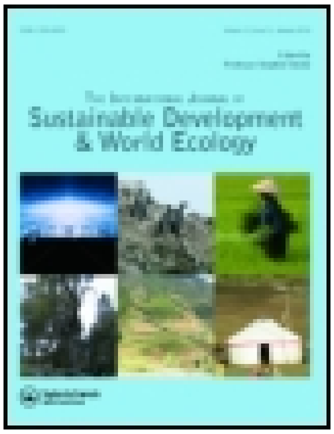

International Journal of Sustainable Development & World Ecology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tsdw20

Energy transition and its implications for environmentally sustainable development in Africa

Ben C. Arimah [a] & Obas John Ebohon [b]
[a] Department of Environmental Science , University of Botswana , Gaborone, Botswana
[b] Developing World Built Environment Research Unit, De Montfort University, The Gateway , Leicester, LE1 9BH, United Kingdom
Published online: 02 Jun 2009.

Int. J. Sustain. Dev. World Ecol. 7 (2000) 201–216

Energy transition and its implications for environmentally sustainable development in Africa*

Ben C. Arimah[1] *and Obas John Ebohon*[2]

[1]Department of Environmental Science, University of Botswana, Gaborone, Botswana
[2]Developing World Built Environment Research Unit, De Montfort University, The Gateway, Leicester LE1 9BH, United Kingdom

Key words: energy transition, environment, sustainability, development, policy, Africa

SUMMARY

Energy transition is the process whereby there is an increase in the volume and proportion of commercial energy, to the extent that it replaces traditional fuels as the main source of energy and having enormous implications for the physical and biotic environment. This energy-environment process has rarely been the focus of research investigation in Africa. Using cross-national data drawn from the African continent, this paper examines and accounts for inter-country variations in the nature and extent of the energy transition process. The empirical analysis reveals that, for the continent as a whole, the extent to which commercial energy replaces traditional fuels is quite low. It varies between 33% and 39%. However, inter-country variations were found to be as high as 90% in countries such as Algeria, Egypt, Libya, Mauritania, Morocco and South Africa; and less than 15% for such countries as Benin, Burkina Faso, The Central African Republic, Ethiopia, Lesotho and Uganda. The key factors explaining inter-county variations in the energy transition process are the level of urbanization and the extent of forest and woodland resources. Other factors of secondary importance include economic growth, incidence of poverty, affordability of electrical appliances, energy trade status of the country in question and the price of commercial fuel. Finally, the paper shows that the identification of these key energy transition-inducing variables is a necessary prerequisite to an effective energy and environmentally sustainable development policy formulation in Africa.

INTRODUCTION

In the years ahead, African countries must face up to the major challenge of making the transition from traditional to conventional sources of energy. This challenge poses two major problems associated with energy trade deficits and high dependence on traditional energy. Evidently, with the exception of countries like Algeria, Angola, Cameroon, The Congo Republic, The Democratic Republic of Congo, Egypt, Gabon, Libya and Nigeria, all countries within the continent are

*An earlier version of this paper was presented at the 1999 Open Meeting of the Human Dimensions of Global Environmental Change Research Community, held at the Institute of Global Environmental Strategies, Shonan Village, Kanagawa, Japan, between June 24–26, 1999. The authors are grateful to the participants of the session in which the paper was presented for their various comments, constructive criticisms and suggestions. The usual caveat applies.

Correspondence: Obas John Ebohon, Developing World Built Environment Research Unit, De Montfort University, The Gateway, Leicester LE1 9BH, United Kingdom. e-mail: ebohon@dmu.ac.uk

dependent on imported oil for petroleum products and power generation. Second, there is a high dependence on traditional energy, which includes wood, charcoal, plant residues and animal waste. Apart from being a highly inefficient source, the dependence on traditional fuel involves an over-exploitation of natural resources, which leads to deforestation, desertification, soil erosion, soil impoverishment and other forms of environmental degradation (Duhamel, 1987; Nyang'oro, 1992; Aweto, 1995).

According to Cavard (1989), energy transition is the process whereby there is an increase in the volume and proportion of commercial energy to the extent that it replaces traditional fuels as the main energy source. Cavard (1989) further notes that this replacement process is complex, and can include, together or in succession to, the introduction of commercial energy into new sectors, or new uses of commercial energy, or the replacement of traditional energy in existing uses. It is also possible for the energy transition process to commence without any actual fuel substitution in established uses. This then produces an increase in commercial energy consumption without any reduction in the consumption of traditional fuels.

In Africa, there exists a dearth of scholarly research on the energy transition process and its likely impact on the environment. Previous studies have focused entirely on the consumption of traditional energy – particularly fuelwood, since this type of energy accounts for as much as 90% of total energy consumed in some African countries (Millington *et al.*, 1994). Consequently, little or no attention is paid to the extent to which conventional energy replaces such traditional sources of energy, especially the process by which such a transition takes place. While the nature, pattern and factors governing energy transition in regions such as South and Southeast Asia, as well as in Latin America, are known with a high degree of certainty, those of Africa remain conjectural.

A study of the energy transition process in Africa is important for a number of reasons. First, energy transition has numerous implications for global environmental process. The different forms of energy production and consumption not only constitute major factors in environmental degradation, but are also at the forefront of the development process. Second, Africa has one of the highest rates of population growth in the world, and contains some of the world's poorest countries (World Bank, 1995). These two factors have obvious implications for the energy transition process in this region; an increase in population growth will, over time, bring about an increase in demand for fuelwood, which in most cases leads to unsustainable exploitation of forest and wood resources (Armitage and Schramm, 1989; Nyang'oro 1992). Similarly, increasing levels of poverty implies a continued dependence on traditional energy. The end result in both cases is the depletion of forest resources and consequent negative externalities. As aptly observed by Iwayemi (1993), overcoming the various energy and environmental problems facing Africa requires the provision and utilization of higher quality fuels, resulting in a more balanced energy mix. This, however, raises the pertinent question of how to achieve an increase in commercial energy consumption *vis-à-vis* traditional energy without adversely affecting the continent's already fragile ecosystem, given that the production and consumption of commercial energy are major contributors to greenhouse gases.

The purpose of this paper is to shed light on what has become a marginalized issue in African energy-environment research, namely, the energy transition process. By adopting a regional approach, the paper seeks to examine and account for variations in the nature and extent of the energy transition process among African countries. In so doing, answers would be provided to the following questions. What is the pattern of the energy transition process in Africa? How does the energy transition process vary between African countries? How do environmental, human and development-related factors affect the process of energy transition in the various African countries? What are the environmental implications of the energy transition process, and how do these impinge upon sustainable development? Answers to these questions are pertinent, furthering our understanding of this important, but neglected aspect of the African energy–environment interface.

