

# THE CHALLENGE OF DEFORESTATION IN TROPICAL AFRICA: REFLECTIONS ON ITS PRINCIPAL CAUSES, CONSEQUENCES AND SOLUTIONS

K. BOAHENE\*

*African Society for Environmental Management, PO Box 2205, 3500 GE Utrecht, The Netherlands*

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## ABSTRACT

Economic development is dependant on factors including capital, labour force and natural resources. Forests are natural resources which, if properly managed, can provide habitats for animal and plant species, pasture for livestock, wood for shelter, timber and fuelwood, land for agriculture and can have a favourable effect on weather and climatic patterns. Nevertheless, deforestation has been a widespread phenomenon in tropical Africa, with an annual forest clearance of between 1.3–3.7 million ha. This paper reviews the pattern of deforestation in tropical Africa by examining its causes and consequences, as well as assessing the prospects for the attempts being made to control it. It identifies forest clearance for subsistence farming as the principal determinant of deforestation, but does not consider the ignorance of small-scale farmers as the underlying cause. Given the deteriorating agricultural production, the paper argues that the principal issue is not how to stop forest depletion, but how to manage forest resources to enable the community meets its objectives on an effective, fair and efficient basis. An approach which releases part of the rural population from the land or provides an alternative form of a secure livelihood is an example of the sustainable strategies for managing forests. © 1998 John Wiley & Sons, Ltd.

KEY WORDS: deforestation; Africa; causes; consequences; sustainable strategies; conservation

## INTRODUCTION

Deforestation has been an age-old activity of humankind. The Mediterranean was deforested before the 5th century, and Europe also went through a series of deforestation and regeneration prior to the 16th century (Thomas, 1956, Thirgood, 1981). The bulk of Haiti's rainforest was already destroyed by the end of the 19th century (Lewis and Coffey, 1985), and in Ethiopia, India and Lebanon, forest had been depleted much earlier (Eckholm, 1976). While deforestation has slowed down in the industrialized countries in recent times, it has accelerated in the developing economies (Table 1). According to FAO (1982), about 37 000 km<sup>2</sup> of forested areas in tropical Africa is cleared per annum. Recent estimates by Salih (1992) shows that the rate of deforestation in tropical Africa outstrips the rate of tree planting by 29 to 1. If the present trend of deforestation continues, all of tropical Africa's closed and open, productive forests are expected to be depleted within nine decades.

There are, of course, local variations in land use and deforestation in tropical Africa. For example, in areas such as Nigeria, the Ivory Coast, Ghana and Madagascar, agriculture has been thriving and deforestation has accelerated, whereas in some parts of Zaire, Congo and Gabon, the rainforest is remote and inaccessible (Table II). West African rainforest areas are noted for tree-crop production, but in the arid environments, grazing is the main agricultural activity. The imminent role of tropical forest in the earth-atmosphere system means that the destruction of forest has serious environmental and socio-economic consequences. The focus of this paper is to survey the main causes of deforestation and its associated problems in tropical Africa and to

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\*Correspondence to: Dr K. Boahene, African Society for Environmental Management, PO Box 2205, 3500 GE Utrecht, The Netherlands. E-mail: oduro@xs4all.nl

Table I. Percentage of land converted to regular cropping: 1880–1978

Regions	1860–1920	1920–78
United States and Canada	212	–1
Europe	17	0.7
USSR	108	37
Africa	26	112
Asia	43	47
Latin America	35	146
Oceania	377	197

Source: FAO Production Yearbook, 1979; Richards, 1986.

Table II. Extent of deforestation in selected African countries, 1989

Countries	Extent of forest cover (km <sup>2</sup> )	Amount of deforestation (km <sup>2</sup> )	Rate of deforestation (%)
Cameroon	164 000	2300	1.4
Congo	90 000	800	0.9
Gabon	200 000	800	0.4
Ivory Coast	16 000	2500	15.6
Madagascar	24 000	2000	8.3
Nigeria	28 000	4000	14.4
Zaire	1 000 000	4200	0.4

Source: Myers, 1989; Third World Guide, 1993/4

examine the prospects for prevailing deforestation-abating strategies in an attempt to direct policy solutions. Due to the quantity of studies on deforestation, this paper discusses only a representative selection of works. It is organized as follows. First it reviews the principal causes of deforestation and then examines the resulting environmental effects. Finally, it concludes with an evaluation of measures adopted to control forest depletion.

