Promoting Stewardship of Forests in the Humid Forest Zone of Anglophone West and Central Africa

FINAL REPORT
of a collaborative research project undertaken by

The United Nations Environment Programme

and

The Center for International Forestry Research

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PREFACE

Sustainable forestry development combines the concepts of economic growth and environmental conservation; as such it is reasonable to expect it be on the agenda of many national and international organisations dealing with economic development and environmental conservation. The United Nations Environment Programme (UNEP) is one such organisation which gives attention to sustainable forestry development in the context of the United Nations Conference on Environment and Development. *Agenda 21* gives UNEP a comparative advantage in placing its activities at the interface of the integration of environment and development.

It is in this context that UNEP conceived the project whose results are reported in this document, with the Center for International Forestry Research (CIFOR) as the collaborating partner responsible for the project's implementation. The project focuses on the West African humid forests of Ghana and Nigeria, with information provided on Liberia and Sierra Leone to the extent possible. Cameroon, a country which is officially Francophone but with a large English-speaking population, has been included in the study in order to provide more complete coverage of Anglophone West African countries where this type of forest exists.

The general objective of the project was to integrate all available information on West African humid forest formations in order to catalyse initiatives at national, regional and international levels which may foster the adoption of sustainable forest management principles throughout the region.

The project reported here will contribute to a larger joint project currently being undertaken by CIFOR and the Government of France for the Francophone countries of Côte d'Ivoire, Cameroon, Central African Republic, Congo and Gabon.

An Advisory Group composed of representatives from CIFOR, UNEP, ATO, FAO, ITTO, and several national institutions and NGOs helped oversee the project. UNESCO and IUCN were also invited to join the Advisory Group but were not able to do so, although they were kept informed about the project and its progress. Field work was contracted to the Forest Research Institute of Ghana (FORIG) under the direction of Dr. Albert Ofosu-Asiedu, and to Prof. Philip Kio of Nigeria. Under their direction a synthesis was prepared to summarise forest management technologies and options in the region. They also organised thematic workshops which evaluated land use practices and related policies, institutional arrangements, and other forms of government intervention which affect sustainable forest management. Additional workshops examined inter-generational issues and technical forest management issues. A stakeholders' consultation was also convened to obtain the views of various stakeholder groups. The present report is a product of all these efforts.

The report is organised into nine chapters. The first chapter gives an account of the forestry situation in West and Central Africa, with emphasis on vegetation distribution and factors affecting forest management. Chapters 2 and 3 highlight past and present silvicultural and forest management practices and also consider management control systems. The relevance of biodiversity and the role of non-timber forest products are explored in Chapter 4. Intergenerational issues, socio-economic factors influencing sustainable forest management, and the

relevance of policies and legislation are addressed in Chapters 5, 6 and 7. Chapter 8 outlines strategies and incentives which might be adopted to promote sustainable forest management. The report concludes in Chapter 9 with suggestions for research which could be undertaken to fill gaps in knowledge which became apparent in the course of this project.

In the hope of maximising its utility to foresters, environmentalists, government decision makers and other interested parties throughout the tropics, this report is being published simultaneously in both English and French. Copies of the publication will be available without charge from both UNEP and CIFOR until supplies are exhausted.

ACKNOWLEDGEMENTS

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The English-language original of this document was translated into French by Mr. Guy Ferlin, Forest Engineer, Les Cigales, Chemin de Bellevue, 83110 Sanary sur Mer, France.

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INTRODUCTION

Anglophone West and Central African countries with tropical moist forest include Sierra Leone, Liberia, Ghana and Nigeria. Although not officially Anglophone, Cameroon is included in this report because it has a large English-speaking population. These five countries lie approximately between latitudes 5° N and 10° N, and longitudes 15° E and 13° W. They cover a total land area of 1.8 million km^2 of which 28.6% fall within the high forest zone.

This chapter reviews the status of forestry resources in these countries as drawn from submissions by Owusu (1995) and Soladoye (1995) in country reports on Ghana and Nigeria respectively and from a paper on "Sustainable Forest Management in West Africa: Ecology and Conservation" (Okali and Fasehun 1995).

PHYSICAL FEATURES, VEGETATION, LAND USE AND TOPOGRAPHY

West Africa is generally low lying, exceeding 1,000 m altitude only in a few places. The general landscape consists of sandy coastal plains crossed by many rivers with mangroves bordering their estuaries. It rises inland to relatively low plateaux dissected by rivers, and interrupted in places by residual inselbergs and small higher plateaux such as the Fouta Djallon (1,500 m), the Upper Guinea Highlands (1,947 m), the Jos Plateau (1,200 m) and the Chappal Wadei (2,419 m) at the border between Nigeria and Cameroon.

Geology and Soils

Pre-Cambrian rocks of the basement complex underlie the sub-region predominantly. South of latitude 12° N, about two-thirds of the land surface consist of these formations while the remaining third is covered by more recent sedimentary formations. The basement complex consists of schists, phyllites, quartzites, granites and gneisses. Soils developed over the more basic rocks are chemically the richest with high clay contents. The poorest basement complex soils are those over quartzite and other quartz-rich rocks. In general, where the annual rainfall is less than 1,700 mm, soils that developed directly over the basement complex rocks tend to be more fertile than those over sedimentary formations. Conversely, where the rainfall is high, as in the moist

forest lands, the upland soils, irrespective of parent material, are heavily leached and ferrallitic. Most soils in the moist forest zone are of the latter type (Ahn 1970) and readily lose their fertility once the vegetation cover is removed. Soil differences of geological origin have been linked to variations in forest type in Nigeria (Hall 1977).