CONCEPT OF SUSTAINABLE DEVELOPMENT

The concept of sustainable development can be seen to represent a major shift from previous development paradigms as it seeks to incorporate environmental considerations into social and economic development. Sustainable development brings together two strands of thought concerning the link between human activities and the environment (Hardoy *et al.*, 1995). The first concentrates on meeting the goals of development, while the second seeks to control or limit the adverse ecological and environmental consequences of human activities. Current concern for sustainable development with a strong environmental theme arose during the mid-1970s and early 1980s and was occasioned by a number of factors. First, was the heightened awareness of the finite nature of nonrenewable resources (Ward, 1976; Hardoy *et al.*, 1995). Second, increasing changes in concerns about environment and development mean that greater attention is paid to the vulnerability and damage to global life-support systems arising from human activities. In this respect, various environmental implications of human activities, such as depletion of the stratospheric ozone layer, global warming, pollution of the world's waterways and oceans, declining forests and woodlands, as well as degrading land and soil quality, became the resource concerns of sustainable development (Soussan, 1992). Third is the wider acceptance that, in addition to allowing for needs to be met, economic growth should seek to minimize the destruction to the environment.

The idea of sustainable development was first put forward by the International Union for the Conservation of Nature (IUCN, 1980) in the *World Conservation Strategy*. In this initial formulation, sustainability was seen in ecological terms, with little emphasis on economic development. This approach was criticized on a number of grounds. First, it was seen to be anti-development, as it adopted a static equilibrium approach to the development–environment interface, and considered any human impact on the environment as negative. Second, Soussan (1992) notes that such a simplistic formulation tended to attack the symptoms rather than the causes of environmental degradation. For instance, it called for a halt to forest clearance without due cognizance to the underlying forces responsible for accelerating forest clearance. Rather than viewing poverty and environmental degradation as consequences of existing international economic relations, poverty and the actions of the poor were increasingly determined in a vacuum. These observations called for the reformulation of the concept of sustainable development to correct for the anti-poor bias in the IUCN (1980) report. This eventually led to the creation of the World Commission on Environment and Development (WCED), known as the Brundtland Commission.

The Brundtland Report – *Our Common Future* – accorded universal acceptance to the concept of sustainable development in both developed and developing countries. Similarly, the concept was officially recognised by the United Nations at the Rio Earth Summit on Environment and Development in Brazil in 1992 (UNCED, 1992). Since the publication of *Our Common Future*, sustainability or sustainable development has become the barometer against which development initiatives are judged. This emphasis is reflected in the numerous definitions and multidimensional interpretations given to the concept. In fact, there is still little agreement on the exact meaning (Pearce *et al.*, 1989; Pezzy, 1989; Iwayemi *et al.*, 1995). However, the most popular definition is that of the Brundtland Commission in which sustainable development is seen as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). Implicit in this definition is the notion of ecological and social sustainability, as well as achieving economic growth and maintaining the integrity of the environment on a sustainable basis. Elaborating on this definition, Soussan (1992, p. 25) notes that:

> 'In essence, the vision of sustainable development set out in the Brundtland Report is a call for policies which recognized the need for economic growth, and seek to maximize growth, but which do so in a way which does not jeopardize the position of vulnerable people or deplete the future viability of the resource base. It calls for a different attitude to economic development, in which the *quality* of growth is seen to be as important as the *quantity* of growth.'

The foregoing debate reflects the problems that characterized the global economy, especially in the mid-1980s where economic stagnation or decline, widening disparities between the income and prospects of the rich and poor within national and across international boundaries were accentuated. It was also a period of increasing awareness that the pattern of economic development designed to tackle poverty in the underdeveloped countries, or to enhance and maintain lifestyles in the developed countries have major implications for the physical and biotic environment (Soussan, 1992).

Although the concept of sustainable development as elaborated in the Brundtland Report sets the direction for future reorientation of development policies, it has not escaped criticism on a number of grounds. The Brundtland Report, apart from containing a number of ambiguous statements which are difficult to translate into concrete actions, sets a broad agenda for change without due cognizance of the various barriers to such transformation (Soussan, 1992, p. 26). A further criticism is that the concept of sustainable development conveys different meanings to different people, and is thus open to multiple interpretations (Jacobs, 1994). This confusion arises mainly from the looseness of the operational definition adopted in the Brundtland Report.

In attempting to give more meaning to sustainable development, Pearce *et al.* (1989) advanced three precepts by which it can be attained. The first pertains to giving proper values to the environment which entails increased emphasis on the value of natural, built and cultural environments. The need to assign proper values to the environment is necessitated by the fact that the environment itself can be regarded as an increasingly important factor that contributes to the achievement of development objectives. In the past, development has often been at the expense of the environment and, in particular, methods used to bring about economic development have led to environmental degradation (Soussan, 1992; Ngobese and Cock, 1997). It therefore follows that the sustained management of environmental resources requires an appreciation of their full value, as well as the payment of an appropriate price for the accompanying benefits.

The second precept relates to the futuristic notion of the debate. More specifically, this pertains to extending the time horizon over which development policies are viewed. In this respect, Pearce *et al.* (1989) proposed that both short- to medium-term impacts and long-term future effects of development policies should be of major concern. This concern will include the inter-generational and intra-generational effects of the way in which the resource base is managed for the attainment of the goals of development. Soussan (1992) notes that the key idea inherent in this precept is that one generation should leave the next generation a stock of environmental capital or resource endowment at least as great as that inherited by them. The last precept advanced by Pearce *et al. (1989)* pertains to intra-generational equity, which emphasizes the necessity of providing for the needs of the least advantaged members of the society. This constraint is important because, under current global conditions, it is the poor, disadvantaged and vulnerable groups that are worst affected by environmental problems and are least able to respond to the attendant effects. Poverty alleviation is, therefore, a precondition for achieving intra-generational equity, thereby enabling the poor and other disadvantaged groups to live more decent lives.

From the foregoing discussion, sustainable development can be seen as a process by which economic, social, environmental, energy, agricultural, industrial and technological policies result in development that is economically, socially and environmentally sustainable. This, in turn, implies a new approach to development in that it promotes fairness and opportunity for all people and not just a privileged few. Sustainable development requires that current and future developments take place without further destroying the world's natural resources and without threatening its carrying capacity. Sustainable development also recognizes that the carrying capacity of the environment must be regarded as an absolute limit to human activities rather than being traded-off against the goals of development.

