo-resins, etc.) by weight, the higher the available heat per unit of wood. Differences rarely exceed 10-20%, even between the most resinous coniferous species and the more resin-free hardwoods.

(v) Heating value: The heat produced by unit volumes of wood at different species is determined by the above factors of specific gravity, moisture content and extractives. Of these, differences in specific gravity are likely to be the most important in modi-fying any choice based on volume yield/ha. Moisture content and extractives are less important, although the former may have a significant effect on handling and transport.

(vi) Durability: Where it is necessary to dry fuelwood before use, its natural durability may be important in reducing losses from termites, borers or fungi.

(vii) Special Characteristics: Certain characteristics of a potential fuelwood species may become limiting for particular uses. Emission of sparks is a disadvantage in an open domestic fireplace or when burned in proximity to flammable buidlings. Odor from combustion may rule out the use of certain species for cooking, fish drying and tobacco curing. Neither characteristic would matter if the wood was used in a furnace for production of mechanical or electrical power.

The following example illustrates the sort of evaluation which may be made when considering alternative species for firewood species. Both Eucalyptus grandis and Eucalyptus paniculata thrive in similar conditions in Africa on warm, moist frost-free sites. Published data (Wattle Rsearch Institute, 1972) indicate that the volume yield of Eucalyptus grandis is about 2.1 times that of Eucalyptus paniculata. But the specific gravity of Eucalyptus grandis at 10% m.c. is only 0.6 that of Eucalyptus paniculata, the m.c. when green is twice as much as the heating value per m^3 green is only 0.57. The net advantage for fuelwood is with Eucalyptus grandis, but only by 20%. Eucalyptus paniculata is much more durable than Eucalyptus grandis (less loss in drying) and is in considerable demand for durable poles. Both species copice well, are resistent to the snout-beetle Gonipterous and produce excellent honey. Eucalyptus grandis, being a quick starter, closes canopy and shades out weeds more quickly and thus is easier to manage in the establishment stage. In this case, it is likely that Eucalyptus paniculata would be favored where there is a demand for durable poles,

Eucalyptus grandis where there is not. As an insurance against unforeseen hazards, it would be wise to plant a proportion of the area to each.

Source: FAO,1977

APPENDIX H

FORESTRY CASE STUDIES

(i) Acacia Senegal Gum and Tree Fallow System, Sudan

Gum arabic has been a known item of trade for over 2,000 years and records of the Sudan gum trade show sales increasing from 126 tons in 1825 to 52,000 tons in 1965 after which exports fell to 42,000 tons in 1970.

Gum was originally tapped from wild trees. Subsequently, in areas close to temporary villages of centers of population, areas of trees were owned, then developed a system of villages with agriculture employing an *Acacia senegal* fallow. With recent increases in population the value of land for cultivation is so great that in certain areas *Acacia* is forced out of the fallow, as there is insufficient time for the establishment of gum gardens. Apart from affecting gum production, the shortening of the tree crop fallow rotation adversely affects soil fertility and stability, and this can affect food production and the peasant economy. Apart from its value in producing gum as a cash crop, the *Acacia* plays an important function in many other facets of peasant life, for example:

(a) Thorny branches are used for fences and enclosures;

(b) The trunks are used as house-building poles, or with the branches provide firewood or charcoal;

(c) The trees markedly increase soil fertility;

(d) Blocks of trees protect the soil from wind erosion;

(e) Small shoots, in leaf or leafless, are a source of fodder for camels and goats;

(f) When in leaf, the trees provide dense shade for grazing animals;

(g) The roots are utilized for rope making and for lining wells.

Other than land pressure, adverse factors affecting the tree crop are fire and overgrazing. Fire reduces yields of gum and kills off established trees, whilst overgrazing in the forms of browsing or pollarding has a similar effect but seldom causes tree death.

The peasant family averages an annual income from agriculture of S£ 66 and some gum tapping is economically necessary to supplement this income. In 1966 the average return from gum would represent a 25 to 28 percent addition to this agricultural income.