## CAUSES OF DEFORESTATION

### *Agriculture*

The most important cause of deforestation in tropical Africa is the expansion of subsistence agriculture and the extraction of trees for fuelwood (Allen and Barnes 1985; Andersen 1986; Hosier and Milukas, 1989). The extension of subsistence activities into forestland is, to a great extent, the result of poverty, limited alternative employment and inadequate technology (Hamilton 1984; Osemeobo 1988). The high annual population growth of about 3 per cent is not a root cause of deforestation, but it does exert pressure on the resource base, especially where production technology is inadequate. Boahene (1996b) has shown that, in two rural communities in the eastern region of Ghana with almost the same population density, forest depletion has been halted in the community where farmers have teamed up with local forestry agents to implement an improved forest management innovations.

Limited farm technologies in most tropical African communities, have for a long time led farmers to practise shifting cultivation. In the rainforest, the normal period of cultivation ranges from 2–4 years, and a fallow period of 8–15 years is required (Lewis and Berry, 1988). However, the fallow period has been shortened to about a quarter as more land is required for production, leading to a decline in the regeneration of trees, soil fertility and agricultural yield (Reijntjes, *et al.*, 1992). An expansion of cash-crop production, especially in the 1950s and 1960s, contributed greatly to deforestation caused by commercial farming (O'Connor, 1979). In recent years, the high incidence of pests and diseases and the scarcity of productive land in the old cocoa areas has led to the flight of cash-crop farmers to previously uncultivated forested regions in Ghana, Nigeria, Cameroon and the Ivory Coast (Arhin, 1985; M'bondji, 1993; Yapi, 1993).

The deteriorating terms of trade for primary exports means that producers have to increase production substantially in order to maintain previous income levels.

### *Logging*

Undisturbed forest is being logged at the rate of 7 per cent per annum in West Africa, 0.5 per cent in Central Africa and 3.3 per cent in East Africa (FAO, 1982, 1986). Commercial timber operators cut trees on land to which they have obtained temporary concession, whereas local small-scale loggers clear forest which they see as no man's land (Osemeobo, 1988; Repetto and Gillis, 1988). The loss or lack of property rights has therefore been recognized as one of the underlying causes of deforestation induced by logging (Andersen, 1991). The granting of concessions for timber operators has occurred for two main reasons: (i) the desire to raise revenue for development and (ii) as favours for political party functionaries or multinationals. Since timber extraction is unregulated and the revenue obtained from timber operators is not used for forest management, logging has led to a rapid depletion of forest. The heavy infrastructure that logging requires and the extensive road network and yarding areas it opens in the forest to farmers and poachers worsen deforestation.

Table III. Fuelwood consumption compared with annual increase in the stock of trees by 1985 (in 100 m<sup>3</sup> y<sup>-1</sup>) in selected African countries

Region	Annual increase of stock	Annual consumption of tree stock	Difference of tree stock
Mauritania	97	963	-866
Senegal	7200	4600	2600
Niger	1400	4100	-2700
Sahel	17000	22000	-5000
Northern Nigeria	13500	23300	-9800
Ethiopia	13600	34000	-20000
Sudan	44400	75800	-31400

*Source:* Anderson and Fishwick, 1984.

### *Fuelwood*

Tropical Africa depends on fuelwood for about 90 per cent of its total energy supplies (Dunkerly and Ramsey, 1983; Simon, 1991). Anderson and Fishwick (1984) have shown that the consumption of fuelwood has outstripped the mean annual increase in tree stock by up to 200 per cent (Table III). Fuelwood is still cheaper than alternative forms of fuels, for instance, by 1970 constant prices, charcoal prices have not increased over a decade (Hosier and Milukas, 1989). Even if the price of fuelwood were to increase, demand would not be drastically reduced due to the unavailability of substitutes. The majority of villages have no access to electricity and facilities for using liquefied petroleum gas are next to non-existent. Low incomes also make it difficult for both urban and rural households to substitute commercial fuel for fuelwood (Leach and Mearns, 1988). Note, however, that there are severe contrasts in local fuelwood deficiencies, for example fuelwood consumption in Kano (northern Nigeria) is five times higher than supply, whereas the rest of Nigeria has a surplus (Williams, 1993). There is virtually no wood for about 50 km around Niamey, the capital of Niger and in Accra, the capital of Ghana, the haul for wood can be as long as 100 km.

