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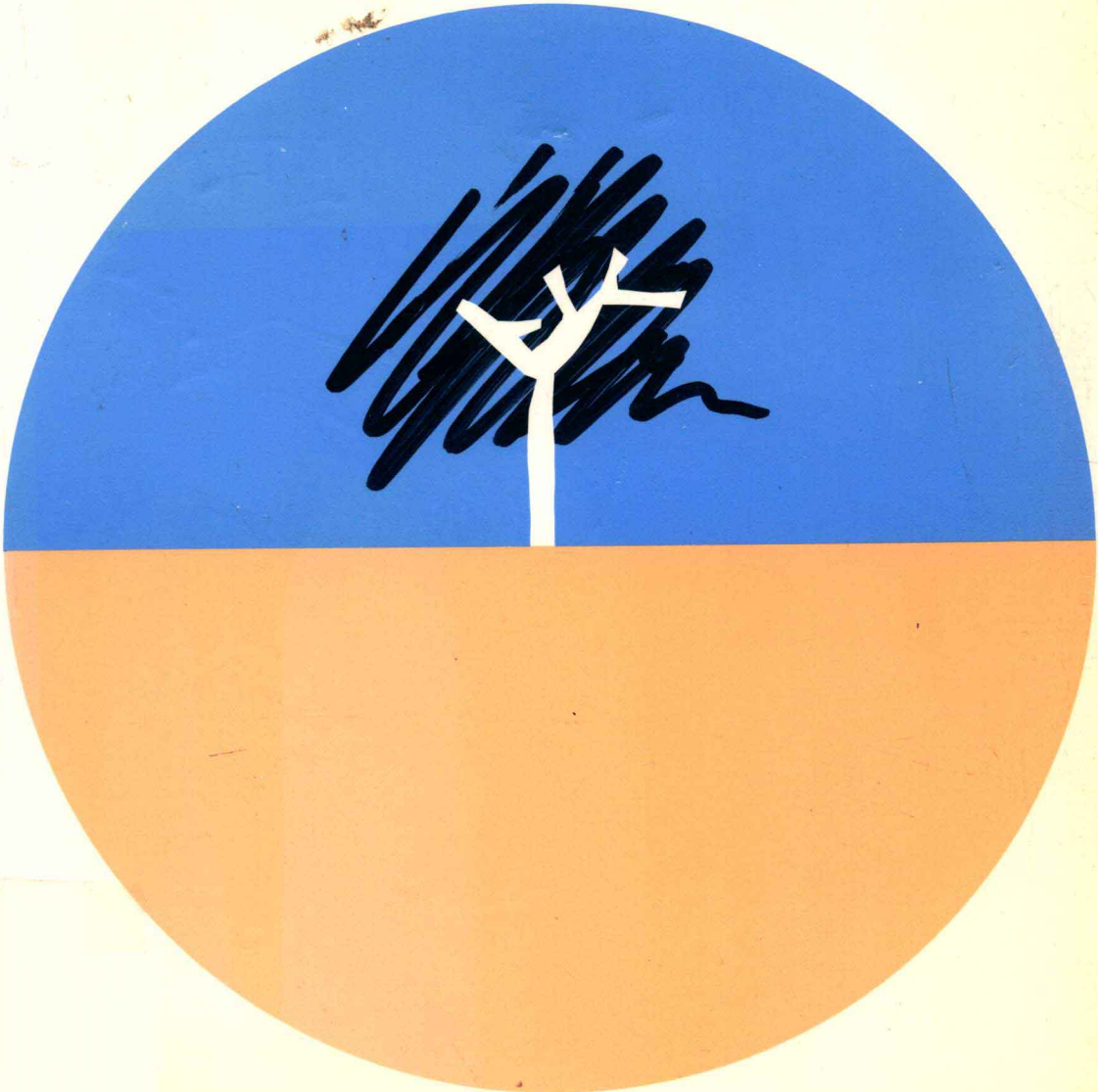

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Equivalents

The following equivalents have been used:

1 m^3 = 35.31 ft^3
1 m^3 wood = 700 kg
1 m^3 solid wood = 2 steres (2 m^3 stacked wood)
1 stere = 350 kg
1 stere = 0.276 cords (1 cord = 8 × 4 × 4 ft stacked wood)
1 stere = 0.5 m^3 solid wood
1 bundle = 1 headload/cycle load = 22 kg
1 donkey load = 3 bundles = 66 kg
1 kWh = 860.5 kcal
1 naira (₦1) = 100 kobo = US$1.50 (in 1983)

References to tons are to metric tons

Editorial Note and Acknowledgements

The Kano Rural Energy Research Group was set up in 1982 under the sponsorship of the United Nations University (Development Studies Division), in the Department of Geography, Bayero University, Kano, and under the direction of Professor Michael Mortimore. The group consisted of members of the staff of the department, with the addition of R.A. Cline-Cole, Training Fellow of the United Nations University, who was assigned to the project for two years. The group submitted an interim report to the United Nations University in April 1983.