INTER-COUNTRY VARIATIONS IN THE LEVEL OF ENERGY TRANSITION

Since energy transition is defined as the process whereby the volume and proportion of commercial energy increases so as to replace traditional fuels as the main energy source (Cavard, 1989), the concept of energy transition can be considered as the share of commercial energy in relation to total energy consumed. Such a measure will, in turn, reflect the proportion of commercial energy used *vis-à-vis* traditional fuels, and thus be indicative of the extent of the energy transition process since total energy consumed is a combination of both commercial and traditional energy sources.

The pattern of inter-country variations in energy transition among the 47 African countries considered is presented in Table 1, covering two periods – 1980 and 1995. Apart from being limited by data availability, these two periods were chosen in order to determine the nature of the change in the energy transition process over time. Generally, Table 1 shows that there has been a decline in the energy transition process. For instance, a reduction in the overall share of commercial energy consumption was experienced in 27 or 57% of the countries considered in the study. For the continent as a whole, the Table shows that, in 1980, commercial energy as a proportion of total energy was 38.8%. This proportion decreased to 33% in 1995. In comparison with other developing regions of the world, the process of replacing traditional fuels with commercial energy is occurring at a slower pace. For instance, in South Asia, the share of commercial energy in relation to total energy utilization was 63% and 74% in 1980 and 1995, respectively. Corresponding figures for Southeast Asia were 81% and 88% for the same period, while those for Latin America were 80% and 84% for 1980 and 1995, respectively.

Distinct patterns in the level of energy transition among the various countries can be identified. It then becomes possible to classify these countries on the basis of high, medium and low levels of energy transition. Countries with high levels of energy transition include Algeria, Egypt, Mauritania, Morocco, South Africa, Tunisia and Zimbabwe. Within this group of countries, commercial energy as a proportion of total energy consumption varies between 66% and 99% for the two periods under consideration. In fact, with the exception of Tunisia and Zimbabwe, the extent of energy transition within this group of countries is well over 90%.

The high level of energy transition within these countries is likely to be a reflection of a number of factors. First, with the possible exception of Mauritania and Zimbabwe, other countries within this group can be regarded as having high levels of economic growth and development when measured in terms of GNP per capita. Second, apart from Mauritania and Zimbabwe, the other countries can be described as net energy exporters. This presupposes that these countries are self-sufficient in commercial energy resources. Third, with the exception of Morocco and Zimbabwe which have 20.1% and 22.5% of forest cover and woodlands respectively (UNDP, 1997), other countries in this category lie within the arid/desert regions of the continent. Such regions produce less fuelwood because of fewer trees. In order to meet fuel requirements these countries rely heavily on commercial energy. Finally, virtually all countries with high rates of energy transition have relatively high levels of urbanization. For instance, Libya with an energy transition rate of 99%, has about 86% of its population living in urban centres. This pattern is replicated in other countries in this category. In effect this implies that as countries become more urbanized, they consume greater amounts of commercial energy in relation to traditional fuels.

Countries with medium levels of energy transition include Angola, The Democratic Republic of Congo, Côte d'Ivoire, Gabon, Mauritius, Nigeria and Senegal. For this category of countries, the level of energy transition varies between 30% and 50% for the two periods, with Mauritius, Gabon and Senegal having the highest rates. The energy transition process within this group partly reflects the level of economic development and the energy exporter status of most of the countries. With respect to the former, countries like Mauritius and Gabon have one of the highest levels of GNP per capita in Africa, while The Democratic Republic of Congo, Côte d'Ivoire and Senegal have GNP per capita which can be described as average within the African context. In the case of the latter, a number of countries – Angola, The Democratic Republic of Congo, Gabon, and Nigeria are net energy exporters and it can therefore be theoretically argued that they have a comparative advantage in the development of their commercial sources of energy, resulting in faster replacement of traditional with commercial fuels.

The countries with low levels of energy transition can be divided into two categories –

Table 1 Commercial energy use as a percentage of total energy consumption in Africa

Country	*1980*	*1995*
Algeria	97.3	98.0 (0.7)
Angola	52.9	40.5 (–23.4)
Benin	15.1	7.5 (–50.3)
Botswana	64.3	–
Burkina Faso	8.6	6.7 (–22.7)
Burundi	7.3	11.2 (53.4)
Cameroon	30.6	22.7 (–25.8)
Central African Republic	9.2	11.0 (19.6)
Chad	12.6	9.8 (–22.2)
Congo (Democratic Republic)	20.5	16.1 (–22.5)
Congo Republic	44.1	39.0 (–11.6)
Côte d' Ivoire	46.5	32.8 (–29.9)
Egypt	95.0	96.7 (1.1)
Equatorial Guinea	20.0	33.0 (65.0)
Eritrea	7.6	10.0 (31.6)
Ethiopia	7.6	10.0 (31.6)
Gabon	66.4	48.2 (–27.4)
Gambia	20.3	18.8 (–7.4)
Ghana	31.8	21.0 (34.0)
Guinea	31.6	30.1 (–4.7)
Guinea Bissau	23.9	29.5 (23.4)
Kenya	24.6	23.9 (–2.8)
Lesotho	0.0	0.0 (0.0)
Liberia	35.0	8.0 (–77.1)
Libya	98.1	99.2 (0.9)
Madagascar	22.9	16.2 (–29.3)
Malawi	10.9	13.2 (21.0)
Mali	14.8	12.6 (–14.8)
Mauritania	99.3	99.0 (–0.30)
Mauritius	55.9	58.4 (4.5)
Morocco	94.6	95.3 (0.74)
Mozambique	27.4	14.0 (–48.9)
Niger	22.0	20.4 (–7.3)
Nigeria	36.3	43.4 (19.6)
Rwanda	15.2	14.3 (–5.9)
Senegal	51.4	44.1 (–14.2)
Sierra Leone	36.5	30.6 (–16.2)
Somalia	23.0	14.0 (–33.1)
South Africa	95.5	96.1 (0.6)
Sudan	23.6	23.6 (0.0)
Swaziland	34.0	0.0 (–100.0)
Tanzania	16.3	10.4 (–36.2)
Togo	61.7	26.9 (–56.4)
Tunisia	84.6	87.1 (13.4)
Uganda	12.8	10.8 (–15.6)
Zambia	45.4	28.8 (–36.3)
Zimbabwe	66.4	72.6 (9.3)
Africa	38.8	33.0 (–14.9)