### *Other Causes*

Deforestation has been explained within the framework of political economy, namely the rise of colonialism and government agencies, wars and the loss of authority of indigenous leaders. Shepherd (1991) asserts that much of the local resource management has depended on the understanding and authority of local leaders. Colonial rule and subsequently post-independence governments with their centralized administration, however, undermined the position of the leaders by appointing political officials to head local communities. The appointed officials did not have the authority to enforce local laws, so the loss of influence of the

elders rendered the institution of sacred groves<sup>1</sup> no longer tenable (Brokensha and Castro, 1987). European expansionism meant that land was taken from local management and given to commercial farmers, mostly Whites and individuals with political connections (Behkne, 1985; Postma, 1990). Further, state appropriation of community land by independent tropical African governments has disrupted the system of agriculture. For instance, during the *ujamaa* era in Tanzania, the Sukuma ethnic group was told to leave its small hilltop forestland to go and live elsewhere (Shepherd, 1989). The government could not immediately occupy the deserted area and it soon fell into the hands of urban charcoal burners.

## ENVIRONMENTAL CONSEQUENCES OF DEFORESTATION

### *Forest and Climate*

Trees absorb CO<sub>2</sub> from the atmosphere and store the carbon as wood or in soils. The conversion and burning of forest for farming and the harvest of forest for timber and fuelwood cause a net release of CO<sub>2</sub> from the biota to the atmosphere. These activities inject about six billion tons of carbon into the atmosphere every year (Silver and DeFries, 1990). The release of CO<sub>2</sub> coupled with the existence of other trace gases, such as methane (CH<sub>4</sub>), chlorofluorocarbons (CFCs), nitrous oxide (NO<sub>x</sub>) and tropospheric ozone (O<sub>3</sub>)<sup>2</sup>, are expected to induce a global warming through the greenhouse effect. Global climate models show that as the atmospheric CO<sub>2</sub> doubles, the long-term increase in global temperature is expected to be 2–5°C (Revkin, 1988; Ellis, 1991; Royer and Mahouf, 1992)<sup>3</sup>.

A rise in mean global temperatures will bring about changes in the regional weather and climatic patterns of tropical Africa. A northward extension of the Inter Tropical Convergence Zone (ITCZ) due to changes in global pressure belts will increase the area over which the southern trade winds are effective. This will contribute to a northward shift in the equatorial rain belt with an accompanying extension of the southern arid belt near the equator. The rainforest areas of West Africa will suffer more because precipitation patterns are dominated by ITCZ compared with East Africa where rainfall is of the convective type due partly to the presence of the East African highlands. Also, the drier conditions in the Sahelian countries will worsen. Moreover, the melting of small glaciers and the thermal expansion of ocean water associated with temperature increase is expected to cause a rise of sea level. The New Zealand Climate Committee has estimated that if warming were to melt a greater proportion of Antarctic ice, it would lead to a global rise of sea level of approximately 8 m (Ellis, 1991). The Ivory Coast, Gambia, Sudan, and the coastal southern African states are among the low-lying countries which would experience immense flooding due to a rise in sea level.

### *Forest and Hydrology*

A major consideration regarding the forest–rainfall relationship is that a sudden upward movement of air (over forest) can trigger the building of cumulus cloud and initiate rain (Proctor, 1985). Forest is far more effective than other vegetation types at trapping other kinds of precipitation, especially fog, cloud and moisture. Thus, rainfall has declined in many deforested parts of tropical Africa, including Eritrea, Tigray and Wallo Provinces of northern Ethiopia; in the Sahel, from Chad and Niger to Mauritania; and in Zambia, Zimbabwe and Mozambique in most years since 1968 (Lamb, 1985; O'Connor, 1991).

The high permeability of forest soils enhances the moisture balance in the catchment area as well as reduces the risk of catastrophic floods and low flows. Rivers in high-rainfall, forested areas have a higher

<sup>1</sup>They are areas believed to be an abode of a god or deity. The trees in that area are not allowed to be felled and the area itself cannot be cultivated. Such sacred areas are established on the top of hills or on a ridge so the trees may have an inadvertent conservation effect as well.