The planning and writing of this final report, like the project, have benefited from the full participation of all the members of the project group. Regular consultations and exchanges of views have, we believe, helped to crystallize objectives, strengthen arguments, and encourage fresh insights. Within this framework of collective responsibility, the authorship of the chapters of this report is as follows:

Chapter 1	M.J. Mortimore
Chapter 2	J.A. Falola and H.A.C. Main
Chapter 3	H.A.C. Main, M.J. Mortimore, and F.D. O'Reilly
Chapter 4	J.E. Nichol
Chapter 5	R.A. Cline-Cole
Chapter 6	M.J. Mortimore

The cardinal objective that has guided the editor, Professor Mortimore, has been to balance the perspectives of individual authors against the need for a coherent presentation consistent with the importance of the subject. In addition to those whose names appear above, the project also benefited during its formative stage from a contribution by S. Patrick, whose departure on a study fellowship later necessitated his withdrawal from active participation.

The Rural Energy Research Group and the Department of Geography are grateful to Professor Ibrahim Umar, formerly Vice-Chancellor of Bayero University, whose active encouragement made the project possible. Dr. E.A. Olofin, Head of the Department of Geography, has done everything possible to facilitate the completion of this report. The group wish to put on record their appreciation for the contribution made to this study by Malam Muhtari Sadique, whose experience in field research in Kano spans 25 years and is second to none, and Malam Aminu Shehu, now both of the Computer Centre, Bayero University. The group also wish to acknowledge the help of K. Tandoh (Faculty of Technology) and E. Yacim (formerly, Department of Geography) with the bomb calorimeter tests; Alhaji H.M. Turabu, Chief Conservator of Forests, Kano State; and H.M. Burkill (Royal Botanic Garden, Kew) with botanical information. John F. Antwi and S.O. Taiwo (Cartographic Unit, Department of Geography) prepared the maps and diagrams for this report, whose completion was helped in various ways by J. Wumani, E. Isim, and B. Odimkemere of the Department of Geography Office.

Summary

1. *Introduction.* In the light of an impending crisis which is widely perceived to be threatening wood fuel resources in developing countries, the Kano Rural Energy Research Project set out to investigate the quantitative and organizational dimensions of wood fuel production, consumption, and exchange, and the ecological implications of wood fuel resource management. The area chosen for the study was the Kano region, in northern Nigeria, where a major urban metropolis is extending its firewood hinterland beyond the Kano Close-Settled Zone (where intensive agroforestry is practised) to woodlands at ever greater distances. The study investigated consumption in urban Kano, the rural-urban trade in firewood, the ecology of wood fuel, and the management of wood resources in the hinterland. It was carried out between April 1982 and 1986.

2.1. *Fuel Consumption in Metropolitan Kano.* In furtherance of the first objective, surveys were carried out from April 1982 to June 1983, covering 395 households and 115 businesses and institutions in Metropolitan Kano. The households were distributed in nine residential zones of the urban area, and the non-household sample covered nine types of business or institution, divided between the formal and informal sectors of the urban economy.

2.2. *Household Consumption.* Mean monthly consumption of firewood in a sample of 80 households was found to be 332 kg, and highly variable between households and zones; at prevailing prices this level of consumption then represented an expenditure of ₦24.66 — one-fifth of the national minimum monthly wage. The major use is for cooking, and 70 per cent of the households use fabricated metal stoves for this purpose. Wood is bought predominantly from small retailers, and although clear patterns of consumer preference may be discerned, supply limitations usually dictate a mix of firewood species.

