

The Impact of Rural Energy Use on the Environment During the Economic Reforms Period(1981-1992): Some Evidence From Tanzania

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Abstract

The article briefly presents the energy situation in Tanzania, discusses the relationship between structural adjustment programmes and emerge use problems. It looks at the objectives of these SAP programmes to see the effects on the energy sector and how these, in turn, affect the environment. In the article, a number of observations are made including the following ones: the pattern of electricity tariff revisions which have been affected by TANESCO, have created a structure which may be environmentally devastating by encouraging the consumers to use more fuelwood and charcoal for their energy needs; from the official aggregate data for urban fuelwood and charcoal consumption, the own price responsiveness for fuelwood demand, was found to have been negative and inelastic; a substitution relationship was found to have existed between kerosene and fuelwood; as income rises urban consumers use less fuelwood and conversely, if urban dweller's income falls relative to rising prices or increased unemployment, more people will turn to the use of fuelwood and charcoal for their everyday energy needs; the urban population coefficient for fuelwood, indicates that an increase in the urban population puts pressure on woodfuel demand through consuming more woodfuel; the positive relationship between electricity price and charcoal demand, means that a substitution relationship existed between the two energy sources for the period of analysis (1977-1995) and finally examples drawn from Lushoto and Nzihi provide empirical evidence that factors such as cost of fuel availability and ease of access to fuelwood do influence choice of fuel source by most consumers.

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1.0 Introduction

The structural adjustment programmes initiated by both the World Bank and IMF, have their origins in the global economic events of 1973/74, predominantly influenced by the first oil price shock. The sudden and sharp rise in oil prices hit the non-oil producing developing countries more severely than others. The aftermath of this event was a world trade contraction and a sharp decline in export prices of many commodities, thus aggravating the ability of these countries to meet their financial and other obligations.

The introduction of Structural Adjustment Programmes (SAPs) was thus prompted by the economic crises ensuing after the oil shocks. The main objective was to help correct trade imbalances of the ravaged economies of mainly developing countries, through short term, medium and finally long term Structural Adjustment Lending (SAL).

In most of the developing countries, and Tanzania in particular, the oil crisis ran parallel with the woodfuel crisis. While the depletion of woodfuel sources due to indiscriminate woodfelling for energy needs (e.g., agro-based industries, brick-making, fish drying, etc.) led to severe deforestation, the spiralling oil prices resulted in Tanzania using up to 62% of its export earnings in 1985 to import oil (Kulindwa, 1994).

In short, the argument being advanced here is that, SAPs implemented in Tanzania for the past eight years were not the cause of energy problems experienced over time, but rather these structural adjustment programmes aggravated the problems already existing as will be discussed later.

This paper aims to investigate how energy use impacts the environment, and vice-versa. It starts by looking briefly at the energy situation in Tanzania. This is followed by a discussion of the relationship between SAPs and energy use problems. In this section we also look at the objectives of these programmes to see if the energy sector was explicitly considered as one of the priority areas. Also, we trace the various SAP policies' effects on the energy sector and how these, in turn, affect the environment. In section four we provide empirical evidence on energy use by rural households and agro-industries based on field work conducted in six villages in Iringa Rural and Lushoto Districts in April 1994. Finally, we conclude our study by giving some policy recommendations.

2. Background to the Energy Situation in Tanzania

2.1. General Overview

Energy is a basic need, a critical resource, and an integral part of any economy. Its performance affects all other economic activities as well as the environment,

both directly and indirectly. When discussing the energy situation, we consider the supply (e.g., production and/or importation of different energy sources) vis-à-vis end-use or consumption. In short we are looking at the balance between demand and supply.

The social welfare of the people is directly linked with the energy sector through domestic energy supply and utilisation. However, the energy input to other sectors of the economy affect the people indirectly through the provision of industrial products, transport and other social services. Also, energy use has implications on the natural environment in terms of extraction of woodfuel, and reduction of carbon dioxide emission/absorption capacity.

There are a number of existing and potential energy sources in Tanzania apart from woodfuel. These include solar (the sun and windpower), coal, natural gas, geothermal, hydropower and biogas. Hydropower potential has been estimated at 4,000MW of installed capacity, while proven and recoverable high quality natural gas resources at Songosongo is estimated to be 18 million Tons of Oil Equivalent (TOE), and that at Mnazi bay, estimated to be 15 million TOE (SADCC, 1986). According to a coal sector study (Ministry of Energy and Minerals, 1987), coal production was estimated at 150,000 tons of raw coal per annum.