Source:
i. World Bank (1988) *World Development Indicators*
ii. United Nations Development Programme (UNDP) (1997) *Human Development Report, 1997*
iii. United Nations Centre for Human Settlements (UNCHS) (1996) *An Urbanizing World Global Report on Human Settlements, 1996*
Figures in parentheses represent the percentage increase/decrease over the pervious period

those with moderately low levels and those with very low levels. The former includes Cameroon, Equatorial Guinea, Ghana, Guinea Bissau, Niger and Sudan, where energy transition levels vary between 20% and 30%. A common feature of these countries is that they are well endowed with forest and woodland resources. With the exception of Niger and Sudan, countries in this group have about 30% to 76% of their land area covered with forest and woodland resources (UNDP, 1997). This area in turn is conducive for the production of fuelwood, the largest component of traditional fuels. In the latter category are Benin, Burkina Faso, Burundi, Chad, Ethiopia, Malawi, Mali, Rwanda, Tanzania and Uganda. Table 1 shows that, within this group of countries, the level of energy transition is very low as the replacement of traditional fuels by commercial energy sources is well below 20%. In fact, in countries such as Burkina Faso, Burundi, Ethiopia and Lesotho, the rate of energy transition is less than 10%. The very low level of energy transition within this group is, in part, a reflection of the low level of economic activity and the high incidence of poverty. Available findings based on various criteria for defining poverty (World Bank, 1998; Arimah, forthcoming) reveal that, within the African continent, this group of countries has the highest incidence of poverty. It therefore follows that where poverty levels are high there will be the tendency for a high dependence on traditional energy sources *vis-à-vis* commercial energy.

The inference that might be drawn, though tentatively, from the foregoing is that inter-country variations in the energy transition process mirror differences in economic development, level of urbanization, energy exporter status of the country, extent of forest and woodland resources and incidence of poverty.

EXPLANATORY FRAMEWORK FOR INTER-COUNTRY VARIATIONS IN THE LEVEL OF ENERGY TRANSITION

The model utilized in this paper seeks to explain inter-country variations in the energy transition process. In particular, we hypothesise that inter-country variations in the level of energy transition can be accounted for by differences in: the rate of economic growth; the incidence of poverty; the degree of urbanization; the price of commercial energy; the number of motor vehicles; the ownership of electrical appliances; the country's energy status as a net exporter; the region in which the country is located; and the country's land area covered by forest and woodland. Linking these variables into an equation, we have the following:

$$COMENGY_{it} = f(EG_{it}, POV_i, URBAN_{it}, FLPRICE_i, VEHICLE_{it}, ELECTAP_i, ENGEXP_i, REGION_i, FOREST_i) \quad (1)$$

where: $COMENGY_{it}$ is commercial energy use as a percentage of total energy consumption in country i at time t;

EG_{it} is a measure of economic growth in country i at time t;

POV_i indicates whether or not country i is poor;

$URBAN_{it}$ is the level of urbanization in country i at time t;

$FLPRICE_i$ is a measure of the price of commercial energy in country i;

$VEHICLE_{it}$ is the number of motor vehicles per thousand population in country i at time t;

$ELECTAP_i$ is a row vector indicative of the ownership of electrical appliances in country i;

$ENGEXP_i$ indicates whether or not country i is a net energy exporter;

$REGION_i$ indicates the region in which country i is located; and

$FOREST_i$ is the percentage of land area covered by forest and woodland in country i.

A further breakdown and definition of these variables are presented in Table 2.

Specification of variables

As a basis for the empirical analysis, the specification and justification for the choice of variables is discussed. The dependent variables used are the percentage of commercial energy to total energy used for the periods 1980 and 1995. Since total energy consumed has two components – commercial and traditional sources – the proportion of commercial energy utilized provides an indication of its contribution *vis-à-vis* traditional fuels to overall energy use. Furthermore, given the definition of energy transition as the process

Table 2 Definition of variables and sources of data

Variable	*Definition*	*Source*
Dependent variable		
COMENGY	Commercial energy use as a percentage of total energy consumption (1980)	World Bank (1988)
	Commercial energy use as a percentage of total energy consumption (1995)	UNDP (1997)
		UNCHS (1996)
Independent variables		
AVGNP	Average annual growth in GNP between 1960 and 1996 (%)	World Bank (1988)
AVGDP	Average annual growth in GDP between 1980 and 1990 (%)	World Bank (1988)
POVERTY	Equals 1, if a country's estimated annual poverty line for the average household size is less than two-thirds of the African mean (US $1601)*	Arimah (Forthcoming)
URBAN	Urban population as a percentage of total population (1980)	World Bank (1988)
	Urban population as a percentage of total population (1996)	
FLPRICE	Price of gasoline per litre (US $)	World Bank (1998)
VEHICLE	Motor vehicles per thousand people (1980)	World Bank (1988)
	Motor vehicles per thousand people (1996)	
RADIO	Radios per thousand people	UNDP (1997)
TV	Television sets per hundred people	UNDP (1997)
ENGEXP	Equals 1, if country is a net energy exporter*	United Nations (1994)
REGION	Equals 1, if country is located in North or Southern Africa*	
FOREST	Percentage of country's land area covered by forest and woodland	UNDP (1997)

*Otherwise equals zero

whereby the volume and proportion of commercial energy increases so as to replace traditional fuels as the main energy source, the percentage of commercial energy used in relation to total consumption should provide an adequate measure of the extent of the energy transition process in each country.

With respect to the independent variables, the impact of economic growth on the energy transition process is assessed by two separate variables. In particular, the average growth in GNP between 1960 and 1996 (AVGNP) and average growth in GDP between 1980 and 1996 (AVGDP) are employed as development-related variables for the 1980 and 1996 periods, respectively. We are limited by data constraints in the choice of these variables and their timeframes. Previous studies from both developed (Akarca and Long, 1980; Ang, 1987) and developing countries (Desai, 1982; Arimah, 1994; Ebohon, 1996) have shown that increases in economic growth will lead to an increase in the volume of commercial energy consumed. This is because the energy transition process is in part, a reflection of a country's level of development – as growth proceeds, the volume of commercial energy increases. We therefore posit that increasing rates of economic growth will have a positive impact on the energy transition process.