Climate

The West African climate is controlled principally by the seasonal movement of two air masses (Ojo 1977). From September to February, the Tropical Continental Air Mass spreads southwards from the Sahara to about latitude 5° N, accompanied by the hot, dry and dusty north-easterly wind known as the Harmattan. From March to August, the Tropical Maritime Air Mass, associated with rain-bearing south-westerly winds, moves northwards to about latitude 21° N. The two air masses are separated by the Inter-Tropical Discontinuity Zone (ITD). Movement of the ITD northwards is thus associated with the rainy season while its southward movement brings the dry season.

The amount, duration and regularity of rain decrease from south to north. In some parts of the coastal region (e.g. Calabar in south-eastern Nigeria and the coastal belt from Guinea to Liberia), annual rainfall may exceed 3,000 mm, while to the north-east of Nigeria annual rainfall averages only 500 mm. From Nigeria to Liberia, rainfall tends to be bimodal in the south, but to the north and further west in Guinea, rainfall becomes increasingly concentrated in a single season. The duration of the dry season is shortest (one or two months during January and February) at the coast, and longest (eight to nine months from October to May) in the far north (Fig. 1). The alternating north and south movements of the ITD are responsible for the orientation of the climatic and vegetation zones in a latitudinal pattern in West Africa. Oceanic currents contribute to dry climatic conditions which give rise to coastal savanna in eastern Ghana, Togo and Benin Republic - the so-called 'Dahomey gap'.

Temperatures near the coast are relatively constant throughout the year, with mean daily maxima and minima close to 34° C and 22° C respectively. In the north, day temperatures during the dry season can be as high as 43° C and fall below 10° C at night.

Vegetation

Two main vegetation formations – forest and savanna – dominate the West African landscape, extending across the sub-region in broad belts parallel to the coast (Fig. 1). The West African forest belt belongs to the Guinea-Congolian phyto-geographical region (White 1983). This

forest belt extends westwards to Guinea along the coast from Nigeria, where it merges with the main stretch of the African rainforests from Cameroon to Zaire. The extension is however not continuous, being interrupted by savanna in the 'Dahomey gap'. The major forest types which occur within the belt are, from the coast northwards, mangroves, freshwater swamp forests and lowland forests.

Mangroves

Mangroves are most extensive in the deltas of the large rivers where the vigour of the sea surf is broken by sand banks. They also occur in small bays and lagoons, where soils are brackish, between high and low tide marks. Thus they may appear as narrow strips extending for several kilometres inland along the banks of the major rivers. Mangroves, which occur in all the West African countries, are most extensive in Nigeria (10,515 km^2) where they have developed in association with the Niger delta and the extensive lagoon system, but may have virtually disappeared in some countries like Togo under pressure from exploitation. The most common tree species in West African mangroves are *Rhizophora racemosa, R. harrisonii*, *R. mangle*, *Avicennia germinans (*syn. *A. africana. A. nitida)* and *Laguncularia racemosa*. The trees form a dense forest tangle generally about 10 m high, but some trees can reach a height of 45 m (Rosevear 1947). The sedge *Cyperus articulatus*, the grass *Paspalum vaginatum* and the fern *Acrostichum aureum* are common associates of the trees especially where the forest canopy has been opened. Logging, fuelwood cutting, illegal hunting and, especially in Nigeria, petroleum exploitation and invasion by the exotic palm, *Nypa fruticans*, are major threats to the West African mangroves.