The main sources of energy in Tanzania are woodfuel, oil and electricity. Oil and electricity are the commercial ones, while woodfuel (fuelwood and charcoal) is the traditional non-commercial source which does have dual categories depending on where they are found. For instance, in urban areas woodfuel is mostly commercial, while in rural areas it is both commercial and non-commercial.

According to the aggregate energy balance for Tanzania in 1991, woodfuel was estimated to supply about 88% of the total energy requirements. Use of woodfuel by rural households accounted for about 69% of the total energy, while agricultural and rural industry use accounted for about 11% of the total woodfuel supply. Household consumption of woodfuel was estimated at 82.3% of the total. Electricity consumption by the households was 37% of the total by 1993 (URT, 1994). A very small proportion of petroleum products is consumed by households in a form of illuminating kerosene and liquefied petroleum gas (LPG) (URT, 1992).

As a result of a continuous and increasing pressure on the woodfuel energy source by households and the conversion of woodlands and forests into crop land, commercial logging, etc., some analysts have asserted rather alarmingly that the country's wood reserves estimated at some 38 million hectares

(URT/UNIDO: 1981) could be entirely wiped out by the late 21st century. A depletion rate of 400,000 ha. per annum due to clearing for agriculture alone is often quoted. A tentative estimate of the rate of deforestation caused by fuelwood extraction is put at 575,000 ha per annum (Bagachwa, *et al*, 1995).

The rapid rate of deforestation calls for a sustainable management of forests and woodlands, i.e., balance between demand and supply. With afforestation and effective use of woodfuel (through use of more efficient stoves, more efficient technologies for the preparation of charcoal), the seemingly uncertain future in the supply of woodfuel might be reversed and environmental balance improved. Since our analysis is centred on activities in rural areas with the bearing on energy and the environment, we will pay more attention to wood-based energy; its effect on the environment with respect to its utilisation.

2.2. Woodfuel supply and demand situation

Studies done on woodfuel to date have shown somewhat different estimates of the potentiality of its supply and demand. But, at least all studies concur that, woodfuel is the most important energy source in Tanzania since it caters for the greater percentage of the country's energy requirements, mostly in the domestic sector for cooking, heating, etc. (see Table 1).

Table 1: Tanzania's energy supply proportion by type of source.

Source	Quantity*	% Contribution of Energy Source
Fuelwood	617.54	81.65
Charcoal	50.36	6.66
Coal	0.70	0.09
Electricity	4.66	0.6
Petroleum	37.12	5.0
Crop residues	44.65	6.0
Total	756.32	100.0

*million Gigajoules.

Source: Ministry of Water Energy and Minerals, Energy Department (1992).

As far as consumption is concerned, the distribution of the total energy consumed in 1991 as follows (Kulindwa, 1994): households: 78.5%; industry: 12%; transport: 2%; Commercial: 4.3%; and agriculture : 3.2%.

As already seen, estimates on the potentiality of the woodfuel supply differ greatly from one study to another with a few exceptions. This shows the complexities involved in trying to estimate the potential supply, and the rate of consumption of forest products. Firstly, not all wood is for woodfuel. Even if every wood species were to be used for woodfuel production, a diversity of calorific efficiency levels exist among different species. The total area covered by the three main vegetation types in Tanzania was put at 38.0 million hectares. Closed forest was about 2% of the total area, woodland covering 76% of the total area, and the remaining 22% is bushland and thicket (Mwandosya and Luhanga, 1983). Whereas the harvesting of fuelwood and poles takes place in the bushland and thicket vegetation types, nearly 50% of the closed forests are for sawn logs, and 50% for poles and woodfuel. Furthermore, 70% of the woodland is for fuelwood and poles for building, and the remaining 30% was for sawn logs for use in furniture and construction activities. Other uses of forest products include drugs and medicinal herbs, industrial oils, dyes and resins.

Fuelwood is also used for agro-industries such as tobacco-curing, tea drying, fish smoking, and also local brewing, brick-burning, pottery and ceramics. For example, it is reported that 150m³ of fuelwood are required to cure a tonne of tobacco (URT, 1992, p.22). In 1989 alone, a total of 11,554 tonnes of tobacco were produced. Assuming all these were cured using wood, then they might have required about 1.733 million cubic metres of wood, consuming 43,327 hectares of woodland. In the case of tea, 1m³ of fuelwood is required to dry between 120-140 kg of tea. Given a rising trend in tea production, it is clear that more wood is required for processing tea.

Most of the uses outlined above are important, but are not the major causes of deforestation. The major causes of deforestation include clearing of woodlands for agricultural expansion, or getting rid of pests such as tsetse flies. Deforestation is also caused by indiscriminate burning of woodland for easy farmland clearance, shifting cultivation, and the demand of charcoal and poles created by urbanisation. An attempt to quantify the relative importance of factors contributing to deforestation in Tanzania has revealed the estimates shown in Table 2.