A high incidence of poverty, unlike increasing levels of economic growth, can adversely affect or even halt the energy transition process. In this regard, Wood and Hall (1994) note that a high dependence on traditional fuels, particularly biomass and fuelwood, is an indication of poverty and underdevelopment. In order to examine the impact of poverty on the level of energy transition, we use the variable POVERTY, which is a development-related variable defined as the probability of a country being poor. This is a dummy variable that takes on a value of 1 if a country's estimated annual poverty line for the average household size is less than US$1601. This value represents the estimated annual poverty line for the average household size for the entire African continent (Arimah, forthcoming). Countries with poverty lines of less than $1601 will be deemed to be poor. While acknowledging that the poverty line is bedevilled with certain conceptual and methodological weaknesses, it nonetheless provides a measure of the extent of poverty among countries in the absence of other reliable data. A negative impact of poverty on the energy transition process is hypothesized. Another factor that can affect the level of energy transition is the degree of urbanization. In fact Cavard (1989) sees urbanization or urban growth as a major factor in the penetration of commercial energy. The degree of urbanization (URBAN) which can be regarded as a human-related variable is defined as the proportion of a country's population residing in urban centres. We posit that this variable will enhance the energy transition process as urban activities are such that greater amounts of commercial energy are utilized. While noting that traditional fuels, particularly fuelwood, are commonly consumed in African cities, their proportion and absolute intensity of use, or quantities, are lower than those of commercial energy.

The price of commercial energy will invariably affect the rate at which commercial energy replaces traditional fuels as the main energy source. For instance, Armitage and Schramm (1989) observe that high energy prices and the costs of appliances make it impossible for households in Africa to convert from fuelwood and charcoal to kerosene and other commercial fuels. The variable FLPRICE, which measures the price of gasoline per litre, is used as a proxy to determine the effect of commercial energy prices on the extent of the energy transition process. The ideal variable to use would have been the relative energy price, the price of commercial energy to that of traditional energy. However, the lack of such data on a cross-national basis for the African continent precludes its utilization. We nonetheless posit that the higher the price of commercial energy, the lower will be the rate of transition from traditional to commercial energy sources.

The last set of development-related variables that can accentuate the energy transition process are the number of motor vehicles per thousand population (VEHICLE) and ownership of electrical appliances, in terms of television sets (TV) and radios (RADIO). The number of motor vehicles is indicative of the levels of car ownership, physical mobility, and the extent to which petroleum products are consumed within a country. It therefore follows that countries with a large number of motor vehicles are more likely to replace traditional fuels with commercial energy sources at a faster rate than those with fewer vehicles. The ownership of television sets and radios are indicative of both the extent to which commercial energy is utilized and the level of affordability of these appliances. It is hypothesized that countries with high levels of ownership of both appliances will experience a greater increase in the energy transition process.

The dummy variable ENGEXP is indicative of countries that are net energy exporters, and represents the extent to which inter-country variations in the level of energy transition can be attributed to whether a country is a net energy exporter. We posit that ENGEXP will have a positive impact on the energy transition process. This is anchored on the premise that net energy exporter countries have greater commercial energy resources produced with lower overheads and invariably consume more commercial energy in relation to traditional fuels. A regional variable which pertains to the geographical region in which the country is located (REGION) is introduced to account for differences in energy transition due to country location. An examination of Table 1 broadly shows that the degree of energy transition is highest in northern and southern Africa. This variable captures a number of immeasurable inter-country differences that can affect the energy transition process, and we expect it to have a positive impact on the extent of energy transition. The final variable utilized is the percentage of the country's land area that is covered by forest and woodland (FOREST). This variable has an environmental dimension and is expected to have a negative impact on the energy transition process because countries with large land areas covered by forest and woodlands are more likely to depend on traditional energy, particularly fuelwood, thereby making it the major source of energy.

We note, however, that our list of independent variables does not consider some other factors that can affect the energy transition process. For instance, we have not considered some of the inefficiencies that characterize the production and delivery of commercial energy, particularly petroleum products. Such inefficiencies have been known to result in commercial energy shortages and can, paralyze transport networks, undermine commercial and industrial capacities and result in sub-optimal consumption of domestic appliances (Ebohon, 1996). These variables may reverse the energy transition process. Similarly, we have not included certain social and cultural variables, the cost of appliances that use commercial energy, the availability or access to commercial energy and the possible impact of structural adjustment programmes which have been adopted in most African countries. All of which are likely to affect the energy transition process. The exclusion of these variables is due to lack of required data and/or the difficulty associated with measuring them.

DETERMINANTS OF THE ENERGY TRANSITION PROCESS

The multiple regression results for inter-country variations in the energy transition process for the periods 1980 and 1995 are presented in Tables 3 and 4, respectively. For each period the following estimation strategy was adopted. First, each model was estimated with all ten independent variables (second column). Second, variables with low t values and those with pair-wise correlations in excess of 0.8 were deleted. This is because Hauser's (1974) rule of thumb indicates that a pair-wise correlation above 0.8 is an indication of the

Table 3 Energy transition regression models (1980), dependent variable: COMENGY (1980)

Variable	*(i) Full set of variables*	*(ii) Reduced set of variables*
AVGNP	2.721(1.67)***	2.352(1.75)**
POVERTY	–3.563(0.39)	–
URBAN	1.258(3.30)*	1.177(3.72)*
FLPRICE	7.265(0.40)	4.393(0.27)
VEHICLE	0.165(1.03)	0.140(0.99)
RADIO	0.009(0.22)	–
T V	–0.416(0.29)	–
ENGEXP	5.709(0.66)	5.626(0.69)
REGION	5.842(0.68)	5.258(0.65)
FOREST	–0.237(1.60)***	–0.245(1.74)**
Constant	–4.823(0.30)	–0.474(0.04)
r^2	0.674	0.672
Adj. r^2	0.584	0.613
F ratio	7.454	11.406
N	47	47

*Significant at the 0.01 and above (one-tail test)
**Significant at the 0.05 (one-tail test)
***Significant at the 0.1 (one-tail test)
Absolute t values are in parentheses
– Not included in the model

Table 4 Energy transition regression models (1995) Dependent variable: COMENGY (1995)

Variable	*(i) Full set of variables*	*(ii) Reduced set of variables*
AVGDP	1.286(0.98)	1.249(1.02)
POVERTY	–12.712(1.48)***	–11.294(1.38)***
URBAN	1.021(3.68)*	1.087(4.17)*
FLPRICE	33.335(1.89)**	25.07(1.58)***
VEHICLE	0.116(0.74)	–
RADIO	0.039(0.94)	–
TV	1.613(1.15)	2.829(2.91)*
ENGEXP	15.760(1.95)**	15.077(1.99)**
REGION	2.700(0.32)	–
FOREST	–0.379(2.55)*	–0.422(3. 14)*
Constant	–29.469(1.81)**	–21.028(1.46)***
r^2	0.705	0.692
Adj r^2	0.623	0.636
F ratio	8.598	12.498
N	47	47

*Significant at the 0.01 and above (one-tail test)
**Significant at the 0.05 (one-tail test)
***Significant at the 0.1 (one-tail test)
Absolute t values are in parentheses
– Not included in the model

occurrence of multicolinearity among the independent variables. The re-estimated models with the reduced set of variables are shown in the third column of the Tables. The results show a reasonable fit in terms of the number of significant variables and the level of explanation. Specifically, the r^2 values reveal that the regression models account for between 67% and 70% of inter-country variations in the energy transition process. The Tables further show that the combination of significant variables in each model differs. This necessitates consideration of the determinants of the energy transition process for the two periods.