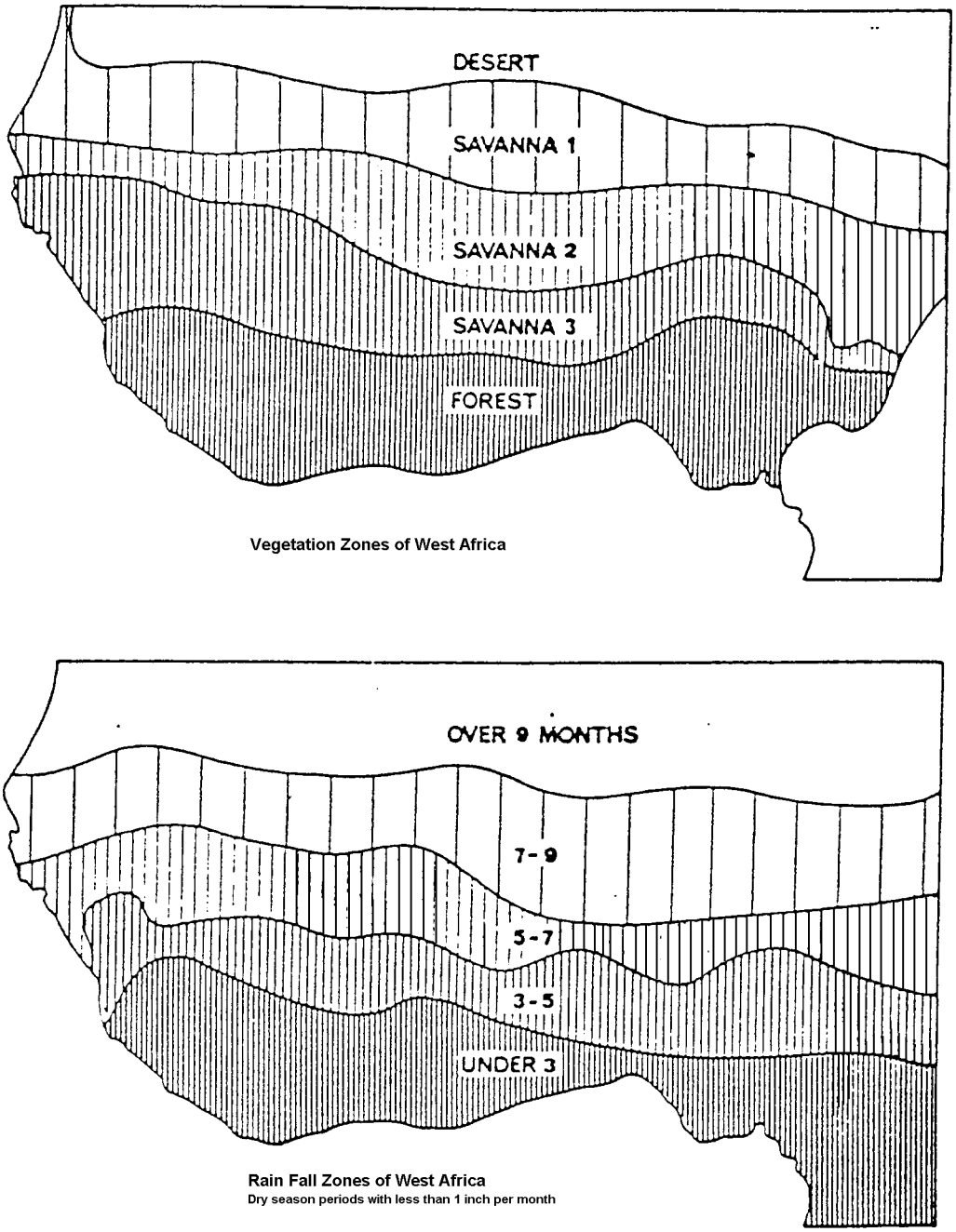

Figure 1. *Comparison of West African vegetation and rainfall zones.*

Swamp Communities

Progressing inland, mangroves give way to freshwater swamp forests. These swamp forests are commonly flooded during the rainy season, but dry out in the arid season. They often fringe the rivers and estuaries that flow into the lagoons, with their waterfronts dominated by species such as *Raphia, Pandanus,* rattans or *Alchornea*. The fringing section of the swamp forests is seldom more than 15 m tall but, behind it, important commercial timber species, such as *Mitragyna ledermannii*, *Symphonia globulifera*, *Lophira alata* (ironwood), *Nauclea gillettii* and *Alstonia boonei* may attain heights of up to 45 m in Nigeria. The main canopy of the forests is formed by smaller trees which commonly include *Spondianthus preussii, Oxystigma manni*, *Anthostema aubryanum*, *Carapa procera*, *Uapaca* spp., *Garcinia* spp. (the source of bitter kola and chewing sticks) and *Cleistopholis patens* (used in canoe building). Some of these trees have stilt roots (e.g. *Uapaca*), pneumatophores and knee roots (e.g. *Mitragyna*) as adaptations to the poorly aerated substrate.

Lowland Forest Belts

Still further inland, the lowland forest belt is the main source of timber, and contains the greatest biodiversity of the vegetation types found in West Africa. The belt was originally covered by true forests, similar to those existing today in some forest reserves. The complexity of the belt is its source of wealth, but it also makes successful forest management difficult.

In Ghana, seven vegetation types are included within the lowland forests, each with its distinct associations of plant species, structure and physical environment. Wet evergreen forests occur in the region with the highest annual rainfall and poorest, heavily leached soil. It is followed in the north by moist evergreen forests with annual rainfall between 1,500-1,700 mm. Next is the moist semi-deciduous forests on the richest soils with an annual rainfall of 1,200-1,800 mm. This is the most important formation for timber production, being rich in commercial species such as utile (*Entandrophragma utile*), African mahogany (*Khaya ivorensis*) and wawa/obeche (*Triplochiton scleroxylon*) which readily attain heights greater than 50 m. Dry semi-deciduous forests occur at the northern fringe of the moist semi-deciduous forests, where the annual rainfall drops below 1,500 mm. These variants of lowland forests occur in comparable environmental conditions throughout West Africa, but their floristic compositions differ between the western and eastern stretches of forests separated by the 'Dahomey gap'. The remaining forest types — upland evergreen, southern marginal and

south-east outliers — are probably peculiar to Ghana, but may have equivalents in similar environmental conditions in the other countries.

Trees predominate the lowland forest ecosystem, the largest of which may attain heights exceeding 60 m, and may be wider than 300 cm in girth at breast height. Such large trees are usually few (<10/ha) and occupy the upper canopy. Some authors (e.g. Richards 1952) hold the view that trees in lowland forests are vertically stratified into distinct layers, such that the tallest trees from emergents have isolated crowns and, at a lower level, a canopy layer of trees with touching crowns, beneath which is the understorey of small trees with spreading crowns. In practice, it is often difficult to discern such distinct layers as tree crowns appear to exist at all levels. The tallest trees must in their growth pass through the shorter sizes before attaining their final heights. It is reasonable to expect young individuals of the canopy trees or emergents to exist at various heights in the forest profile, thus obscuring any stratification (Swaine and Hall 1986).