The position of wood is strong relative to other fuels, 67 per cent of households using it for cooking or heating. Its chief rival for cooking is kerosene, also used for lighting; and electricity is used by almost all households, but very little for cooking. An investigation of the socio-economic characteristics of household heads shows that cultural factors are uppermost in determining the levels of firewood use (the most significant variables being state of origin, geographical division, nationality, literacy, and residential location). This results from an association between in-migration and modernization.

2.3. *Non-household Consumption.* This takes place in the food and catering industry (bakeries, restaurants, and roadside food sellers), boarding educational institutions, and prisons. Consumption per month ranges widely, from as few as 16 to as many as 3,200 bundles, equivalent to a range of 350–7,000 kg, and monthly consumption during term-time in the educational institutions as a whole is thought to be in the order of 500 tons per month. Non-household users procure their wood from a wider variety of sources than domestic users, since the scale at which some of them operate pays them to approach wholesalers or even to send trucks into the country. An analysis of species preferences, and the reasons for them, shows that slow burning, heat output, and the production of charcoal as a residue are the most valued characteristics of firewood. The multiple use of energy sources is noticeable among non-household users; the mean number of energy sources used is 2.4, and for secondary boarding schools, 4.2. This diversity arises from the need to substitute energy sources during shortages as well as from functional requirements.

2.4. *Energy Transition.* Notwithstanding widespread agreement among consumers that firewood prices had risen substantially during the five years preceding the survey, a continuing upward trend in demand is predicted on the basis of both household and non-household consumers' expectations. These expectations are related to technical and supply considerations as well as price relativities amongst possible alternatives. The equipment for cooking with gas, electricity or even kerosene is more costly than firewood stoves or the virtually costless three-stone hearth, and less suited to cooking for large households. Wood supply is more reliable than that of any of its competitors. The price factor itself is expected to operate in favour of firewood in future, as subsidies are removed from the prices of petroleum products.

3.1. *The Trade in Wood Fuel.* The firewood hinterland of Kano is divided into two on the basis of dominant modes of transport. The *local* (or precolonial) hinterland was defined, for practical purposes, by the range of a donkey's day journey (about 30 km), since this animal was the dominant mode of transportation until the 1960s. Beyond it is the *distant* hinterland, accessible only by motor transport, where (1) farmers harvest wood from farmland, fallow or bush in small consignments for sale along the roadside, and (2) entrepreneurs send trucks into remote woodland for systematic exploitation on a large scale.

3.2. *The Local Hinterland.* Surveys of traffic in wood fuel, conducted in the 1960s and 1983, show that the local hinterland has declined dramatically during the last two decades. Donkey traffic had fallen, by 1983, to six per cent of its former volume, from 150 to 8.5 tons per day. Including traffic by bicycle, headload, and motor pick-up, the local hinterland now sends about 8,500 tons per year to Kano, only 20 per cent of the traffic by donkey 20 years ago.

3.3. *The Distant Hinterland.* On the other hand, recorded imports from the distant hinterland were running at 425 tons per day in March–April 1983, 96 per cent of it carried by truck. The distant hinterland is extending rapidly, some consignments coming from up to 600 km away. Lightly populated woodland areas are favoured by specialist traders in firewood, who send trucks in on payment of very small fees to local authorities. After payment for the wood, labour, and other costs, profit margins are wide enough to compensate for transport costs, at the prevailing retail prices.

3.3. *Changing Hinterlands.* Large-scale operations are more profitable than small-scale wood transactions, and have attracted merchant capital to the distant hinterland. Other contributing factors are consumer wood preferences (popular woods are scarce in the local hinterland) and the high value set on alternative uses of trees in the local hinterland. The ecological implications of the change in hinterlands is that the view that the forest resources nearest the urban area are at greatest risk from a conservationary standpoint is inappropriate; the greatest risk of degradation is in distant woodlands subject to intensive exploitation, and lacking any provision for replanting or protection.

3.4. *Commercial Firewood Production in the Local Hinterland.* Commercial woodcutting is a specialist part-time occupation among farmers, and most woodcutters work alone, during the dry season, on trees belonging to others. The decision to cut all or part of a tree is made by its owner, in response to an economic contingency at the family level, or because a tree dies. More than half the wood is cut for sale within the community, the remainder being carried to the nearest market, to the roadside, or to Kano. Certain species are cut more frequently (especially *Acacia albida* and *Parkia biglobosa*), partly because of their popularity as firewood and partly because of their relatively high rate of mortality under conditions of drought stress. The second of these trees is prominent amongst new plantings, in which most woodcutters are active. In such planting, the alternative uses of trees are considered as important as their firewood potential. Thus, commercial woodcutting is not a threat to the continuity of the agro-forestry system of the Kano Close-Settled Zone.