<sup>2</sup>In the stratosphere, ozone (O<sub>3</sub>) protects the earth from the ultraviolet radiation whereas in the troposphere, it is an important greenhouse gas.

<sup>3</sup>This prediction must be treated with caution since the relationship between CO<sub>2</sub> and other gases and climatic change is dependent on the influences of other factors such as ocean behaviour, water, vapour, cloud retroaction, fluctuations in the climate system and the increase in concentration of greenhouse gases.

discharge in relation to the drainage area compared with rivers in semiarid or deforested areas (Lewis and Berry, 1988). About 90 per cent of the total river length in Africa is in small streams, and these streams are highly affected by changes in vegetation cover. Large rivers, such as the Niger, the Rufji (in Tanzania) and the Tana (in Kenya), have been also affected by the weather conditions of the wet–dry areas upon which they flow. Lake Chad shrank from 25 000 km<sup>2</sup> to 3000 km<sup>2</sup> between 1983 and 1984 and River Niger was virtually dry at Niamey in 1985 (Mortimore, 1989). Without high discharges from their highland rainforest sources, these rivers would not be permanent streams throughout their long course.

Droughts do contribute to declining agricultural and livestock production and worsen the already deteriorating living conditions as has happened in Somalia and Ethiopia (Hare, 1983, 1993). They could also have political consequences for countries that area already in conflict over water. Sudan and Egypt depend on the Nile. Sudan – the source of the Nile – has been trying to divert a bigger share of the river's water. Downstream, Egypt's population growth rate is one of the highest in Africa, and this has led to an increase in its water need. A series of droughts in Sudan could worsen the conflict (Revkin, 1988). Droughts have contributed to the decline and abandonment of settlements, for example in northern Nigeria, Sudan and Sahel regions, although communities have been developing socio–economic and land-use systems, with increasing difficulty, to adjust to the harsh environment (Udo, *et al.*, 1993).

#### *Forest and Soil Erosion and Sedimentation*

The relationship between deforestation and soil erosion is difficult to measure since the magnitude of erosion depends, among other things, on land-use practice, soil management, location and annual rainfall. Nevertheless, Table IV shows that soil erosion is higher in areas with little or no vegetative cover. In addition, the importance of nitrate as a potential agent appears relatively low in undisturbed forests because nitrifying bacteria function poorly in acid soils, with the soil becoming even more acid as the forest matures. However, when forests are cut and the inhibition mechanisms destroyed, nitrates become relatively important in leaching processes, evidenced in the heavily logged areas in the Ivory Coast, Nigeria and Ghana (Jackson, 1981; Korem, 1985; Lal, 1986). Soil degradation and the loss of soil fertility contribute to a reduction in crop yield, for example, in Nigeria, maize yields have declined from 6.5 t ha<sup>-1</sup> to 1 t ha<sup>-1</sup> due to loss of soil fertility. Tropical Africa is the only region where food production per capita has fallen consistently for over 20 years (FAO, 1986).

Table IV. Type of ground cover (vegetation) and rate of soil erosion

Country	Type of ground cover	Mean annual rainfall (mm)	Rate of erosion (t ha <sup>-1</sup> y <sup>-1</sup> )
Mpwapwa (Tanzania)	Bare plot	500–800	165
Adiopodoume (Cote d'Ivoire)	Bare plot (7% slope)	2100	138
Gempela (Burkina Faso)	Bare soil (7% slope)	800	126
Adiopodoume (Cote d'Ivoire)	Natural bush fallow	2100	0.6
Henderson (Zimbabwe)	Full grass cover (4.5% slope)	750	0.7
Henderson (Zimbabwe)	Bare plot	750	127

Source: Stocking, 1984.

A hydrological problem induced by soil erosion is the one relating to increased sediment reaching stream channels. Silting-up of reservoirs has led to the diminishing of water supply in Madagascar (Randrianarijaona, 1983) and in central highlands of Ethiopia (Lamb, 1985). In Ghana, the Afram River Project – a project which was constructed to provide water in the Kwahu District – has been virtually abandoned after just two years of operation because of drought and sedimentation. It must be noted that not all sediments create negative environmental effects. Some material moving from the mountain tops to the ocean is building deltas, and delta oceans are frequently those of high fertility that contribute substantially to agricultural production. In Cameroon, annual floods used to increase the carrying capacity of the savanna floodplain

until the floodwaters were diverted to facilitate the development of hydroagricultural projects (Drijver and Marchand, 1985).