Woody climbers (lianes) are also characteristic of lowland forests. They rarely exceed 10 cm in diameter but readily reach up to 200 m in length, binding many trees together while reaching the topmost tree crowns. Shrubs, herbs and epiphytes (orchids, ferns, bryophytes and lichens) are also characteristic life forms of the West African lowland forests. The feature which poses the greatest obstacle to management is, however, the great floristic diversity of the forests. Though not as rich as the forests in the American tropics or South-east Asia, lowland forests in West Africa may contain as many as 50-100 tree species greater than 10 cm dbh, at densities of up to 500 trees in one hectare, of which only 2-5 trees yielding a total volume of 30 m^3 may be merchantable. The trees may co-exist with 200-500 other vascular species per hectare. Regeneration of a sufficient number of merchantable trees, among so many potential competitors, has been the main challenge to West African forest silviculture.

In Nigeria, the drier forests are dominated by of the Sterculiaceae (*Cola* spp., *Mansonia altissima*, *Nesogordonia papaverifera*, *Pterygota* spp., *Triplochiton scleroxylon*), the Moraceae (*Antiaris africana*, *Ficus* spp., *Milicia excelsa*) and the Ulmaceae (*Celtis* spp., *Holoptelea grandis*). Dominant trees in the wetter forests include the Leguminosae (*Brachystegia* spp., *Cylicodiscus gabonensis*, *Gossweilerodendron balsamiferum*, *Piptadeniastrum africanum*) and the Meliaceae (*Entandrophragma* spp., *Guarea* spp., *Khaya ivorensis*, *Lovoa trichilioides*), while the trees in the wettest forests include *Klainedoxa gabonensis*, *Lophira alata*, *Nauclea diderrichii* and *Pycnanthus angolensis.*

Shrubs like *Massularia* spp. and herbs such as the Marantaceae constitute the non-timber resources of the West African forests, which are not only vital to the rural economies but have potentials for industrial use.

Land Use

When discussing forest resources in West Africa, all land not cultivated or developed for settlement and associated infrastructure should be included in order to recognise the many forest products and services from such lands which sustain the predominant rural economies. It is even difficult to distinguish agricultural land from forests because of the prevalence of the bush-fallows and the use of natural vegetation for grazing. Many farms and fallows consist of substantial forests (Okali 1995). Over 70% of the population in the sub-region is engaged in agriculture and, because of the rapid increase in population and the continuing extensive use of bush-fallowing and land rotation, forest land in the sub-region is under severe pressure.

The traditional land uses in West Africa are small-scale farming, cattle grazing, urbanisation, fuelwood and pastoralism. To meet the needs of the colonial powers and sustain European industrialisation, large-scale agriculture, ranches and 'improved' natural rangelands, tree plantations of exotic and indigenous species (cocoa, rubber, timber) and game/park reserves were developed.

IMPACT OF POPULATION ON FORESTS

Due to increasing population pressure and current agricultural practices (e.g. shifting cultivation), the area of natural high forests has declined rapidly over the last three decades. Today most of the existing forests occur as reserved forests. The total land area and the population of the various countries are presented in Table 1.

The high forests of West Africa, like the other tropical rainforests of the world, are characterised by a rich and complex floristic composition. For instance, there are over 2,100 plant species in the tropical high forests of Ghana. Of these 730 are tree species with 680 of them above 5 cm dbh (Hall and Swaine 1981). Hawthorne (1989) observed that 420 of the tree species are common and of wide distribution, and that about 126 tree species grow to timber size. From this number, 50 tree species are considered merchantable (Francois 1987; Sayer *et al*. 1992) and 66 have been exported at least once since 1973 (Ghartey 1990).

Table 1. *Comparative statistics for Anglophone West and Central African countries.*

Country	Land Area (km^2)	Forest Zone (km^2)	Reserved Forest (km^2)	% of FZ	Population* (thousands)
Ghana[1]	238,538	81,342	17,895	22.0	17,792
Nigeria[2]	983,213	133,717	20,764	15.5	111,802
Sierra Leone[3]	73,326	7,400	366	5.0	4,912
Liberia[4]	96,320	96,000	13,000	13.5	2,770
Cameroon[5]	475,000	220,000	89,836	40.8	11,082

Sources: 1: Ghana Forestry Department Annual Reports
2: Nwoboshi (1987)
3, 4: Poore *et al.* (1989); FAO (1989a)
5: ITTO Project PD 74/90 Cameroon 1993
* Population as at 1994

Ghana had 8.1 million ha of forest land at the turn of the century (Ghartey 1990). By 1950 about 50% of the original forests had been cleared and almost 79% of it had been lost by 1980 (Sayer *et al.* 1992). At present, the total area of forest estates in Ghana, excluding game reserves, is 2.1 million ha with 1.8 million ha in the high forest zone and only 0.3 million ha in the savanna zone. Production reserves constitute 70% of the total forest estates (ODA/FD 1989). According to the International Tropical Timber Organisation (IIED *et al.* 1993), the forests with continuous canopy outside the reserves are estimated to be 0.3 million ha. A similar situation is found in Nigeria which has a larger forest area than Ghana. During the last decade, the forest area decreased from 14.9 million ha in 1980 to 10.1 million ha in 1990, corresponding to an annual deforestation rate of approximately 3.5% (FORMECU 1985). In Sierra Leone, closed high forests and secondary forests make up 10% (or 0.62 million ha) of the natural forest reserves. The extent of deforestation can be gauged from the fact that 59% (3.8 million ha) of the natural forest resources were classified as "forest regrowth" in 1989.