Determinants of energy transition – 1980 period

The results of the regression model for the 1980 period are presented in Table 3. One of the most important variables explaining inter-country variations in the energy transition process is average annual growth in GNP. Specifically, the AVGNP coefficients suggest that within the 1980 period, a 1% increase in economic growth brought about an increase of between 2.4% and 2.7% in the degree of energy transition. This finding indicates the accentuating effect of economic growth on the energy transition process. It also confirms an *a priori* expectation in the sense that the attainment of high levels of economic growth in the short to medium term (at least for developing countries) requires the replacement of traditional fuels with commercial energy. Comparable findings have been obtained elsewhere. In India, for instance, Cavard (1989) showed that the proportion of traditional energy drops by half when income increases six-fold. Similarly, for Africa, Arimah (1994) has shown that a 1% increase in economic growth occasioned an average increase of about 0.88% in the volume of commercial energy consumed between 1975 and 1990.

The degree of urbanization (URBAN) emerges as the most important variable accounting for inter-country variations in the energy transition process. The URBAN coefficient varies between 1.18 and 1.26. This implies that, in 1980, a 1% increase in the proportion of a country's urban population occasioned an increase of between 1.18% and 1.26% in the country's level of energy transition. This finding conforms to expectations, given that urban centres are the hub of commercial, industrial and other related activities that involve greater utilization of commercial energy. Our findings also agree with those obtained by Cavard (1989) in his study of South and Southeast Asia, which revealed that the proportion and absolute quantities of commercial energy increases with the level of urbanisation.

The last significant variable is the percentage of a country's land area covered with forest and woodland. The FOREST coefficient is negative and indicates that, in 1980, a 1% increase in the land area covered by forest and woodland resources brought about a reduction of about 0.24% in the energy transition process. This result in effect suggests that the energy transition process is proceeding very slowly or even declining in countries with a greater proportion of forest and woodlands and that, for countries with large areas of forest and woodland resources, traditional energy in terms of fuelwood constitutes the major source of energy. This finding is in agreement with that of Aweto (1995) that the size of the land area covered with trees is the major determinant of the production and consumption of fuelwood in West Africa.

Determinants of energy transition – 1995 period

The regression estimates for the 1995 period are presented in Table 4. This model has more significant variables than that of 1980. The first of these is the relative level of poverty which has a negative impact on the level of energy transition. Specifically, the POVERTY coefficient indicates that the energy transition process decreases by between 11.3% and 12.7% if a country is defined as poor, suggesting that poor countries consume a greater proportion of traditional fuels. This result further implies that, as the level of poverty reduces, there would be a gradual shift from the consumption of traditional fuels to commercial energy. If a high dependence on traditional fuels is an indication of poverty (Wood and Hall, 1994), and results in over-exploitation of natural resources leading to various forms of environmental degradation, the importance of our finding for the African continent is that poverty reduction is compatible with, and a prerequisite for, achieving environmentally sustainable development.

As with the 1980 model, the degree of urbanization (URBAN) is the most important variable accounting for inter-country variations in the energy transition process. The coefficients reveal that a 1% increase in a country's urban population will bring about an increase of between 1.02% and 1.09% in the extent to which commercial energy replaces traditional fuels as the main energy source. This finding reconfirms the fact that urban centres, by virtue of their activities, consume a greater proportion of commercial sources of energy.

The variable FLPRICE, designed to account for the effect of the price of commercial energy appears counterintuitive. In particular, FLPRICE implies that $1 increase in the litre price of gasoline will, all things being equal, result in an increase of between 25% and 33% in the level of energy transition. In other words, the higher the price of commercial energy, the higher will be the rate at which commercial energy replaces traditional fuels. The counterintuitive effect of price may be attributed to the fact that it measures the price of a particular fuel, i.e. gasoline, and not the relative price of commercial energy to that of traditional fuels.

The impact of electrical appliances, as measured by the ownership of television sets (TV), has a positive and significant impact on the energy transition process. Specifically, TV reveals that an increase of one television per 100 people will, *ceteris paribus*, result in a 2.8% increase in the level of energy transition. Given that few existing studies have examined the effect of ownership of electrical appliances on the energy transition process, the consistency of this finding cannot be ascertained. However, a plausible interpretation of this finding is that, as ownership and affordability levels of electrical appliances increase, so will the pace at which commercial energy replaces traditional fuels. The regression model for 1995 further indicates that the energy transition process is proceeding faster in net energy exporter countries. The coefficient measuring the impact of the energy exporter status of a country (ENGEXP) implies that, in net energy exporter countries, the extent to which commercial energy replaces traditional energy is about 15% greater than that in non-exporter countries. This finding is plausible, and confirms the notion that net energy exporter countries, on account of their commercial energy resources, are more likely than non-exporters to consume greater proportions and volumes of commercial energy.

Finally, in the 1980 model, the energy transition process is proceeding at a very slow pace for countries with large areas of forest and woodland. The FOREST coefficient indicates that a 1% increase in the land area covered by forest and woodlands will bring about a reduction of between 0.38% and 0.42% in the rate at which commercial energy replaces traditional fuels. While forest and woodland-rich African countries may have no other alternative than to consume a greater proportion of traditional fuels *vis-à-vis* commercial energy, there are far-reaching implications for the unsustainable consumption of forest resources and attendant environmental degradation and pollution.

IMPLICATIONS FOR AN ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT

The empirical results presented in the preceding section have serious implications for environmental sustainability and development in Africa, especially given the continent's energy and environmental profile. These environmental problems are symptoms of the intense exploitation of the physical environment giving rise to the manifestations of environmental degradation experienced in Africa. These include deforestation, desertification, soil compaction, erosion and soil nutrient depletion which have become common features of the African physical and biotic environment. Estimates of the rate of deforestation for the African continent show that up to 13 000 km^2 of forests are cleared each year (FAO, 1995). The incidence of desertification is directly related to deforestation. Statistics presented by the United Nations Environment Programme (UNEP, 1994) clearly reveals that, as in 1992, over a billion hectares of African land has been lost to desertification thereby adversely affecting the ability of the continent to feed itself. This loss is further exacerbated by the perennial droughts that continue to plague the continent. For individual countries the rate of forest depletion varies considerably. For instance, Guinea-Bissau loses between 20 000 to 35 000 ha of land annually, while Senegal and Nigeria suffer annual losses of 50 000 and 250 000 ha of wooded savanna, respectively. The case of Ethiopia is instructive, where forest cover has declined from 40% of the total landmass to just 4% in less than a century (UNEP, 1997).