3.5. *Urban Firewood Distribution.* This is organized hierarchically. Most firewood arrives by truck at a central depot, before being split, bundled, and distributed through a chain of local wood piles, smaller neighbourhood piles, and

itinerant retailers. The organization and costs of local firewood pile operators and barrowmen show that the entire system falls into the urban informal sector. It is uncontrolled, but competitive and cost-efficient from the consumer's point of view, and effective in meeting the spatial and temporal distribution of demand.

4.1. *The Ecology of Wood Fuel.* Population growth, urbanization, land-use change from woodland or fallow to permanent cultivation, and recurrent drought in recent years may suggest a decline in the availability of wood fuel. In order to predict the impact of such changes as well as the stability of ecosystems, an evaluation of the production and regeneration of woody vegetation under different management regimes was carried out in two study areas in the inner and outer Close-Settled Zone (the first less than 20 km west of the edge of the urban area, and the second approximately 100 km south-west of it). The data are derived from air photographs and ground surveys.

4.2. *Inner Close-Settled Zone.* The first study area is densely populated, intensively farmed, and stable in land use. Counts carried out on air photographs dated 1972 and 1981 and ground surveys carried out in 1983–1984 show that the density of trees on permanent farmland increased significantly (18 per cent) during the period. The volume of timber, excluding the tree *Adansonia digitata* (which is not used for firewood), is 8.9 m^3 per ha, almost twice as large as the residual areas of shrubland. The species composition of farmed parkland is markedly diverse (39 species). In residual shrubland, by contrast, timber volume is low and the species few (five). A comparison of the species distribution with the relative popularity of different trees as firewood shows little correlation between the two.

4.3. *Outer Close-Settled Zone.* The second study area is less densely populated and less intensively cultivated, and contains a larger (though diminishing) proportion of fallow and shrubland, and also part of a protected forest reserve. On farmed parkland, evidence was found of a significant increase in tree density from 1972 to 1985 (26 per cent; on a larger sample, it was 10 per cent). Timber volume on farmed parkland is 108 m^3 per ha, much higher than in study area 1 and eight times larger than that on shrubland. The higher volume is due to the trees, though fewer in number, being larger in size. Species diversity is less marked on farmed parkland (22 species) but more developed on shrubland (15). In the forest reserve, significant differences were detected between riparian woodland, savanna woodland, and shrub savanna. The first is more disturbed by grazing and cutting, having fewer but larger trees than the other types. The timber volume of the forest reserve (41 m^3 per ha) is lower than that of farmed parkland, but higher than that of shrubland, and among the species represented, the most common, by a significant margin, is the popular firewood tree, *Anogeissus leiocarpus*.

4.4. *Regeneration.* Timber volume is more closely related to the presence of large trees than to large numbers of trees. Farmed parkland in the outer Close-Settled

Zone is the most productive management regime, and therefore the trend of conversion of shrubland into farmland is beneficial to wood production. The evidence for increasing tree densities on farmed parkland, even close to the urban area, during a period of recurrent drought stress, shows that the replanting and protection of farm trees is widespread and effective. Girth size spectra for the trees sampled show that while the future of the three management regimes (farmed parkland, shrubland or fallow, and forest reserve) is not under threat, two species — *Acacia albida* and *Parkia biglobosa* — have relatively few individuals in the smaller classes. *Anogeissus leiocarpus* shows less evidence of stress, and *Diospyros mespiliformis*, the other tree used mainly for its wood, has a size distribution suggestive of increasing dominance in the future.

5.1. *The Management of Fuel Resources.* The decentralised firewood management system of the Kano Close-Settled Zone defines needs, evaluates supplies, and resolves conflicts between firewood and other uses of trees. The study uses information obtained from individuals in Dugurawa village, which is about 20 km west of Kano in the inner Close-Settled Zone. This is a community which produces its wood fuel on its own land.