The rapid loss of forest resources in West Africa, especially since the 1970s, has been attributed to increasing population pressure. For example, the gross national standing volume of timber tree species in Nigeria for the period between 1978 and 1988 was estimated to be 181 million m^3. The total volume removed in that same period was 72 million m^3 (40% of standing volume). In Ghana, the standing volume of trees above the girth limit (70 cm dbh) was estimated at 103 million m^3 in 1989. The volume of timber trees under the girth limit but above 30 cm dbh was estimated at 95 million m^3 (Ghartey 1990). The total volume of timber extracted in Ghana between 1986 and 1992 was 7.8 million m^3 (7.5% of standing volume) of

roundwood (IIED *et al.* 1993). This indicates that the total volume of wood removed per unit area per year in Nigeria (3 $m^3 ha^{-1} yr^{-1}$) was 5 times greater than that of Ghana (0.62 $m^3 ha^{-1} yr^{-1}$). This greater stress on the forests of Nigeria has been ascribed to the large population of that country. According to FAO (1989a) the high population density in Nigeria (92 persons km^{-2}) has resulted in a great local demand for wood products which often leads to intense political pressure to convert the forests to agriculture.

FAO (1995) reported that Ghana recorded a decline in natural forest area between 1980 and 1990 at an annual rate of 138,000 ha. Corresponding statistics for other Anglophone countries revealed the annual rates for Liberia at 25,000 ha, Nigeria at 119,000 ha, Sierra Leone at 12,000 ha and Cameroon at 122,000 ha.

Increasing population pressure and its resultant impact on forest degradation have been two of the most important factors influencing the evolution of policies, silvicultural techniques and forest management practices in West Africa. Undoubtedly, the choice between natural and artificial regeneration systems for the tropical forests gave rise to many debates and conflicts among early foresters who worked in the tropics.

ECONOMIC FACTORS AFFECTING FOREST MANAGEMENT

Several economic factors have impeded the accomplishment of sustainable development objectives in the forestry sector. Some of these factors are highlighted below.

Forest Resources as Sources of Revenue to Government

In the pre-independence era, forest resources especially timber and timber products constituted a major source of revenue to the colonial governments. One essential consideration for forest reservation in the Anglophone countries was the potential of the forests to provide timber for export. The situation has virtually remained unchanged in the post-independence period. Their forest resources have been exploited to the extent that management plans have virtually been abandoned, while allocation of concessions is sometimes treated as a political patronage. The neglect of planning as a tool to sustainable utilisation of forest resources and development has been a constraint to sustainable forest development in the sub-region.

Low Wages

Some macro-economic policies have had an effect on the purchasing power of wage earners generally in the sub-region. Most employees are experiencing serious economic hardships due to the fall in the real value of money despite the recent increase in their allowances to reduce the adverse effect of economic policies.

Under these circumstances, the day's task ceases to have any tangible connection in the employee's mind to the wages paid, which essentially is a complete breakdown of the employment system. To survive, alternative private income must be sought. This has caused an outflow of better qualified and experienced staff to the private sector, and subsequently the promotion of the less qualified and experienced into the vacant positions. In effect, low employees' morale in the forestry sector has negatively affected the achievement of sustainable forestry development in Anglophone West Africa. In addition, an increase in the incidence of illegal forest exploitation is witnessed, at times with the active complicity of the forestry staff.

Low Funding

The staff members of the forest services are estate managers for the government, the trustees for the communal land owners. For the last seventeen years the efficiency of the forest services in most countries has declined, and they seem to have abdicated their responsibilities as well as participated (for example, in some states of Nigeria) in the destruction of the resources. Though the forest resources are treated as a source of revenue, the government at all levels has not invested enough in their development and management. Equally, they lack the needed manpower and funds to clean and patrol estate boundaries. The government alone is therefore incapable of afforestation on a sufficient scale to guarantee future wood supplies. There must be reliance on individuals and communities, particularly in rural areas, to meet a substantial part of their own needs. The private sector must be involved in the development of forest estates and the management of existing ones to ensure future industrial wood supply. The forest management situation has also been affected by the political instability especially in Liberia, while in Sierra Leone the situation is compounded by a general economic recession in recent years.

Nature of Forest Investment

Many investments in primary forest production have long gestation periods and are highly capital intensive. Most investors would not like to be involved in projects that would tie down their resources for long periods especially in the face of political and economic instability. The situation is further aggravated by the present high cost of capital where potential investors would have to compete for funds available at fairly high rates of interest.

Inadequate Information about Investment Opportunities

The West African public has little or no knowledge about the existing investment opportunities in the forestry sector apart from timber exploitation and sawmilling. At present, no unit in the various forestry departments is responsible for informing the public about investment opportunities and potentials in forestry such as plantation development and in non-timber forest products (NTFP).

Under-valuation of Forest Resources

In West Africa, primary forest product prices vary tremendously among countries and decisions on product pricing are virtually dictated by the government (Ajayi and Omoluabi 1994). Political pressure groups such as the timber associations can influence the level of prices, giving little consideration to the production costs and their economic value, and make wood growing by the private sector unattractive.