It is in relation to these above environmental characteristics that the empirical results of this paper are particularly interesting with regard to environmental policy formulations. First, the empirical findings from the previous section provide useful insights into factors that may influence the transition from traditional fuels to commercial energy sources in Africa. Such insights are crucial to halting the process of environmental degradation in Africa, especially in the light of a population that depends on fuelwood and biomass residue for energy. The link established between poverty and underdevelopment as determinants of African countries' ability to transit from traditional to commercial energy sources is significant. The statistical significance of the income variable, used as a proxy of economic growth in explaining inter-country variations in the energy transition process, is indicative of the fact that poverty alleviation is crucial to the course of environmental sustainability and development in Africa. The importance of this hinges on the deteriorating economic indicators for Africa which show that, of the 30 countries defined as least developed by the World Bank (1995), 21 are in Africa. These countries are unable to feed themselves and rely extensively on bilateral and multilateral financial assistance to achieve internal and external balances. The empirical analysis clearly shows that impoverished countries have poor records of making the transition from traditional to commercial energy sources, and the implications are that Africa's environment will further deteriorate as poverty thwarts energy transition in the continent.

Additionally, the analysis reveals that, given improvements in affordability levels, households are willing to change from traditional fuels to commercial forms of energy. This is hardly surprising given the various hardships, social and opportunity costs associated with the acquisition of fuelwood and biomass energy (Mnazava, 1981; Ebohon, 1992). This result has implications for energy and environmental policy formulation, especially regarding the prominence of the project-by-project micro-strategy for the encouragement of energy transition in Africa, as witnessed by the various fuel subsidy programmes implemented by some African countries. While the project-by-project approach may be necessary, it remains largely insufficient as a strategy for encouraging energy transition and stemming environmental degradation in Africa for which a macro-strategy of poverty alleviation is central to the encouragement to energy switching.

The energy price variable for the 1995 regression model suggests that the capacity to supply commercial fuel is crucial to sustaining the energy transition process. In particular, the price variable indicates that the higher the price of commercial energy, the more consumers are willing to buy. This violates the conventional law of demand, but is not untypical of consumers' behaviour in a situation of prevalent scarcity, forcing reactions towards future price expectations rather than current fuel prices. This is particularly the case as the transition to commercial fuels involves capital expenditure outlay on equipment which, once procured, conditions the price elasticity of demand for conventional fuels towards increasing inelasticity. However, if commercial fuel scarcity persists, the process of energy transition is likely to be reversed. This is seen in the case of the FOREST variable which is used to proxy forest and woodland resources, indicating the availability of fuelwood and biomass resources as possible hindrances to energy transition.

At another policy level the empirical results present the case for diversifying energy consumption away from traditional fuels to commercial energy as a prelude to alternative renewable energy sources. The danger posed by increasing desertification goes beyond fuel scarcity and land degradation to the more serious impact on climate. Increased variability in the climatic conditions of Africa is widely acknowledged and known to have serious consequences for renewable energy production, especially hydroelectric power. Not only will persistent desertification result in fuelwood and biomass scarcity but also the attendant effects on rainfall shortages are likely to accentuate the problems associated with the seasonality of rivers, affecting hydroelectric production. Energy transition is, therefore, an imperative for Africa's environmental sustainability and survival. Furthermore, the production and consumption of commercial energy generates environmental pollution and has accompanying implications for ozone depletion. It is therefore essential that renewable alternative energy sources are at the core of Africa's energy strategy in order to be able to fulfil its environmental obligations locally, regionally and internationally as well as avoid the huge costs associated with environmental remediation, as currently experienced by the industrialized countries. Given Africa's endemic poverty this is a cost that it can ill afford to absorb.

The need to diversify away from traditional fuels to commercial and renewable energy sources is further reinforced by the positive coefficient of the level of urbanization in both models. Though the degree of urbanization in Africa compared to the rest of the world is relatively low, it is nonetheless growing at an accelerating rate. Fuelled by incessant rural–urban migration, the forecast that it will double in the year 2025 is likely to exert more pressure on energy supply. However, the current contribution of the energy debt to total debt burden of African countries, especially the net oil importers, indicates the difficulty of financially sustaining such high levels of energy demand. This is likely to have major implications for economic growth in view of the predominant share in total growth that is accounted for by urban centres. Consequently, not only does it make sound ecological sense to diversify and move to renewable energy sources, but it also makes sound economic and financial sense to do so.

The case for halting Africa's deteriorating environmental situation is very strong and made even stronger by a tacit understanding of the enabling factors that drive energy transition from traditional to clean and renewable energy sources. This argument is based on the biodiversity of the region and its immense global ecological significance. Africa offers a wide spectrum of habitats and ecosystems, some of which are unique and the destruction and loss of these would have major environmental implications. For example, the remnants of forests in Sierra Leone, Sapo in Liberia and Tai in Côte d'Ivoire have been identified as the last essential remains of a structurally complex and species-rich forest of the upper Guinea zone (UNEP, 1994). Similarly, Mount Nimba and the Fouta Djallon highlands, being the major watersheds in western Africa, encompass areas of exceptional biodiversity which, according to the World Bank (1995), are seriously at risk of permanent damage from exploitation. Other notable areas of global environmental significance in Africa include the Congo Basin, which is the second largest connected primary tropical rainforest area in the world. The diversity of flora, fauna and wetlands is immense, providing homes for rare plant species and wildlife, including migratory birds (UNEP, 1994). It is important for Africa that such an environmentally important ecosystem is maintained. However, the huge demand on Africa's environment as a result of poverty, population growth, rural–urban migration and the attendant high rates of urbanization remain a significant and real threat. Hence, an effective environmental management strategy is a necessary prerequisite and predicated upon a deep appreciation and understanding of the energy transition process and its possibility in Africa.