#### *Loss of Plant Species*

Although past extinctions have occurred mostly by natural processes, today human activities, including deforestation, are the main causes of plant extinctions. Until the middle of the century, Madagascar had about 12 000 plant and 190 000 animal species, but about 93 per cent of the original plant species has now been eliminated (WCED, 1987). One of the important tree species under threat in tropical Africa, which has serious ecological and economic consequences, is *Acacia senegal* (Pearce, *et al.*, 1990). It is a thorny, leguminous tree which produces brownish, oblong seed pods, found in most of West Africa, for example Mauritania, Nigeria, Senegal, Mali and Nigeria, and in parts of Ethiopia, Somalia and Sudan. Due to its extensive root system, it is suitable for maintaining soil structure and fertility and for preventing erosion and runoff. The decomposition of its leaves and pods increases soil fertility. It serves as fodder for cattle and other livestock, and the gum it produces is a source of employment and income. The removal of *Acacia senegal* has increased soil erosion, decreased the water retention rate of soil and disrupted rural livelihood. Forest clearance has created severe shortage of fuelwood, especially around the major cities. The depletion of the tree stock has a negative impact on the timber trade and foreign earnings. In 1991, Ghana earned over US \$118 million or equivalent to 28 per cent of the foreign loans contracted from the timber trade. If timber exports were to fall to zero, Ghana would face a deficit on its external accounts (Mintah, 1993).

### CONCLUSIONS AND POLICY RECOMMENDATIONS

Farmers are usually blamed for their unwise farming practices, and environmental pressure groups call for legislation to ban practices considered to be non-sustainable. The majority of the farmers may be illiterate but are not irrational (Upon, 1987; Boahene, 1996a). With limited technology, they have resorted to slash and burn as the main method of forest clearance for increased agricultural production. Farmers have a large number of children per head because, in the absence of institutionalized welfare, they need children to support them during old age. Educating farmers about dangers of environmental degradation, or imposing a ban on logging by rural poor, is necessary but it will not abate deforestation if their access to a secure form of economic activity or improved technology is limited. With declining agricultural production, the principal issue is not how to stop forest depletion, but how to manage forest resources to enable the community to meet its objectives on an efficient and fair basis. This section discusses a number of forest management initiatives.

#### *High-yielding Varieties*

In the past, increases in agricultural production have been achieved through the expansion of cultivated land and the intensive use of labour. However, with the rise in deforestation and the migration of rural labour force to the urban areas, the use of hybrid seeds and new farm practices has become essential. Adoption of hybrid cereals has increased farm incomes and generated agricultural development in savanna areas in Nigeria (Hazell and Roell, 1983), Kenya (Freeman, 1985), Ghana (Sijm, 1993) and Zambia (Kumar, 1994). In the rain forest areas, hybrid tree crops have been promoted to provide a steady stream of income, conserve soil moisture and protect the catchment of streams (see Boahene, 1995, for a review).

Nevertheless, in most areas where hybrid crops have been introduced to small-scale farmers, they have had limited impact due not primarily to their genetic vulnerability but to the lack of complementary resources such as credit, land, labour and extension services, and attractive producer prices. Provision of these resources has therefore been considered as a prerequisite for increased adoption (Bevan, *et al.*, 1989; Kumar, 1994; Eicher, 1995). Further, to overcome the problems associated with technology adoption, such as improper use of inputs, high concentration of wealth and the exploitation by seed-producing multinationals, there is a need to facilitate coordination and control among planning entities and to reach consensus on

needs assessment and their prioritization (Hart, 1989; Lipton and Longhurst, 1989). Diversification of farming systems should be introduced to minimize the dangers of loss of output. For example, in 1985 the production of sorghum in Sudan rose substantially, partly due to a shift from other crops such as groundnuts and cotton, on small-scale tenant farms in government irrigation scheme areas, whereas food production increased in certain parts of Nigeria through the operations of medium- and large-scale farmers (Curtis, 1988).