CHAPTER 2

SILVICULTURE AND FOREST MANAGEMENT PRACTICES

INTRODUCTION

Forest management in the natural high forests of Anglophone West and Central Africa has generally followed the classic European Uniform and Selection Systems. This tradition is strongly related to the history of colonisation of the sub-region by Britain, France and to some lesser extent Germany. The field operations under the various systems are different as a result of the experiences and traditional forest practices of the colonial forest officers. For instance, the British foresters after successfully using the Shelterwood System in the District Camp Forest of Malaysia attempted to use it in Nigeria and Ghana, while the French have used the Layons in Cameroon and Côte d'Ivoire.

Silvicultural and forest management practices that have been tried in Anglophone West Africa date back to 1906 (Taylor 1960) when forest regulatory methods which were essentially timber rules were first applied in Nigeria. The silvicultural systems tested since 1926 include the Uniform, Selection and Enrichment Planting Systems. While the Uniform Systems were intended to make management of the high forest easy, they were not cost effective. The Selection System was comparatively less expensive and therefore more acceptable, especially as it could maintain the heterogeneity of the forest. It is however, more difficult to improve upon due to inadequate knowledge of the dynamics of the forest ecosystem. The Enrichment Planting Systems have been practised only on a small scale compared to the other systems.

THE UNIFORM SYSTEMS

The Uniform Systems aim at producing an even-aged natural forest and entail the removal of the entire marketable standing stock at the same time. In theory, they are applied to basically enhance the regeneration of economic species and thereby increase the economic value of the natural forest. The unique characteristic of the Uniform Systems is the gradual or sequential opening of the forest canopy by removing climbers and undesirable tree species to favour the growth and development of economic trees. Canopy opening under the Uniform Systems is generally severe, often reaching up to 80% of the basal area of the stand (Kio *et al.* 1985).

One of the most important features of the Uniform Systems is the short regeneration period. For example, a regeneration period of ten years was envisaged under the Tropical

Shelterwood System. The short regeneration period is to ensure that the next crop takes over the stand quickly since the final produce is harvested once.

A long rotation period is usually maintained under the Uniform Systems due to the extremely high felling intensity used when harvesting the final stock. For example, a regeneration period of 100 years was generally maintained in Nigeria and Ghana.

The Uniform Systems comprise the following group of silvicultural treatments:

- Tropical Shelterwood System;
- Group Shelterwood System;
- Uniform Shelterwood System;
- Walsh System; and
- Post Exploitation System.

A summary of the general observations under these systems is given below.

Tropical Shelterwood System

The Tropical Shelterwood System (TSS) was developed in Malaysia in the early 1930s (Osafo 1970) and modified in Nigeria at about 1944 (Anon 1971). It was first tried as an experiment in Bobiri Forest Reserve in Ghana in 1947/48 and later expanded to cover other forest types, especially Asenanyo, Benso and Pra-Anum Forest Reserves (Osafo 1970). The TSS was originally aimed at the regeneration of economic species, especially the Meliaceae. Since these species at seedling stage require a certain amount of shade, the canopy is lifted in two stages. This is to prevent an influx of light-demanding weeds which tend to compete with young seedlings of the desirable species.

The TSS aims at drastically modifying the species mixture of the tropical mixed forest to achieve a uniform age-class structure and thereby simplify the management of the tropical high forest (Alder 1994). Theoretically, the TSS was expected to produce a uniform canopy of regeneration made up largely of Class I and II trees. The classification system was, however, not uniform as the species vary among countries, thus leading to slight differences in the way the TSS was practised in these countries.

An essential component of the TSS was the removal of undesirable ‘weed’ species and climbers to release regeneration of Class I and II species (commercially valuable species) from competition. In 1948 sodium arsenite poisoning was introduced for opening the canopy. Poisoning trials indicated that under the TSS it was desirable to open the canopy to medium

density in the first year and to make further openings in the following year. It was also observed that a five year period was adequate to induce the required regeneration before felling the commercial trees. With this observation the TSS became a pre-exploitation operation.

Unquestionably, regeneration under TSS was successful. However, the fast growing Class II and non-commercial species tended to suppress the slow growing economic species, hence the need for repeated climber cutting, poisoning and cleaning. This slows down operations, making them more intensive and expensive. TSS was therefore found to be cost effective only in forests with a good stocking of Class I trees (Osafo 1970).

Assessment of TSS plots in Bobiri, Pra-Anum and Afram Headwaters in Ghana indicated encouraging results in 1951. A good regeneration of *Milicia* species was reported in 1948 from the Afram Headwaters FR following light canopy opening in 1947. However, trials at Subri were less encouraging due to lack of seed trees of the desirable species. Generally, it was observed that as long as the forests had a fairly normal structure, and there was a reasonable number of mother (seed) trees of the desirable species, then regeneration under TSS could be assured (Kio *et al*. 1985). A regeneration period of ten years was envisaged.