2.3. Afforestation Efforts

Although deforestation had started long before the 1973/74 and 1979/80 oil crises, the crises have helped create more awareness about the existence of woodfuel crisis. Due to fuel shortages, energy users in the domestic,

commercial and industrial sectors turned increasingly to woodfuel as an alternative energy source. This was manifested by intensifying afforestation programmes that began in the 1967/68 financial year. The programme, which was part of the overall rural development strategy, was aimed at encouraging individual participants to plant trees around their residential areas, and to establish village collective woodlots.

Table 2: Factors contributing to deforestation in Tanzania.

Activity	Hectares per annum	Percentage
1. Fuelwood extraction	575,000	55.4
2. Land clearing for agriculture	400,000	38.6
3. Tobacco curing	40,000	3.8
4. Commercial logging	17,650	1.7
5. Uncontrolled fires and others	4,335	0.5
Total area deforested	1,036,985	100.0
Less		
6. Natural regeneration (50%)	518,493	50.0
7. Reforestation	3,500	0.3
Estimated net deforestation	514,992	49.7

Source: Bagachwa, *et al.* (1995: 97).

Afforestation activities are undertaken by the government, village communities, and non-governmental organisations, among others. All the villages included in the 1994 Economic Research Bureau/Institute of Resource Assessment (ERB/IRA) survey, had embarked on afforestation programmes which were popularised through schools, churches and other local community institutions. Table 3 shows the afforestation effort manifested by area planted with trees per annum, and the rise and decline after 1988/89.

Table 3: Afforestation efforts in Tanzania (area in hectares)

1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1992/93	1993/94
1871	2849.5	4164.2	5507	5894	2663	2233	1525	4000

Source: Economic surveys (various issues).

There are a multitude of factors influencing the trend shown in Table 2. The general problems include the lack of organisational set-up, the lack of back-up facilities for extension workers, and in most cases a shortage of field extension workers.

However, the expenditure reducing policies adopted under SAP in order to reduce the budget deficit worked negatively on the part of afforestation campaign launched by the government itself. For instance, tree planting registered a hefty decrease of 54% in 1989/90 (Table 3). Figure 1 demonstrates the declining trend in real government expenditure on afforestation from 1970 to 1990. This implied that government assistance was not forthcoming to supplement villagers, efforts in tree planting and care.

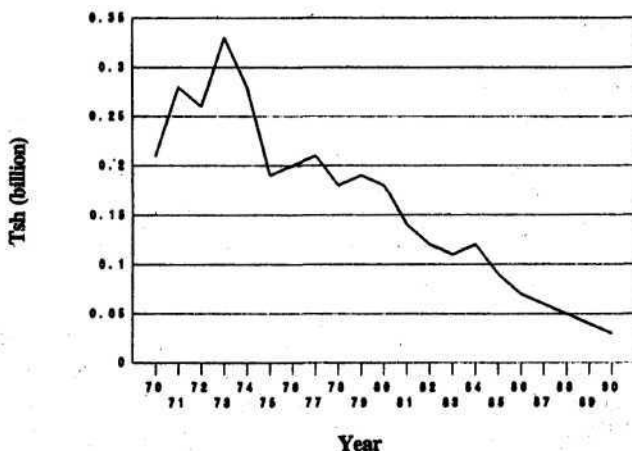


Fig. 1: Real Government Expenditure on Afforestation in Tanzania (1970-1990)

3. The Impact of the Adjustment Policies on The Energy Sector

3.1. Did Previous Adjustment Policies Consider the Energy Sector a Priority?

As discussed earlier, the structural adjustment programmes were initiated partly with the objective of restoring the trade balance of developing countries. However, some other sectors did not receive adequate attention depending on how far they were perceived to be from the major problem, and/or the magnitude of available resources.

In Tanzania, the government reacted to the economic crises of the late 1970s and 1980s by formulating corrective macro-economic policy measures to redress the declining socio-economic conditions. These efforts included adjustment programmes such as the National Economic Survival Programme (NESP) of 1981, the Structural Adjustment Programme (SAP) of 1983, and the Economic Recovery Programme (ERP) that covered the period between 1986-1992. Currently the adjustment programme runs under the rubric of Rolling Plan and Forward Budgeting (RPFb).

In the literature on economic policies in Tanzania, it is pointed out that NESP, as a crisis management policy, put more emphasis on increasing industrial and agricultural output, utilising domestic resources rather than on economic infrastructural development. It is also to be noted that the policy said little about the energy sector. Thus, it was quickly superseded by another programme (SAP) before it was implemented.