5.2. *Indigenous Evaluation.* Energy needs are defined in terms of distinctions between the types of wood fuel (wood, charcoal, and cornstalks), the forms in which fuel is used (split wood, logs, etc.), and its uses (indoor and outdoor fires, "heavy" and "light" cooking). The uses define the quality requirements, which are denominated in terms of such characteristics as rapid or slow combustion, low sparking, or smoking. Wood species are categorized according to their performance, and these properties are systematized in such a way that a group of "universals" or favourite woods emerges. This group includes *Acacia albida*, *Anogeissus leiocarpus*, *Butyrospermum paradoxum*, *Khaya senegalensis*, and *Tamarindus indica*.

5.3. *Laboratory Evaluation.* Bomb calorimeter tests were carried out on fire-ready samples of a number of woods. The popular use of weight (or hardness) as a proxy for energy content was found to be justified since, although calorific value by weight does not correlate with energy content, calorific value by volume does so, and wood is bought in volumetric measures (bundles). The belief that "heavy" or hard woods are the most suitable for charcoal production also has scientific validation, in that their calorific value shows high lignin-extractive content. These findings support the view that indigenous firewood evaluation is an accurate reflection of reality.

5.4. *Efficiency.* Drying techniques are highly effective, reducing the moisture content to levels normally associated with oven-dried wood, and permitting the efficient recovery of net heating value. Cooking techniques do not lend themselves conveniently to evaluation, because married women, who do the cooking, are secluded. Nevertheless, it is noted that combustion control devices are used to

maximize the efficiency of the prevailing three-stone hearth; little use is made of stoves. The conservation of fuel is a recognized objective, as shown by the method used for boiling water for post-natal ablutions.

5.5. *Firewood Management Systems*. In relation to the centralized forestry system operated by government agencies in Kano State, the decentralization of the firewood management system in Dugurawa has recently increased, owing to the weakening of the authority structure in local government. But this development has exposed its strengths. Firewood is only one among many uses of trees. The cutting of live and healthy trees is rare. The need to replace felled trees is recognized, although no longer fully enforced by local government; but the seedlings available from the government nursery (such as neem, eucalypts, and mahogany) are not satisfactory as replacements for the main parkland trees (such as *Parkia biglobosa*), and may have few alternative uses or low value as fuel. This highlights a conflict of objectives between the two systems; exotics dominate production forestry in Kano State, but attempts to get farmers to set up small plantations have failed. Meanwhile, the farmers continue to propagate their farm trees as best they can. Centralized forestry is far from effective at the household and village levels, but the decentralized system operating in the Close-Settled Zone is efficient, logical, and tuned to satisfy consumer demand.

6.1. *Policy Issues*. Metropolitan Kano is the major market for wood fuel in the northern states, and developments there and in its hinterland suggest ways in which other parts of Nigeria (and Africa) may go in the future. Chapter 6 therefore deals with four major policy issues: (1) urban demand and supply; (2) the wood fuel hinterland; (3) alternative sources of wood fuel; and (4) the transition to alternative sources of energy.

6.2. *Urban Demand and Supply*. The estimated consumption of firewood per person in urban wood-using households is 360 kg or 1.03 steres or 0.52 m^3 of solid wood per year. This is comparable to levels of consumption reported from some other localities, although lower than a number of estimates made in other countries in tropical Africa. Firewood is used in conjunction with a range of other fuels, and its price has a restraining effect on demand. On the basis of a model population of one millioin (1983), and making allowances for non-wood-using households (32 per cent) and non-household use, average firewood consumption is estimated to be 273 kg per person per annum (0.39 m^3). Total consumption in Metropolitan Kano is estimated to be 268,000 tons per annum, 383,000 m^3, or 766,000 steres. Assembling the fragmentary evidence from traffic surveys and consumption estimates since 1952, there is some evidence for a decline in the average consumption per person, but due to a population increase, aggregate demand rose by a factor of five. Imports from the local hinterland declined by a factor of five and the demand was transferred to the distant hinterland.

6.3. *Wood Fuel Hinterlands.* The commonly accepted hypothesis of an urban firewood hinterland constrained by transport costs to a proximate and widening zone around urban centres, and subject to progressive deforestation, is inappropriate under northern Nigerian conditions. The burden of providing for urban demand has been effectively shifted from the inner Close-Settled Zone to the further Kano region, but without deforestation. The change has been furthered by producer resistance in the Close-Settled Zone, where trees have alternative-use value, by an improved transport infrastructure, by low petrol prices, and by the availability of merchant capital. Nevertheless, a continuing productive role is expected for small-scale production of wood fuel as a component of an intensive system of agro-forestry.