Table 2. *Costs and revenue of tropical shelterwood system operations in Bobiri Forest Reserve, Ghana.*

Operation	Year	Worker-days/ha	US$/ha
COSTS			
Climber cutting	0	8.5	187
First canopy opening	0	5.0	110
Second canopy opening	1	5.0	110
First cleaning	2	10.0	220
Second cleaning	3	10.0	220
Third cleaning	5	10.0	220
Fourth cleaning	8	10.0	220
Overwood removal	10	4.0	88
Discounted cost at 10%			**1,017**
REVENUES			
First exploitation	6	15.0	300
Final felling	60	60.0	1,200
Discounted revenue at 10%			**173**

Source: Alder (1993)

On the basis of the disadvantages of the TSS, which were found to outweigh the benefits observed, the system was abandoned. A recent appraisal of the system (Alder 1993) only confirms that canopy opening generally enhanced increment. Even though several TSS research studies were conducted in most West African countries, the system was never applied extensively except in Nigeria, probably because of the high costs. From the Bobiri experiments in Ghana, Alder (1993) estimated the costs and revenues from the TSS operations (Table 2).

Group Shelterwood System

This system entails clearing the spaces around exploited stumps, stacking and then burning the branches. Parent trees of desired species are selected, and the undergrowth, climbers and lower storey trees in a surrounding area of about one hectare are cut, stacked and burned away from the parent tree.

Uniform Shelterwood System

Under the Uniform Shelterwood System a whole compartment, instead of selected trees, is cleared of all climbers, herbaceous undergrowth and saplings of inferior species. Large trees of inferior species are girdled and the debris stacked at the base of the girdled trees and burnt to defoliate them before timber exploitation in that area.

Walsh System

Forest regeneration under the Walsh System involves the clearing and burning of a whole compartment, the remaining debris being stacked and re-burnt. The few remnant parent trees left during felling to help regeneration are felled three years later (Fasehun 1995).

Post-Exploitation System

The Post-Exploitation System, similar in several respects to the TSS, also aims at achieving fairly uniform forests rich in commercial species. Treatment of the forests, i.e. cleanings to encourage regeneration and poisoning of undesirable understorey trees, follows first exploitation in year six. Five to six years after exploitation (i.e. twelve years after the initial cleanings) a general poisoning of the overwood (upper crop) is carried out.

Advantages and Disadvantages of the Uniform Systems

The Walsh, Post-Exploitation, Group Shelterwood and Uniform Shelterwood Systems were all widely studied in research plots, however, none of them was applied extensively as a management tool. The advantages and disadvantages of the Uniform Systems are presented below.

Advantages:

- The presence of only a few species made the application of cultural operations easy;
- More valuable timber (economic species) could be obtained per unit area;
- Abundant regeneration of economic species was achieved in the shortest possible time (but not necessarily *targeted* species; see disadvantages below); and
- High survival and growth of the existing regeneration were ensured.

Disadvantages:

- The Systems were not effective in areas with poor stock of seed trees from economic species;
- Considerable damage was inflicted on regeneration and forest soils by the numerous canopy opening operations carried out periodically;
- They caused a reduction in the population of many useful species which were either poisoned or cut to favour the growth of a few valuable species;
- Very few of the targeted species regenerated successfully. The Systems usually produced abundant regrowth of pioneer species which were of low economic value compared to non-pioneers. The regeneration of pioneers was enhanced while that of shade bearers (*sensu* Hawthorne 1989) was suppressed in the high irradiance created as a result of canopy opening;
- In areas where the Systems could not produce more of the economic species the forests were virtually rendered useless with poor stocking;
- The Systems were only useful for managing the forests for timber production. Therefore no provision was made for the maintenance of biological diversity. The sustained functioning of the ecosystem under these Systems was doubtful;
- It was very expensive and the benefits did not justify the cost of operating the Systems, as the expected regeneration was not obtained in all cases;
- Intermediate thinning products were not used effectively; and

- Debris disposal through burning under the Walsh, Group and Uniform Shelterwood Systems was not efficient and resulted in loss of nutrients.

THE SELECTION SYSTEM

The Selection System has been described as the most conservative and widely used silvicultural system in West Central Africa (Parren and de Graaf 1995). The system is applied as a major management tool to induce natural regeneration so as to retain the uneven aged structure of the natural stand but with a more varied species composition than the Uniform Systems, and more commercial species than the untreated natural stand. The system as practised in several countries used scattered felling, described by Troup (1966) as mere 'exploitation felling' that did not necessarily ensure regeneration.

The Modified Selection or Combined System was therefore devised in Ghana in the early 1950s to make the system more efficient and also to enhance regeneration of the desirable species. The treatment was applied at an annual rate of about 31,000 ha and by 1970 when it was suspended, a total area of 259,000 ha of the high forests had been covered (Asabre 1987). Initially, the silvicultural treatment took place after logging. But due to low logging intensity resulting in negligible disturbances that required no post-exploitation treatment, it was found that the treatment could be carried out at the same time with the stock survey (pre-logging period). This procedure became known as the 'Combined Operation'. An assessment of the treatment in 1964 indicated that the stand increment varied with ecological guild and forest type (Osafo 1970). For instance, the pioneer species had their highest growth in drier forests probably because of the more open canopy while non-pioneers responded better in the wetter forests due to the denser canopy.

Several logging silvicultural treatments have been tested to improve results. Notably among these are the improvement thinning, salvage felling and selective felling by diameter limits. In this system, a single tree or group of trees is given to concessionaires for exploitation. Generally, trees selected consist of over-mature trees, trees with broken tops or diseased trees and economic tree species.