#### *Irrigation and Conservation Practices*

Irrigation services have not had a promising history in tropical Africa. Small-scale irrigation projects have been costly and ineffective because they have only been a scaled-down version of large projects (Adams, 1990). They have faced serious problems of water shortage, flooding and salinity, as well as having to rely on external funding for maintenance and for the provision of inputs such as fertilizer and diesel (Ton and De Jong, 1990). Large-scale government schemes have also failed, including in Nigeria, Mauritania, Senegal and Kenya, due to problems relating to terrain, soils and hydrology, skilled labour, foreign exchange, communication, inappropriate planning and corruption (Biswas, 1988; Adams, 1990).

Nevertheless, irrigation remains a prerequisite in agricultural business and land management in drought-stricken savanna and arid areas. Medium- and large-scale private irrigation projects seem to be the most viable projects because the private capital, expertise and technology involved can help to ensure efficient use of resources. The projects should aim at integrating production, marketing and processing in order to develop new products and markets and raise farm income. In Kenya, the numbers of irrigated medium- to large-scale commercial farms is rising, and this has contributed to a flourishing vegetable industry. The rural poor are benefiting from the irrigation projects through their participation in capitalist enterprise and market exchange. Larger, private agricultural enterprises can enter into contracts with small-scale farmers to enable the latter to receive the advantages of modern technologies, marketing and related services (World Bank, 1990). Landless farmers and rural poor get jobs as labourers on the projects and earn a cash income (Adams, 1992).

#### *Land Tenure and Agro-based Industries*

Land reform has been suggested as a way to deal with the problem of landlessness and its impact on agricultural productivity, because unavailability of land has forced small farmers and landless labourers to farm on marginal areas (Feder and Noronha, 1987). Farmers without title to land devote resources to subsistence production and are less inclined to invest in land conservation (Commander, *et al.*, 1989). However, land reform initiated by governments should only be considered as a short-term measure since it might lead to the privatization of land and benefit the wealthy at the expense of the socially disadvantaged groups (Stroosnijder, 1992). The recent complaints that land intended for the rural poor in Zimbabwe and Kenya ended up in the hands of the rich and politically connected individuals illustrate some of the problems involved in public land reform programmes.

Given these problems, it is important to promote land reforms sparked by changes within the community itself. To prevent the restrictions on land sale, Ghanaian small farmers and landless labourers have been entering into a contract of land-sharing – do ma yenkye (literally translated as ‘weed and let us share’) – with landowners (Boahene, 1995). Landless farmers obtain land from large landowners who have limited access to labour, and the former cultivate it. The farmer bears all the costs relating to land preparation, planting of cocoa seeds and the maintenance of the farm. Before the crops bear their first fruits, the farm is shared between the farmer and the landowner. A positive aspect of do ma yenkye is that it is open to both male and female small-scale farmers and for tree-crop farming. About 90 per cent of farmers who obtain land through do ma yenkye have adopted hybrid cocoa, contributing to an increase in farm income and investment in soil conservation.

An effective programme to offset rural poverty should provide the rural poor with the opportunity to maintain steady employment and income. Agriculture, with its dependence on nature and scarcity of inputs,

does not seem to offer this prospect. Rural industrialization releases part of the population from the land and also offers communities the possibility of earning secure income. Rural people are involved in a variety of off-farm activities such as carpentry, masonry, blacksmithing, pottery, trading and wine brewing (Scott, 1995; Boahene, 1996b). With public support, these activities can improve the well-being of the communities. For instance, the shelter provided by masons, furniture made by carpenters and plants exploited for medicinal use can enhance human comfort and health. Blacksmiths produce farm tools which can help raise labour productivity. The former depend mostly on abandoned household utensils, metal scrap, knives and cutlasses for their raw materials to produce handicrafts and tools, and thus serve as the recycling industry for the village. In villages in Zimbabwe, Sudan, the Ivory Coast and Ghana where rural industrialization has been carried out, living conditions have improved substantially (Babiker, 1982; Vijverberg, 1990; Scott, 1995; Boahene, 1996b). Vijverberg reports that in the Ivory Coast the income of rural enterprise households is higher than that of urban enterprise households. However, the promotion of rural industries, for example, woodcraft and cane furniture work, can lead to the depletion of natural resources if the emphasis is put on developing new entrepreneurs and not on promoting infrastructure that will ensure sustained rural diversification, for example providing training, marketing facilities and developing improved sources of raw materials.