6.4. *Sources of Wood Fuel.* Firewood (and charcoal) may be obtained from four major sources: plantations, natural forests, farmed parkland, and fallows or shrubland. Plantations of exotics have been advocated on productivity grounds. But in semi-arid conditions, their productivity has failed to meet expectations (mean annual increments of 3–4 m^3/ha are realistic), and in conjunction with rising costs, and technical and management problems, this suggests that little hope may be placed in them as the main answer to Metropolitan Kano's wood fuel requirements. With regard to natural forests, the low mean annual increments (0.9 m^3/ha) achievable and the small area of woodland available for improved management (less than 5 per cent of the state) indicate that even under strict management, it is improbable that Kano State can achieve self-sufficiency from this source. With regard to farmed parkland, although incremental data are not available, the present study shows that timber volume may be more than double that of protected natural woodland and nearly 10 times that of degraded shrub fallows. The conversion of more shrubland into farmed parkland is therefore consistent with an increased output of wood fuel for both urban and rural needs. While there is a case for plantations and for the improved management of natural forest in certain circumstances, the production of wood fuel from farmed parkland and the conversion of fallows into farmed parkland have been underrated in forestry policy. In the foreseeable future, Metropolitan Kano may be expected to import an increasing proportion of its wood fuel from outside its borders. Unless the commercial exploitation of natural forests in neighbouring states is adequately regulated, the ecological implications are likely to be very serious.

6.5. *Energy Transition.* It is widely assumed that consumer preference for firewood (or other wood fuels) is an artifact of delayed modernization, or of inefficiencies in the distribution of alternative energies. The present study shows that, while cooking requirements, capital costs, supply irregularities, and cultural attitudes are all relevant to this question, at present-Kano prices, wood provides more energy per naira than the alternatives available for cooking and heating. A transition to alternative energies amongst the mass of urban consumers will not occur until these price relativities have changed.

Contents

1
Introduction

Wood fuel is a renewable resource, and has sustained the human race since the invention of fire. It continues to supply a major part of domestic energy requirements for a majority of the world's population. Over two billion people may use it for cooking (Smith 1981: 13). In tropical Africa, this majority is overwhelming. According to Smith (ibid.), only 4 per cent of electricity used reaches the countryside, where alternatives to wood fuel are scarce or costly. The use of wood, charcoal, and other plant materials is not confined to rural areas, however, nor to the lower income groups, nor even to domestic consumers alone.

According to Moss and Morgan (1981: 21), there is little reliable information available on levels of wood fuel consumption: "Not only have field surveys mostly been lacking, but those that have taken place have had to face major difficulties of measurement. . . . Estimates available are based on heroic extrapolation." The FAO and others have estimated a range of wood fuel use from 0.6 m^3 per person per annum in Bangladesh to 4.4 m^3 in the Sudan. Most are between 1.0 and 1.5 m^3. With regard to Nigeria, data on the production of energy from coal, hydro-electric installations, petroleum, and natural gas can be assembled with little difficulty from federal statistical sources (see Schätzl 1979). But according to United Nations, World Bank, and FAO estimates (Earl 1975: 10), more than 90 per cent of Nigerian energy is supplied by wood. If so, then insufficient is known about consumption in the major energy sector to permit effective planning. To imply that wood belongs to the subsistence sector (as Schätzl does, by excluding it from the list of 'commercial' energies) is seriously misleading. Wood fuel, in fact, now features prominently in exchange all over the Federation, laying firmly to rest the myth of "a completely subsistence rural energy production system alongside a mainly subsistent food production system" (Moss and Morgan 1981: 18). In the savanna region, 90 per cent of the wood consumed is firewood (Grut 1972: 41). Total firewood consumption has

been estimated as 10 million m^3 in the Sudan zone and 12 million m^3 in the Guinea zone (Thulin 1970: 19).

The term "wood fuel" is used in this study to refer to firewood, its derivative charcoal, and dry cornstalks (*Sorghum* spp.), which are produced in quantity on farms and used widely as fuel. All three enter trade, but the first is by far the most important; for this reason, and because the trade in charcoal requires a different approach, the study is primarily concerned with firewood. Consumption statistics were scarce worldwide until recently. Now, however, the use of forest resources has become a matter for international concern. It has been estimated, for example, that 11 million ha of tropical forests disappear every year, 3.7 million of them from Africa (UNEP Tropical Forest Resources Assessment 1982, quoted in Kassas 1985); a recent press announcement by the Minister of Natural Resources in Zimbabwe claimed that 7,500 ha of forest are being lost each year; in Zambia, a recent study concluded that 64 per cent of the forest estate within 50 km of Lusaka had been deforested for fuel production by 1982 (Chidumayo 1983); and, in Nigeria, public declamations against "uncontrolled and indiscriminate woodcutting" are as common as elsewhere.