The sole species is Acacia senegal and its silviculture is widely known and methods of regeneration, growing and utilization are well established. The generally accepted land requirement figure is 25 ha of which one quarter is for food production, one quarter under Acacias from 0 to 4 years, and one half under productive Acacia from 5 to 12 years old. Grazing among the trees is incorporated in the fallow cycle. The rotation should ideally be so arranged that a normal series of age classes is established in the Acacia fallow. Acacia regeneration needs to be supplemented by sowing of seed and a stocking of 600 trees/ha is desirable.

It is the policy of the Government to allow the gum trade to continue on the local basis that has evolved and the main intervention in the last 60 years has been to regularize the system of sales to the benefit of the producer. Government can stimulate produc-

tion under the "Mimimum Price Agreement" by stabilizing or raising prices when market conditions allow. This Agreement, which was introduced in 1962, is the formulation of the gum price structure. The Government reviews prices annually and fixes a minimum auction price to the producer and a minimum export price.

In theory all land is owned by the Government, but in practice individuals have rights over land allotted to them and are entitled to the income from such, irrespective of whether they work it themselves or hire it out.

Key Features

The main factor is the strong and continuous demand for gum arabic. The industry is based on a single and well-known species, *Acacia senegal*.

With the development of settled agriculture in the *Acacia* areas, the species has been incorporated into an agricultural system suited to the ecology of the region in which, during the tree fallow period, not only is soil fertility replenished but production of gum is promoted. The local community has shown considerable self-reliance in organizing gum collection and developing the agrisilvicultural system.

(ii) Forestry for Community Development in Tiro, Ethiopia

This pilot project is very much in the initial stages and full implementation lies in the future. The Tiro Subworeda comprises a mountainous valley with a population of 15,000. The people are mainly Oromo who have been sedentary agriculturalist in the area since the nineteenth century. Deforestation is prevalent, but Tiro Forest of 5,000 ha, mainly *Juniperus procera* and *Podo-*

carpus gracilis remains. A 50 km all-weather road has been constructed to allow logging of this forest. The road has had some community inputs and is associated with the forestry project. There are local shortages of fuelwood and poles, but it is considered that the situation will continue to worsen over the years.

Prior to the 1974 revolution there were extensive farm owner occupiers, but since then all land is vested in the state. Many of the former owned cattle, sheep and goats. The land use pattern in the valley has not been studied. The main aspirations of the people are reported to be for clinics, schools and employment. The objectives are:

(a) to intitiate and encourage sustained reliance in forestry within the context of rural development, and

(b) to test and evaluate a methodology for rural development in Ethiopia.

Land use and wood use surveys are preliminary requirements. It is envisaged that 5 to 40 ha blocks will be available on steep slopes; 1 to 5 ha blocks will constitute minor areas, and 0.1 to 1.5 ha areas around dwellings. As only an additional 1 ha is planned for development no technical details are given.

The State Forest Development Agency (FWDA) provides the main management and technical inputs. Within the project area there are 14 Peasant Associations (PA's) who elect a representative committee. All land is nationalized but the people have rights of utilization. The PA's control land and labor. Forests over 80 ha in area are state forests controlled by the FWDA, forests of less than 80 ha are generally classified as for the community and are controlled by the PA. The project is carrying out social

studies to understand the local population's attitude to forestry.

The PA contributes land, labor and community organization. The FWDA contributes technology, seedlings, training, transportation and tools. All of the material benefits are intended to accrue to the community and the state benefits from environmental effects.

The project is at too early a stage for any achievements to be recorded.

(iii) The Shamba System in Kenya

The Wa Kikuyu tribe were by tradition shifting cultivators in the forest areas and had cleared extensive areas prior to the establishment of the forest estate in the early part of this century. The employment of Wa Kikuyu as licensed cultivators in the Forest Department's Shamba System is first recorded in 1910. The number of participants had risen to over 9,000 by 1975.

The Wa Kikuyu and some related tribes are industrious agricultural people having a considerable demand for land to cultivate. In 1966 the Forest Department considered that there remained some 140,000 ha of existing forest reserves, mainly in the Kenya highlands, suitable for this system, and the soils are generally productive under agricultural crops.