### *Afforestation*

Agroforestry – a local forest management initiative, involving the growing of trees along with the planting of agricultural crops – has been adopted across tropical Africa (Owusu, 1990; Jason, 1991; Heathcote, 1992). In Nigeria, to counter the threat of desertification in the northern states of Borno, Sokoto, Kano, Katsina and Bauchi, annual tree-planting campaigns have been implemented, and between 1989 and 1999 an estimated 400 000 ha of forest trees and protection belts are expected to be created (Chorkor, 1993). Demonstration farms for agroforestry have involved packages of alley-cropping techniques for dissemination to farmers through the extension services. The problem is that in some parts of Africa, including Ghana, agroforestry plant species have involved limited use of local forest species, which makes the project unsuitable for the forest environment (EPC, 1991). The exotic fast-growing species prescribed for individual farmers in afforestation programmes (e.g. *neem* and *Cassia siamea*) dominate the undergrowth of forests, repress the regeneration of forest seedlings and worsen soil fertility. Owusu (1990) reports that the labour required to manage a project is sometimes not available. Afforestation should therefore appraise the quality as well as the quantity of biomass, and this requires promoting species which can be adapted most easily to local technologies and socio-economic constraints.

The creation of national parks has become part of the programme to protect endangered plant and animal species, and national legislations relating to the establishment of national parks have been enacted (Simon, 1991; Chorkor, 1993). In Cameroon, the laws state that 20 per cent of the national territory is to be designated as state forest (Alpert, 1993). The existence of these parks is essential but, ironically, their long-term survival depends on the ability to manage forest outside the parks. Land degradation forces the poor to encroach on protected areas, which drastically increases the cost of policing the reserves. Also, continued deforestation alters local and regional climates, through drought and high temperatures, which makes it difficult for protected species to survive.

### *Provision of Alternative Forms of Fuel and Energy*

On the issue of fuelwood consumption, electricity and gas seem to be the alternatives for fuelwood, especially in the urban areas. In Ghana, the switch to gas is estimated to save some 7 million kg of trees from being felled (Hardi, 1992). However, many tropical African countries are importers of petroleum products and their limited foreign earning ensures that there is always a shortage of these products. For countries with petroleum deposits, governments have become the sole regulators of fuel and energy and the state energy agencies have been fraught with inefficiencies. The setting up of independent energy boards is crucial to eradicate incompetencies and reduce production costs and thus makes the products affordable to

households. The political will for the establishment of these boards has been lacking, because it implies the transfer of power from the state to individual entrepreneurs and the loss of revenue through taxes and royalties. In Nigeria, petroleum alone contributes to about 82 per cent of government revenue (Obadan, 1991). The structural adjustment programmes undertaken by African countries will contribute towards the creation of a rationalized petroleum industry, but households can only afford the products if there is a corresponding increase in real incomes (Aubynn, 1994).

Hydroelectric power (HEP) has a greater potential in tropical Africa because of the excellent physical nature of many river basins, for example, rivers develop single arteries and have steep gradients on their course (Lewis and Berry, 1988). The capacity utilization of most dams has not been reached so the prospect of providing energy from existing dams for household is great (Moxon, 1984). The high cost of connecting every village to the national electricity grid is the main problem militating against the adoption of electricity as household fuel. Ghana offers an example in which communities and the government have teamed up to provide electricity for villages. Rural communities have been raising money through specially arranged communal activities. Where communities show initiative by purchasing an electricity transformer and/or poles, the government provides the expertise, the cables and related materials required for the project. This partnership has helped extend HEP to many towns and villages, which may not have got it had the decision been based on their economic importance. In spite of the benefits of HEP, new dam projects should be thoroughly evaluated because river systems in tropical Africa usually necessitate large dams which are not always economically justified and have negative environmental effects.

The use of solar energy is also seen as a means to overcome the shortage of fuelwood. In Kenya and Cape Verde, two Dutch organizations – TOOL and BEZA – have begun a project to popularize solar cookers (Weerd, 1996). Cooking on a solar cooker is twice as fast as on wood. The stove costs about US\$45 – a substantial amount for a rural household with a wage of less than US\$20 per month. Further, the solar cooker cannot be used for baking and deep frying, which is the most common means of cooking in tropical Africa, and like the electric stove, it does not give food a smoky taste. The use of the solar cookers will mean that households will have to adjust their eating habits and will therefore affect the acceptability of these technologies in the community.