This concern derives from doubts about the renewability of forest resources in the medium or longer term under present levels of demand, and their projected increase in the future. Industrial demand for timber and paper, agricultural clearance, and fuel collecting are the three major agents responsible for the quickening pace of forest destruction in the world. The present study is concerned with the third of these. Global concern now focuses on energy consumption in Third World countries subject to rapid demographic growth and urbanization, especially in zones considered to be ecologically "fragile", amongst which the Sahelo-Sudanian zone of West Africa, where the present study is located, is often numbered.

In such countries, the "energy crisis" has a double face. In the first place, spiralling costs threaten to reduce further the living standards of the urban poor, unless action is taken soon to improve their access to cheap energy. Urban energy costs may amount to 20 per cent of the national minimum wage (and very many urban workers earn less). In the second place, impaired regenerative capacity may set up processes of degradation in woodland. According to some, such degradation is equivalent to desertification, which, however, is too multi-variate a phenomenon to be taken up here (Mortimore, in press).

Energy and environment, economics and ecology should, therefore, be considered in conjunction (Cline-Cole 1986). In the past, conservationists and their arguments have not received a fair hearing in Nigerian decision-making; they have been little understood by both governments and the public (notwithstanding the fact that many farmers, for example, act in keeping with conservationary tenets). Arguments which are understood, however, are those of economy and equity. On the grounds of social justice it is essential to make energy available which can be afforded by the ordinary rural and urban populaces, and which does not incur massive public expenditure or foreign exchange.

Preliminary to investigating the situation in Kano, the economic and ecological perspectives of the wood fuel question need to be distinguished.

Economic Perspectives

Given continuing dependence on wood fuel by the majority of households, and present rates of population growth (from less than 1 per cent to more than $2\frac{1}{2}$ per cent in the present century), an increase in total demand may be expected. This growth in demand does not necessarily correlate with population growth because of the intervention of other factors, notably the rate of substitution of alternative energies, changes in efficiency, and underlying social changes, such as income distribution, family structure, and life patterns.

Given the spatial convergence of populations upon urban centres, the increase in demand leads to a dispersal of woodcutting and an increasing transport component (in terms of money or time) in the costs of fuel acquisition. Urbanization, with its associated network of highways, creates spatial inequalities in the price of wood fuel, in the demand pressure exerted on woodland, and in the ecological status of such woodland. These patterns change continuously.

Urbanization also creates a sectoral division in the firewood economy between producing, distributing, and consuming subsectors. As profits increase, merchant capital is attracted into large-scale wood operations. In rural areas, such functional divisions might be expected to be weakly developed because woodcutting and carrying are within the capabilities of most families. However, the impact of increasing scarcity in rural areas is to strengthen such divisions, owing to the increasing costs of collecting one's own fuel.

If urbanization is associated with positive trends in disposable family incomes, together with changes in living patterns and domestic technology, a trend towards alternative forms of domestic energy might be expected. The "energy transition" hypothesis is modelled, like its demographic counterpart, on the historical experience of industrial economies. However, a number of factors may operate against such an expectation: the prices of alternative energies may fail to undercut those of the wood fuels; the growth of urban incomes may be slowed by the stagnation of employment in the formal sector (where wages are regulated) and the reciprocal growth of the informal sector (where they are not); in-migration running ahead of employment may help to maintain high dependency ratios with low incomes per capita. In addition to these macro-economic factors, the high capital costs of alternative cooking or heating equipment, irregularities of supply, or persistent cultural preferences may slow the adoption of alternative energies.

Population growth, urbanization, and energy substitution therefore emerge as the critical economic components of the wood-fuel equation.

Ecological Perspectives

Urbanization leads to the incorporation into fuel hinterlands of more distant forest resources. However, this does not occur on a static surface. Land-use changes are taking place all the time, and may be considered in three categories. First, the transfer of land from productive to unproductive use — in forestry terms — usually takes place in accordance with priorities determined without reference to the wood