The 1983 Structural Adjustment Programme was a second independent government effort to restore output levels to pre-crisis levels, improve public finances, reduce inflation, and improve internal and external imbalances. It was stated explicitly that in order to reduce the burden of imported energy on the balance of payments, maximum effective use of known potential domestic energy sources was to be sought. The most remarkable savings were envisaged to come from phasing out diesel generators in hydroelectric power generation. However, since SAP was hinged on foreign capital inflows and only 35% of the expected assistance was received, its objectives were not attained.

Over the years following the petroleum crisis, a number of measures have been taken to cope with the crisis. Following the oil crisis of 1973, some measures had been instituted to try and conserve consumption of petroleum. These measures mainly affected the transport sector by rationing fuel, and imposing a ban on Sunday driving. The shortages of oil products experienced during the 1980s were mainly caused by the world market price fluctuations, and the shortage of foreign exchange to procure oil products, more than the effects of the adjustment programmes.

The ERP, as a continuation of the SAP, did have similar objectives as those adapted by SAP in its effort to achieve sustained growth in real incomes and welfare improvements. The energy sector was considered as one of priority areas, but one notes that the energy source touching the majority of the population was not addressed explicitly in the ERP document. More resources were allocated mainly for investment/rehabilitation of power generation and distribution, completion of Mtera Hydroelectric Scheme, extension of the

National Grid, and the importation of oil. The traditional energy source was left for the annual budget—subsidies which keep dwindling due to restrictions on public spending policies. Declining government efforts have been shown in Figure 1. ERP II's major concern was to redress the negative effects brought about by ERP I on the welfare of the people through social services delivery.

On the whole, it can be observed that the structural adjustment programmes have not induced a significant shift in the structure of energy supply and consumption. Instead, access of households to domestic energy sources has probably remained the same, or worsened. Lack or shortage of domestic energy might mean a poorly cooked meal or even missing it altogether. In the long run, the shortage of energy becomes an underlying cause of environmental degradation due to unsustainable utilisation of the biomass resource base. This is because biomass resources are easily accessible to most people.

The two sides of the energy crisis (increase in oil prices and depletion of woodfuel sources) are interrelated and mutually reinforcing. On the one hand the supply of woodfuel is constrained by such factors as clearing of land for agriculture and settlement, excessive felling of wood for timber and building poles. The continuous rise in demand for wood-based energy sources is caused to a large extent by the persistent rise in oil based energy sources, high and rising electricity tariffs, declining real incomes of consumers, lack of more efficient technologies, lack of effective energy alternatives, and increasing population, especially in urban areas.

3.2 How do SAP policies affect energy and the environment?

In the Tanzanian context, the analysis of linkages between economic reforms and the energy sector proceed from the understanding that the country faced the energy crisis before SAPs. However, SAP policy measures may have not been effective in mitigating the underlying causes of the energy crisis, but rather exacerbated the problems in this sector. In this section we trace the effects of SAP policies through its policy instruments and analyse the nature and direction of the relationship between SAP, energy and the environment.

1. Exchange Rate Adjustments

The devaluation of the Tanzanian shilling is intended to encourage exports and discourage imports. Since exported commodities use natural resources, a reduction in the exchange rate provides more incentives for their extraction.

Exports of forestry products increased from 3,174m³ in 1980 to 25,651m³ in 1991. In the case of forest resources which are important for the supply of woodfuel, increasing the rate of extraction means more deforestation. An increase in distances to woodfuel supply areas leads to the increase of the cost of supply, hence increased price of woodfuel to final consumers.

The devaluation of the shilling also increases the price of imported fuels such as petrol, diesel, kerosene and liquefied petroleum gas, as well as electricity generating equipment, thus inducing substitution for woodfuel. This increases the demand for fuelwood and hence contributes to an increase in the rate of extraction.

2. Market Liberalisation and Other Institutional Reforms

Specific liberalisation measures include trade deconfinement, price decontrol and privatisation, all of which create a liberalised atmosphere for all sorts of trading domestically and externally. The result of liberalisation has been an increase of non-traditional exports in recent years. For example, the 1993 economic survey reports the export of charcoal worth Tsh 19,400m for 1992 (URT, 1994). Due to marketing reforms, tea and tobacco firms seek both internal and external markets for their commodities without having to pass through the marketing boards. This development has given rise to aggressive marketing and increased trade. For tobacco and tea farmers, the result has been the expansion of production. Furthermore, the tea farmers of Mponde in Lushoto district recorded a 20% increase of green tea leaves in the 1993/1994 season. The impact of such expansion, if not done in a sustainable manner, is to exacerbate deforestation.