The main difference between the "shamba" system and many "taungya" systems is the considerable integration of the cultivators into the Forest Department. Under the "shamba" system as organized in the 1960's the resident workmen agreed to work for the Forest Department for nine months each year; to clear in his own time the

low value cut over indigenous bush cover from a specific area of land (0.4 to 0.8 ha) each year; to allow the Forest Department to plant trees in the cleared land (the shamba) after 18 months; and to keep these trees weeded for three years. By tradition, the men carry out the initial clearing, but the subsequent "shamba" cultivation is by women.

The Forest Department guaranteed the resident workman nine month's work per year; supplied a house and land for shamba cultivation; assisted in felling large unmerchantable trees during clearing; allowed the growing of annual crops (maize, potatoes, beans, peas and other vegetables) and the depasturing of 15 sheep. The resident worker's duties included nursery work, planting, weeding, pruning, house and road construction. The produce from the participant's shamba was considered as part of his emoluments. An assessment made in the 1960's showed that depending on distance from areas of demand and the state of the market, and after providing for his family's needs, the surplus agricultural produce could be worth up to 2.8 times the annual minimum agricultural wage applicable in the area. The apparent savings to the Forest Department, by considering the "shamba" as part of emoluments, were to some extent offset by the necessity to employ a labor force large enough to prepare adequate areas of land for reforestation. The surface "shamba" produce made a significant contribution to national food requirements. In 1962 and 1963 the maize marketed by this 1% of the population contributed 6% to 10% of the total smallholder production and it was estimated that potato production formed an even large proportion of national production. In the mid-sixties,

increased agric ltural production from smallholdings, created by splitting larger farms, reduced vegetable prices and had an adverse effect on the income from the shamba system.

In 1976 there was a radical change in the system. All the resident forest workers are employed for a full year and have the status of civil service workers. If they wish to cultivate crops they have to rent the land from the Forest Department. This virtual elimination of the "shamba" system has resulted in significantly increased direct establishment costs. It was estimated that of the 9,000 shamba workers, only 6,000 full-time workers were required to meet the labor needs of the plantation program.

Key Factors

(a) Land hunger and the availability of industrious traditional shifting cultivators.

(b) The facility with which shifting cultivation could be developed into the "shamba" agrisilvicultural system and good fertile soil in forest areas.

(c) The sharing of agricultural preparation and cultivation between men and women permitted men to take up paid employment for nine months each year.

(d) Increased government inputs of housing, social services and settle forest villages have assisted in the continuation of the system. On the other hand, the creation of settled communities has created problems of transport as the distance between village and shamba has increased.

(iv) Village Afforestation - Dodoma District, Tanzania

Community forestry is part of the 'Ujamaa process', wherein the state wishes to mobolize all resources towards the elimination of poverty, ignorance and disease. The basic unit is the 'Ujamaa Village' and forest policy requires the encouragement and assistance of forestry by local and village organizations. Dodoma district contains some 120 villages with some 500 families each. The people are mainly farmers and per capita income is T.sh.34 to 45 per annum. There is an average per capita holding of five head of cattle, and this creates considerable pressure for grazing land. Community plantations commenced in 1967, but have been placed on a sounder basis since 1973. Fuel and other forest needs are taken from an ever-diminishing natural savanna forest.

The primary objective is to establish local woodlots for fuel and poles for local needs. Other aims include tree planting for soil and water conservation, and to reclaim depleted land.

A preliminary general soil survey was carried out. Some eight tree species were used including Cassia, Eucalyptus, Grevillea, Neem and Eucalypts, with the last named being the main woodlot trees. Eucalypts are a ten-year rotation with an m.a.i. of 12 m^3 ha. Plants are raised in departmental nurseries in polythene pots. The seedlings are transported to villages and villagers carry out planting and tending with technical advice from the forest department. Tending has proved a constraint in particular areas.