CONCLUDING REMARKS

Using cross-national data from the African continent, this paper has sought to achieve three inter-related objectives: to investigate the extent and nature of the energy transition process, whilst paying attention as to how this transition varies between different African countries; to isolate and determine the impact of the factors that condition the extent to which commercial energy replaces traditional fuels; to examine the implications of the energy transition process for environmentally sustainable development. The empirical analysis revealed that, for the continent as a whole, the extent to which commercial energy replaces traditional fuels is quite low – varying between 33% and 39%. However, inter-country variations were found to be as high as 90% for countries such as Algeria, Egypt, Libya, Mauritania, Morocco and South Africa; and less that 15% in such countries as Benin, Burkina Faso, Central African Republic, Ethiopia, Lesotho and Uganda.

Further analysis indicated that the key factors accounting for inter-county variations in the energy transition process are the level of urbanization and the extent of forest and woodland resources. The factors of secondary importance include economic growth, incidence of poverty, affordability of electrical appliances, energy exporter status of the country in question and the price of commercial fuel. The identification of these factors is fundamental to sustainable energy and environmental policy formulation in Africa. The urgent need for African countries to make the transition from traditional fuels to commercial and renewable energy is predicated upon their fast deteriorating physical and biotic environments, and the need to attain accelerated economic growth which cannot be sustained on traditional energy sources. However, the desire for growth must reflect the carrying capacity of the biotic and physical environment for it to be sustainable and allow for both intra- and inter-generational equities. It is concluded that an understanding of the energy transitional process in Africa is a necessary prerequisite for effective sustainable energy and environmental policy formulation.

REFERENCES

Akarca, A.T. and Long, T.V. (1980). On the Relationship between Energy and GDP: A Reexamination. *Journal of Energy and Development,* **10**, 47–58

Ang, B.W. (1987). A Cross-Sectional Analysis of Energy Output Correlation. *Energy Economics,* **9**, 274–86

Arimah, B.C. (1994). Energy Consumption and Economic Growth in Africa: A Cross-National Analysis. *OPEC Review,* **18**, 207–21

Arimah, B.C. (forthcoming). Poverty and Social Development in Africa, in Labaas, B. (ed.) *Building and Sustaining the Capacity for Social Policy Reforms.* (Aldershot: Ashgate)

Armitage, J. and Schramm, G. (1989). Managing the Supply and Demand for Fuelwood in Africa, in Schramm, G. and Warford, J.J. (eds) *Environmental Management and Economic Development.* (Baltimore: John Hopkins University Press)

Aweto, A.O. (1995). A Spatio-Temporal Analysis of Fuelwood Production in West Africa. *OPEC Review,* **19**, 333–47

Cavard, D. (1989). Energy Transition in South and Southeast Asia, *Natural Resources Forum*, **13**, 216–26

Desai, D. (1982). Estimating Energy Demand: The Developing Countries, *Energy Journal*, **8**, 79–99

Duhamel, A. (1987). Renewable Energies in Africa: Examples of Fuelwood and Solar Energy. *African Environment*, Vols. **5** and **6**, 42–68

Ebohon, O.J. (1992). Empirical Analysis of Energy Consumption Behaviour: An input to an Effective Energy Plan in Nigeria. *Energy Policy*, **20**, 781–96

Ebohon, O.J. (1996). Energy, Economic Growth and Causality in Developing Countries: A Case Study of Tanzania and Nigeria. *Energy Policy*, **24**, 447–53

FAO (1995). *World Agriculture: Towards 2010.* (Rome: FAO)

Hardoy, J.E., Mitlin, D. and Satterthwaite, D. (1995). *Environmental Problems in Third World Cities*, (London: Earthscan Publishers)

Hauser, P.D. (1974). Some Problems in the Use of Stepwise Regression Techniques in Geographical Research. *Canadian Geographer*, **18**, 148–58

IUCN (1980). *World Conservation Strategy.* (Gland, Switzerland: IUCN)

Iwayemi, A. (1993). Energy Development and Sub-Saharan Economies in a Global Perspective. *OPEC Review*, **17**, 29–45

Iwayemi, A., Ogunkola, O., Jerome, A. and Adenikiju, A. (1995). *North–South Perspective on Sustainability: Energy Policy and CO_2 Emissions in Nigeria*, Report Submitted to the Nigerian Environmental Study/Action Team. Ibadan, Nigeria

Jacobs, M. (1994). Towards a Methodological Critique of Sustainable Development. *Journal of Developing Areas*, **28**, 237–52

Millington, A.C., Critchley, R.W., Douglas, T.D. and Ryan, P. (1994). *Estimating Woody in Sub-Saharan Africa.* (Washington, DC: World Bank)

Mnazava, E.M. (1981). Fuelwood: The Private Energy Crisis of the Poor. *CERES' Food and Agricultural Organization Review*, **14**, 35–9

Ngobese, P. and Cock, J. (1997). Development and Environment. In Fitzgerald, P., McLennan, A. and Munslow, B. (eds), *Managing Sustainable Development in South Africa.* (Cape Town: Oxford University Press)

Nyang'oro, J.E. (1992). Africa's Environmental Problems. In Gordon, A.A. and Gordon, D.L. (eds), *Understanding Contemporary Africa.* (London: Lynne Renner Publishers

Pearce, D., Markandya, A. and Barbier, E.B. (1989). *Blueprint for Green Economy.* (London: Earthscan Publishers)

Pezzy, J. (1989). *Economic Analysis of Sustainable Growth and Sustainable Development*, Environment and Development Working Paper. (Washington, DC: World Bank)

Soussan, J.G. (1992). Sustainable Development. In Mannion, A.M. and Bowlby, S.R. (eds) *Environmental Issues in the 1990s.* (Chichester: John Wiley)

UNCED (1992). Agenda 21: *The United Nations Programme of Action from Rio.* (New York: United Nations)

UNCHS (1996). *An Urbanizing World: Global Report in Human Settlements 1996.* (New York: Oxford University Press)

UNDP (1997). *Human Development Report 1997.* (New York: Oxford University Press)

UNEP (1993). Our Planet. *United Nations Environment Programme Magazine for Sustainable Development*, **6** (5)

UNEP (1994). *The Convention on Biological Diversity: Issues of Relevance to Africa*, Regional Ministerial Conference on Biological Diversity. (UNEP/AMCEN/RCU71 (A))

UNEP (1997). *Global Environmental Outlook.* (Nairobi: UNEP)

Ward, B. (1976). *The Home of Man.* (London: Penguin Books)

World Bank (1995). *Towards Environmentally Sustainable Development in Sub-Saharan Africa.* (Washington, DC: World Bank)

World Bank (1998). *World Development Indicators.* (Washington, DC: World Bank)

WCED (1987). *Our Common Future.* (Oxford: Oxford University Press)

Wood, S. and Hall, D.O. (1994). *Bioenergy for Development.* (Rome: FAO)