3. Budgetary Policies

These have sought to increase revenues and reduce expenditure. A fall in government expenditure allocations to afforestation programmes and management of forests contributes to unsustainable extraction of wood due to inadequate monitoring and enforcement of recommended extraction practice. Expenditure reducing policies also work against community afforestation programmes by reducing assistance from the government in terms of extension staff, seedlings, and related inputs. Removal of subsidies on seedlings, for instance, resulted into a drastic rise in their prices. Furthermore, staff responsible for the enforcement of rules and regulations are de-motivated by low and irregular salary payments, lack of equipment, and arbitrary permits that

infringe on existing regulations from higher levels in the administrative and/or political machinery. The outcome of this is to give opportunities to unscrupulous traders and civil servants to degrade our environment for their selfish interests.

4. *Energy Prices*

There is a set of ERP measures that affect the environment by altering the pattern of energy use through increased energy prices. As noted earlier, devaluation and removal of subsidies on domestic energy price induces consumers to shift to woodfuel and therefore put more pressure on the biomass resource.

Available data (see Table 4) indicate that between January 1988 and March 1993, electricity tariffs have been revised several times. The table presents the charges for residential, light commercial, light industry and agriculture tariffs. In most of the categories shown, prices rose tremendously in 1991 up to 114.28% for the domestic sector; 75% for light commercial; and 97.9% for agriculture. Cross-subsidisation worked in favour of light commercial and light industry by reducing their prices by 16.67% and 21.87% respectively. The most important categories in terms of woodfuel consumption are the residential (tariff 1) and agriculture (tariff 4A) categories. For both of them, price increases have been high compared to the other categories. Although prices were reduced by 57.14% in 1992 for tariff 4A, it rose again by 63.33% in 1993. The increase in the overall electricity price, and the pattern of electricity tariff revisions, create a structure which may be environmentally devastating by encouraging consumers to use more fuelwood and charcoal for their energy needs.

On the other hand, the nominal price of kerosene has risen from Tsh 46 per litre in 1982 to Tsh 113 per litre in 1992, almost 2.4 times. In real terms this represents an increase of 58% for the eleven year period, or 5.3% annually. The price of gas has risen from Tsh 5.65 per kg in 1982 to Tsh 133 per kg, also a twenty-four fold increase or 66% in real terms. This represents 6% annual price increase.

The increases in prices of electricity, kerosene and gas should be compared to charcoal whose nominal price increased sixteen fold from 1982 to 1992. In real terms, the average price of charcoal rose by 13.4% in the eleven year period, or 1.2% per year, an increase which is much lower than that of the other energy sources. It is obvious that substitution from electricity, gas and kerosene towards charcoal is favoured by the price developments.

Table 4: Percentage change of electricity tariffs from previous revision

	1. Residential (units)		2. Light Commercial (units)		3. Light Industry (units)		Agric. (units)
	0-100	101-1000	0-200	201-1000	0-1500	1501-3000	No range given
Jan. 1988*							
Jan. 1989: 1	25	20	0	33.2	-22	6.7	60
2	66.7	66.7	-60	60	60	60	8.6
June 1989: 1	0	11.1	0	18.75	2.56	1.4	31.25
2	0	0	0	0	0	0	0
Aug. 1989: 1	66.7	5	50	5.26	0	0.58	23.8
2	100	100	0	66.7	66.7	6.7	100
Jan. 1990: 1	0	9.5	33.3	5	15	1.95	26.92
2	0	0	0	0	0	0	0
July 1990: 1	6.25	8.69	0	30.43	39.83	20	45.45
2	0	0	0	0	0	0	0
Jan. 1991: 1		12	0	16.67	0	6.67	97.9
2	17.64	30	100	100	100	100	0
July 1991: 1	100	114.28	75	-16.67	-21.87	28.57	26.32
2	23.0	23	0	0	0	0	0
Jan. 1992: 1	50	66.7	42.85	16.67	0	6.67	16.67
2	33.3	33.3	25	0	0	0	0
Oct. 1992: 1	33.3	25	16.67	5.7	10	3.33	-57.14
2	0	0	0	0	0	0	0
Jan. 1993: 1	25	12	28.57	8.10	9.09	3.22	16.67
2	50	50	0	0	-1000	-1000	0
Mar. 1993: 1	20	7.14	28.57	12.5	16.67	3.12	63.33
2	0	0	40	50	0	0	25
July 1993: 1	67	100	161	87	207	142	94
2	33	33	43	33	33	33	60
June 1995: 1	15	16.6	NA	NA	NA	NA	NA
2	0	150					

Notes: 1 = % change in electricity price per Kwh; 2 = % change in service charge
* = base year

NA = Not available because not desegregated in the TANESCO reports consulted.