The project comes under dual control of the District Commissioner or Party District Secretary who is a political appointee and the District Development Director who is a civil servant. All of the land is state owned. The Forest Department provides technical advice, extension, transport and nurseries for plants. Villagers are trained in forestry practices but no financial incentives are paid. The forestry staff of one professional, two foresters and nineteen others is insufficient for the required program. The scheme also involves the Ministries of Agriculture, Land and Education.

The community provides labor and the government provides land, technical services and extension. The main community benefits are:

(a) Fuel and poles;

(b) Increased agricultural production due to reduced erosion, and from time saved by not having to travel distances for fuelwood;

(c) Income from sale of surplus products;

(d) Technical knowledge of forestry.

Some 650 ha of plantations were established between 1972 and 1976, and this represents approximately 40 percent of targets. Some of the plantations are already producing and meeting needs. Some areas have been lost due to insufficient tending, fire or grazing.

Key Factors

(a) Government's sustained commitment to raise the rural standard of living.

(b) Need for integrated approach to land use to reduce the conflict between agriculture and forestry.

(c) The 'Ujamaa process' has replaced the traditional systems with a new 'non-tribal' approach, but the development of local forestry appears to require greater extension or incentives to encourage participation.

(d) The technical requirements for the local woodlots require to be more clearly defined and the number of species is perhaps greater than necessary.

(e) Community inputs and benefits have not been quantified so it is difficult to convince people that their labors will be worthwhile in rewards. Failed plots must have an adverse effect on participation.

Source: PAO, 1977

APPENDIX I

AN EXAMPLE OF AN ENERGETICS SYSTEM

(i) Morren, 1978 (pf.)

(ii) Deschler, 1965 (pff.)

(For greater detail of this approach,

See:

Little, M., and Morren, G. (1976) -

Ecology, Energetics and Human Variability.

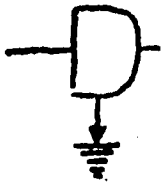
Wm. C. Brown. New York.)

Energy Source
(Sun, Fuel, Food, etc)

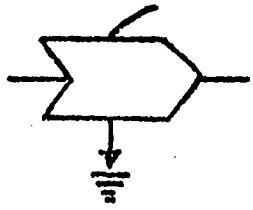
Passive Storage
energy moved into storage; potatos into a cellar, oil into a tank

Heat Sink
heat lost, 'degraded', in 'real' processes but necessary to them.

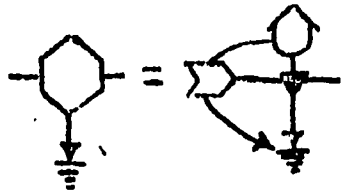
Potential Gener
Work
Energy delivered t
storage against
force.



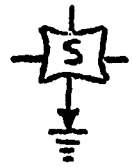
Energy Receptor
reception of 'pure' energy, light, heat, etc.



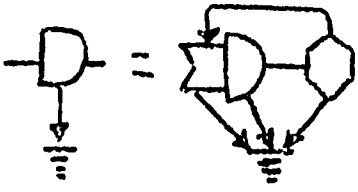
Work Gate
one flow of energy ('work') makes possible another flow of energy.



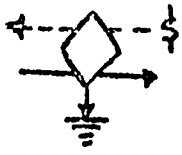
Self-Maintence
a unit that can store energy can also direct it to the support of its own activities; e.g. an organism, population, etc.



Switch
flows with only o
off states contro
other flows.



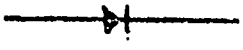
(Receptor) Green Plant
self-maintaining unit directs energy to operation of receptor function.



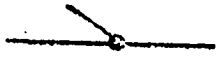
(Economic) Transaction
flow of energy adjusted to socially defined value (subject to debate)

Constant Gain Amplifier
Gain (not just flow as in work gate) dependent on supply of energy from above.

Active Impedan
'back force' or re
tance against
increased input.