#### *Prevention of Logging*

The enactment of legislation has become common in the effort to control logging, especially by large-scale timber operators. However, its effectiveness against the rural poor will partly depend on the provision of alternative forms of economic activity. In Ghana, a special taskforce was set up on the initiative of villages to monitor logging and its environmental effects, which will help ensure compliance. Similarly, the setting up of a regional plan, e.g. the Central Africa Regional Action Plan (CARAP) comprising Cameroon, the Central Africa Republic, equatorial Guinea, Gabon, São Tomé and Príncipe, and Zaïre for the rationalization of the use of tropical forests is a step in the right direction. Their task might include the banning of the export of endangered tree species, imposing levies or withdrawing the licences of companies which lumber endangered tree species, undertaking an inventory of equipment and personnel in the wood-processing industry to prevent inefficiencies and waste, and helping local people and companies in afforestation programmes. The success of such a regional agency will depend on the availability of funding, but a tax levied on timber products, especially exports, can provide funds to support these activities.

The industrialized countries have a responsibility with regard to the conservation of forest in tropical Africa. In 1992, the European Union (EU) imported 28 per cent of the world's tropical timber, and Africa was its largest buyer (Misser 1992). As long as demand exists for tropical woods, farmers and timber operators will always be motivated to cut trees. It has been suggested that the industrialized countries ban the importation of endangered tropical tree species (Hardi, 1992; Robbins, 1992). For instance, the EU which has 336 of the 1000 votes in the International Tropical Timber Organization, can play a significant role in controlling timber exports. According to the Worldwide Fund for Nature, by 1995 The Netherlands was the only country in the EU which had developed a policy aimed at trade based on sustainable management. The

industrialized countries can provide funds for financing environmental projects, for example, in 1990, the EU granted US \$29.4 million to fund the activities of the Central Africa Regional Action Plan for rationalizing forest use (Robbins, 1992; Misser, 1992).

### *Environmental Education*

Education is an essential management tool for acquiring support for environmental protection. For environmental education to be effective, it must, among other things, be tailored to the needs and concerns of the various people in the communities and train highly qualified people to work in the field. Boahene (1996b) has shown that for small-scale farmers, the problems that affect their ability to obtain a secure livelihood are major sources of complaint. About 90 per cent of 103 small-scale farmers interviewed in the eastern region of Ghana considered drought and soil erosion as serious environmental problems, while none of them viewed global warming as a problem. Future changes in climatic patterns induced by global warming do not seem to bother the rural poor when they find it difficult to provide for their daily survival. Global warming is mostly seen in the context that because it is a threat to the industrialized countries that is why there is so much campaigning about it (Vick, 1990).

Thus, in designing environmental education for the rural communities, it is necessary to emphasize the local environmental problems associated with deforestation. For large-scale timber operators and urban dwellers, by reason of their education, environmental education can include discussions about global warming and the depletion of the ozone layer.

Besides raising environmental awareness, education should involve the dissemination of improved technologies to rural people as well as large-scale timber operators. Devising specialized programmes, aimed at communicating the often complicated and controversial environmental problems and methods, is time-consuming and requires efficient environmental extension centres which are at the moment virtually non-existent at the local and regional levels. Therefore, the setting up of environmental educational centres as focal points for local environmental action is essential (Mariov and Sandler, 1993). Moreover, these centres can also help plan environmental curricula, carry out educational programmes in schools and teach communities to adopt sustainable technologies.

Formal environmental subjects need to be vigorously introduced at the various levels of the educational systems, namely at the elementary school to raise environmental awareness at an early age and at post-secondary school to ensure a continuing source of environmental experts. The organization of informal environmental education through discussions among members of the community, local and national events and field trips are other important means for raising environmental awareness. In Kenya and Ghana, it has been shown that knowledgeable farmers (the so-called 'target farmers') are as important disseminators of innovations as extension agents (Bevan, *et al.*, 1989; Boahene, 1995). There is a long way to go in ensuring efficient forest management, but if the various issues discussed in this paper are considered, it will contribute towards the design of a more coordinated, fair and effective approach to the use of forest resources.

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