Source: Own Calculation from Appendix table 5

4.0 Empirical Evidence From Regression Results and Two Case Studies

Conventionally, the demand for goods is determined within the framework of an economic analysis. In our case, the demand for the different energy sources is influenced by several factors, including: the level of income of the consumer, availability of close substitutes, and the prices of these substitutes. Each of these factors influences the demand of a particular energy source in different ways. In particular, the responsiveness of the consumer to using a particular energy source depends on how much income one gets, and the proportion of that income used to purchase the energy source. The availability or non-availability of substitutes of an energy source determines the speed at which the consumer can decrease or increase the use of that particular energy source, given a price rise as well as availability of the energy source.

From the official aggregate data for urban fuelwood and charcoal consumption, the above relationships have been quantified for the case of Tanzania. The price responsiveness for fuelwood demand was found to be negative and inelastic (see Appendix 1). This means that either fuelwood price is not yet a significant factor influencing the consumption of fuelwood, and/or that fuelwood is a necessary good whose demand is conditioned by its own availability and accessibility, as well as the availability of effective alternatives and the level of income of the consumer. A substitution relationship was found to exist between kerosene and fuelwood. This has important implications on the use of the two energy sources in the domestic sector. Given that these two sources can perform similar tasks of cooking and heating, a rise in the price of kerosene, relative to the price of fuelwood, for instance, will result into a decline and selective use of kerosene for lighting, while at the same time increased fuelwood utilisation will occur for cooking and heating. This change of energy use mix, has major environmental implications in the form of increased wood-felling and deforestation.

Another important factor in both the fuelwood and charcoal equations is the average urban income. This was found to be negatively related to fuelwood consumption. This means that, as income rises, urban consumers use less fuelwood (see Appendix I). This implies that fuelwood falls into the inferior goods category. Conversely, if urban dwellers' income falls relative to rising prices, or increased unemployment due to retrenchment, more people will turn to the use of fuelwood and charcoal for their everyday energy needs. Urban population is important in determining the structure for energy demand, especially if the majority of this population falls within the woodfuel consuming category. The urban population coefficient for fuelwood (+1.33), indicates that

an increase in the urban population puts pressure on woodfuel demand through consuming more woodfuel.

The positive relationship between electricity price and charcoal demand, indicates that a substitution relationship exist between the two energy sources even during the period of analysis (1977-1990). Here the relative prices of these two energy sources is crucial in influencing the consumption of either of them.

Empirical evidence from case studies of Lushoto and Iringa Rural districts confirm these quantified relationships. The tea factory in Mponde, Lushoto District, for instance, began by using woodfuel for tea drying. After some time the distance and availability of fuelwood was seen to threaten the smooth functioning of the factory. This resulted into fuelwood being substituted by coal. Transport costs and related problems made the factory switch from coal to diesel. However, as diesel prices soared over time, it was deemed economical to use woodfuel to produce steam. The factory has established its own woodlot for its supply of fuelwood.

Another price related example was found in Nzihi village in Iringa Rural. Large scale tobacco farmers have been using woodfuel as their main source of energy for curing tobacco. Currently, a power line is being extended through their area which will provide electric power for their tobacco curing activities, as well as their domestic uses. Discussions with several large-scale tobacco farmers revealed that the prospect for the farmers to use electricity for tobacco curing were slim. Among the reasons advanced included the high and increasing price of electric power to agro-based industries. They argued that, while the electric barns are expensive, it is possible to use electricity for the blower. However, their long-run intention is to use coal instead. In the meantime, they continue to use woodfuel, and at the same time establish woodlots.

The evidence from Lushoto underscores the fact that costs, availability, and easy access matters in the consumers decision making. Furthermore, it exhibits the possibility of switching from one energy source to another for some activities. In this example, there is no direct SAP policy implication on the energy switching exercise undertaken. However, with the SAP marketing reforms, more tea is bought and processed for the domestic and export markets. This consequently requires more fuelwood for drying, with the inevitable outcome of more tree felling.

The Nzihi example, on the other hand, gives clear signals of how energy consumers respond to price changes with respect to choice of which energy source and technology to use given the available alternatives, and other factors such as financial resources. The increase in the price of electricity has been the

outcome of SAP measures to promote efficiency through competition. This measure require firms to operate on commercial and competitive basis. This move necessitates the price increases for electric power in order for the company to break even, and make some profit. The result of this, while seemingly positive for the electric supplying firm, is to discourage the use of this energy source by some consumers. Subsequently, this encourages consumption of less efficient and relatively more polluting energy sources such as coal and woodfuel.