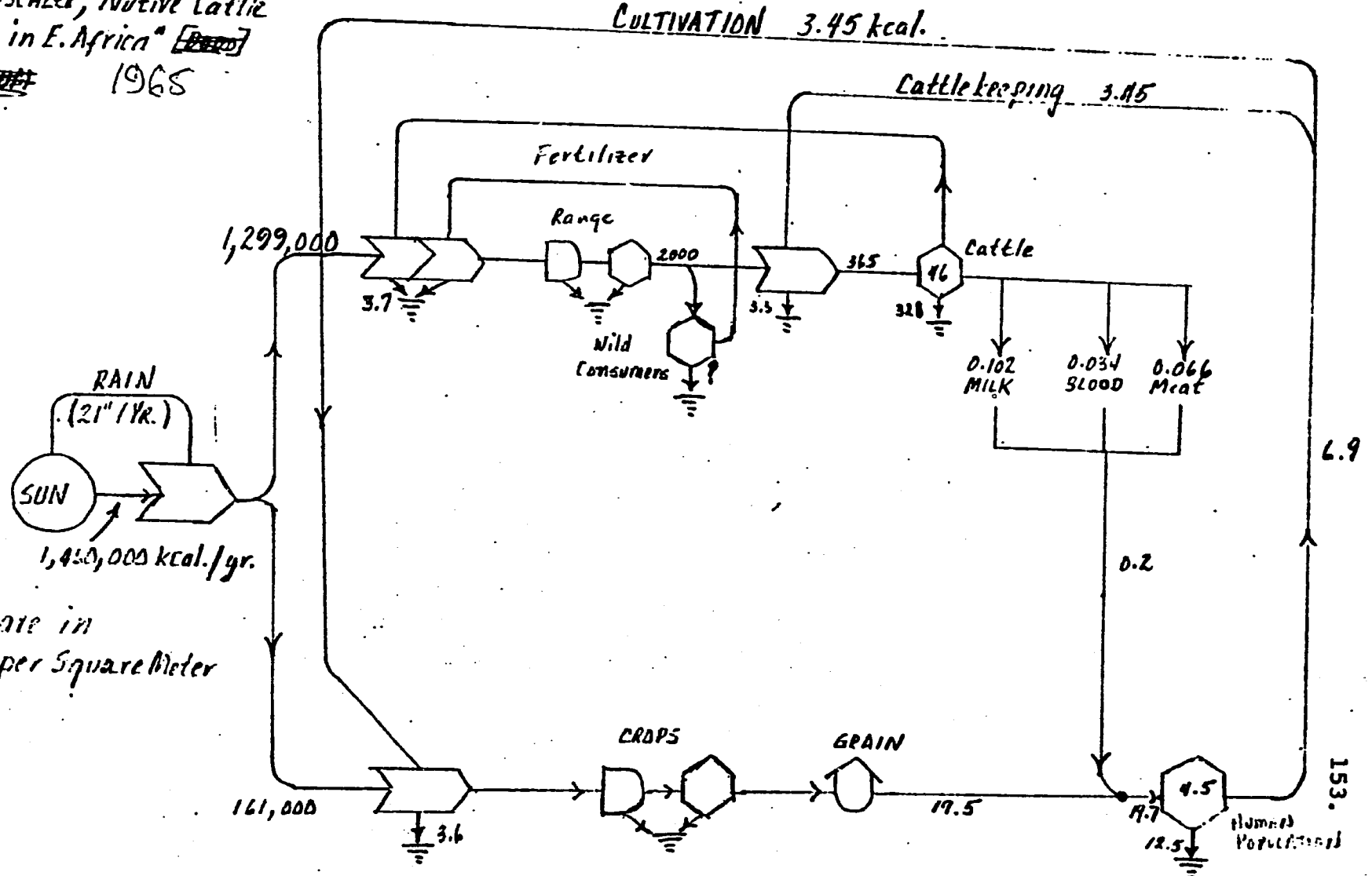
One Way Valve
Flow can pass in one direction only.



Adding Junction
Two flows of similar type come together.

Energy Circuit Graphical Language - each module represents a basic energy process or a standard combination of them.
(Mower 1978)

Data From: Deschlee, "Native Cattle Keeping in E. Africa" 1965



All Quantities are in kilocalories per Square Meter per year.

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