5.0 Conclusion and Policy Recommendations

This paper has drawn attention to the fact that the energy crisis of the early 1970s was one of the major causes of global economic destabilisation, and of the Tanzanian economy in particular. This brought the need for having structural adjustment programmes (NESP, SAP, ERP I, ERP II). However, the programmes have not been able to induce the desired changes in the energy sector. This might partly be explained by the objectives they set to achieve. Indeed, some of the problems have been exacerbated under the ERP's after 1986.

Therefore, there is need for policy makers and economic actors alike, to understand more clearly and consider the implications of the current pattern and trend of energy use on the environment. These implications include:

1. Increased demand for fuelwood due to population increase. Price increases for substitutes like electricity, gas and kerosene, and their unstable supply lead to deforestation. For example, 12 tonnes of wood are required to produce 1 tonne of charcoal (URT, 1992). The impact of charcoal-making on the woodlands surrounding towns, municipalities and villages is devastating and very visible in the absence of afforestation and reforestation.
2. Due to unreliable supply of hydroelectric power, domestic, commercial and industrial users have had to resort to importing standby generators, thus contributing to existing emissions of carbon dioxide. In the face of electricity rationing, Tanzania Electric Supplies Co. (TANESCO) is reviving its diesel plants to stabilise the supply of electricity in the city of Dar es Salaam. The effect to the environment due to this exercise is to increases the level of emission of carbon dioxide. Since these power stations are situated within or near residential areas, health hazards are inevitable.

3. Vast amounts of woodland are cleared not only for cultivation but also for crop drying, the most notorious being tobacco curing which requires 150 cubic metres to cure every tonne. As far as tea is concerned, 120-140kg of dried tea require about 1m³ of fuelwood. This translates to 3.75 hectares of wood for curing 1 ton of tobacco, and 1 hectare of wood for drying 5 tonnes of tea. This contributes to deforestation.
4. If the potential for hydropower is to be maintained, watersheds must be protected and siltation minimised. However, the construction of hydropower requires reservoirs which take up substantial amounts of arable land, and in most cases affect flora and fauna when land is inundated. An integrated approach is required to take care of the various trade-offs.
5. The production of electricity from coal as considered in the development of the Kabulo and Mchuchuma is a welcome transformation, but it is associated with emissions of Carbon dioxide and sulphur, among others, into the atmosphere which leads to global warming and acid rain that could affect forests and agricultural land. Careful analysis should be undertaken, and appropriate steps taken to circumvent the negative effects of this development.

5.1 Policy recommendations

The following recommendations emerge from this paper.

1. The Tanzania energy policy document has already identified a set of thirteen measures that ought to be taken in order for the energy sector to contribute positively to environmental preservation (URT, 1992:23). These cover such aspects as reviewing, strengthening and enactment of laws and regulations regarding the protection of catchment areas and existing reservoirs for power generation, requiring environmental impact assessment (EIA) before the exploration of any new energy sources, supporting afforestation and reforestation efforts, including raising peoples awareness and monitoring atmospheric emissions, to mention a few. What needs to be emphasised though, is the formulation of an operational plan for implementing the policy.

2. To support and encourage agro-industries such as tea processing and tobacco-curing to use alternative sources of energy such as electricity, coal and others. In the case of coal, measures should be taken to ensure that pollution agents associated with its utilisation are minimised.
3. To put more emphasis into research and development of non-wood energy sources such as solar, wind power, biogas, etc., to support innovative entrepreneurs to turn research results into useful technologies by creating a fund for such activities. This can be achieved through support from government, non-governmental organisations, and other interest groups.
4. To promote and support afforestation programmes by encouraging agro-forestry and establishment of woodlots through beneficiary participation.
5. To institute an integrated pricing mechanism for the different energy sources so as to influence an energy consumption pattern that is commensurate with the desired energy and environmental objectives.
6. To enact laws making it compulsory for big woodfuel users such as tobacco and tea growers to have woodlots for their own reliable supply of wood-based energy.
7. To encourage and work towards the development of a regional integrated power supply network in order to stabilise and improve the quality of electric power supply in the region for a more efficient and stable economic growth. The implication of this is to encourage an increased use of electricity so as to reduce the dependency on woodfuel and other sources.

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APPENDIX I: The Demand for Wood-based Energy: Regression Results

$$1 \quad FW = 1.72 - 0.11P_{fw} + 0.23P_{ke} - 0.36Y_{ur} + 1.33POP_{ur}$$

$$(0.18) \quad (-1.14) \quad (1.6) \quad (-0.20) \quad (2.78)$$

$$R^2 = 0.94 \quad D.W = 2.19 \quad F = 38.00$$

$$2. \quad CHA = 7.896 - 0.043P_{cha} + 0.82P_{ke} + 0.162P_{el} - 0.820Y_{ur}$$

$$(1.129) \quad (-0.453) \quad (4.361) \quad (1.264) \quad (-0.535)$$

$$R^2 = 0.98 \quad D.W = 2.83 \quad F = 116.7$$

where:

FW = fuelwood,

CHA = charcoal,

P_{ke} = price of kerosene,

P_{el} = electricity price,

POP_{ur} = urban population

and Y_{ur} = urban income.

APPENDIX II: Table 5: Changes in selected electricity tariffs 1988-1995.

Time/Price/ Service Charge	TARIFFS						
	1. Residential (units)		2. Light Commercial (units)		3. Light Industry (units)		4. Agric. (units)
	0-100	101- 1000	0-200	201- 1000	0- 1500	1501- 3000	Unlimited
Jan. 1988							
1 Price (Shs/Kwh)	0.6	0.75	1	6	5	6	1
2 Service charge(Shs)	15	15	250	250	250	250	9200
Jan. 1989;							
1	0.75	0.9	1	8	3.9	7	1.6
2	25	25	100	300	300	300	10000
June 1989							
1	0.75	1	1	9.5	4	8.5	2.1
2	25	25	100	300	300	300	10000
Aug. 1989							
1	0.8	1.05	1.5	10	4	10.25	2.6
2	50	50	100	500	500	500	20000
Jan. 1990							
1	0.8	1.15	2	11.5	4.6	12.5	3.3
2	50	50	100	500	500	500	20000
July 1990							
1	0.85	1.25	2	15	6.4	15	4.8
2	50	50	100	100	500	500	20000
Jan. 1991							
1	1	1.4	2	17.5	6.4	17.5	9.5
2	65	65	200	1000	1000	1000	20000
July 1991							
1	2	3	3.5	15	5	12.5	12
2	75	75	200	1000	1000	1000	20000
Jan. 1992							
1	3	5	5	17.5	5	15	14
2	100	100	250	1000	1000	1000	20000
Oct. 1992							
1	4	6.25	6	18.5	5.5	15.5	6
2	100	100	250	1000	1000	1000	20000
Jan. 1993							
1	5	7	7	20	6	16	15
2	150	150	250	1000	-	-	20000
March 1993							
1	6	7.5	9	22.5	7	16.5	24.5
2	150	150	350	1500	1500	1500	25000
July 1993							
1	10	15	23.5	42.00	21.5	40	47.5
2	200	200	500	2000	2000	2000	40000
June 1995'							
1	11.5	17.5	NA	NA	NA	NA	NA
2	200	500					

Source: TANESCO, Planning Department, November, 1995

Notes: 1. Here, there was a change in the tariff categories, where light commercial, light industry, agriculture etc., were lumped into low voltage supply (above 7500 Kwh) and high voltage supply category (11KV and above). The unit charge for the low voltage category is Tshs 51.85 per Kwh and a service charge of Tshs 3,289.5 per meter reading. The unit charge for high voltage is Tshs 53.5 per Kwh and a service charge of Tshs 3289.5 per meter reading.

NA = Not available because not desegregated in the TANESCO reports consulted.

APPENDIX III: The Energy-Environment Link

The following is a list of environmental and other socio-economic issues related to the energy sector. It was based on energy scenarios for Senegal but they seem to be of equal concern for a country like Tanzania. (Lazarus, *et al.*, 1994:11-12).

Issue	Indicator
Land Degradation:	Cumulative land cleared for charcoal production Soil erosion
Natural ecosystems:	Loss of bio-diversity/loss of habitats as a result land clearing
Agricultural Productivity:	Soil and nutrient loss
Indoor air pollution:	Household emissions of CO ₂ NO ₂ , HC, SO ₂ , TSP
Local Air Pollution:	Emission of NO ₂ , Ozone, HC, sulphur dioxide, air toxins
Global Warming:	Green house gas emissions carbon dioxide (CO ₂) Volatile hydrocarbons (CH ₄ , HC)
Water Use and Pollution:	BOD, COD suspended solids, chemicals, toxins, thermal discharges, silt, water availability.
Employment:	Jobs created/cost
Rural welfare:	Effects on local farming systems and subsistence activities. Local firewood availability
Economic development:	GDP, Natural resource accounts.