The Selection System is currently more favoured as a management tool in the natural forests than the Uniform Systems. Some of the major advantages and disadvantages are:

Advantages:

- Biological diversity in terms of plant and animal species is encouraged;
- Both timber and non-timber forest products are abundant, such as canes, sponge, chewing stick, gums, raphia, poles, bushmeat;
- With the wide range of species available, it is possible to respond more flexibly to the changing demands of the people and to new opportunities over time; and
- Cyclical removals from the forests based on the minimum diameter felling limits are possible. Such a system fits well into the dynamics of the high forests, as areas previously exploited under the Selection System are now being worked a second time under current felling prescriptions in Ghana with satisfactory results (Nolan 1989).

Disadvantages:

- Logging is selective, hence timber volume harvested per unit area is low. However, with more species becoming economically valuable this situation could improve; and
- Damage to residual crop trees per unit area and also per unit volume of timber harvested is often higher under this system as compared to the Uniform Systems.

Improvement (Liberation) Thinning

Improvement or Liberation Thinning involves thinning before or after commercial exploitation of mature trees to reduce crown and root competition. However it is limited to the removal of non-economic trees in favour of economic ones, the less valuable ones in favour of more valuable species (Osafo 1970). Two main activities – climber cutting and removal of undesirable species – are performed in this treatment. These operations involve weeding or removal by cutting or poisoning of all climbers and undesirable species that may impede the growth and development of the desirable species. Trees removed are mainly those with heavy low crowns which may be found to restrict the crown space of the desirable species or cast dense shade on them. Weeding and thinning are carried out within a specified radius from the desirable trees. Economic tree species of diameter greater than 50 cm at breast height are not treated because at that size the crown will be in the upper canopy.

Improvement Thinning is also found to reduce the commercial rotation age of tropical timber tree species (Hutchinson 1987). The system involves the selection of individual trees for removal without considering the stocking of the stand. It may be useful, therefore, to

determine the volume or basal area of trees to be logged as part of the thinning. The treatment may also be improved by determining well-defined thinning intensities that would favour the various species guilds. The major problem associated with Improvement Thinning is the use of arboricides which, though easier and more effective, have a deleterious effect on the environment and affect biodiversity.

This treatment was extensively used in Ghana between 1960 and 1970. It is estimated an area of 259,000 ha was treated. Experimental results from Ghana and Côte d'Ivoire indicate that the treatment enhances growth, especially in forests with advanced regeneration of commercial trees (Osafo 1970; Maitre, 1986). However, the Improvement Thinning programme of West Africa, like that of Malaysia, was suspended without further assessment due to the following reasons:

- The forests needed more extensive felling to remove the overwood of mature and dying trees in the shortest possible time; and
- The arboricide (i.e. sodium arsenide) being used was banned and time was needed to develop other methods of killing the undesirable trees.

Salvage Felling

This term, which generally refers to commercial logging, aims to remove the overwood and over-mature trees. In poorly stocked natural forests all utilisable trees are salvaged before conversion to a plantation. In the selection forests this treatment is carried out as a cleaning operation to remove the dead and dying trees and to provide growing space for suppressed trees. In practice the treatment involves the felling of the trees of diameter above a certain minimum considered to be the maturity point for the various species. Usually the felling takes place within a specified period all over the forest, similar to the adjustment period adopted in the classical Selection System for bringing an irregular forest to a normal stocking level (Adam 1989). However, due to the limitations in defining the point of over-maturity for various species, the treatment can lead to the loss of desirable or superior genotypes. The point of maturity for the various species will have to be scientifically determined.

The wholesale removal of all emergent economic trees could lead to higher mortality of saplings of species incapable of adapting quickly to sudden changes in irradiance in the forest environment. The salvage period also needs to be long enough to ensure adequate recovery from logging damages as well as give sufficient recruitment for the next felling cycle.

When the diameter distribution at the compartment level is not taken into consideration, it could lead to clear felling in places with a preponderance of larger trees. Salvage felling has been used mainly in Ghana but also to a limited extent in Nigeria and Côte d'Ivoire. The treatment leads to varying logging intensities under different forest conditions which can result in a marked reduction of trees with lower diameters as well as the mature trees that will be available for felling in the next cycle (Adam *et al*. 1994). It is suitable only in forests which are being logged for the first time. Even under such situation, the felling intensity should be determined with due consideration to the diameter distribution of the stand.

Selective Felling

Selective felling has been practised extensively in West and Central Africa and is characterised by the removal of individual trees of economic species scattered over a given forest area. It comprises two main operations, namely timber inventory and yield regulation. Slight variations in the practice of the system, however, are found in these countries.

Timber Inventory

This operation is commonly referred to in West Africa as stock survey (Baidoe 1970; Redhead 1971). A stock survey is usually undertaken before permission is granted to a concessionaire to exploit a compartment or annual coupe in almost all the countries in the sub-region. The main purpose of the stock survey is to identify the current stocking of exploitable trees as well as those of the replacement crop. It also provides information on the location of the exploitable trees to facilitate proper road and skid trail layout. The most important use of the stock survey data is to calculate the volume of the exploitable trees and mark out the selected trees. It involves a complete enumeration of all commercial timber species above a certain minimum diameter, e.g. 50 cm dbh in Ghana (Baidoe 1970) and 42 cm dbh in Liberia (Parren and de Graaf 1995). In Ghana and Nigeria the stock survey is mainly conducted by their forestry departments, whereas in Liberia and Cameroon it is done exclusively by the concessionaires (Gatter 1984; Tropenbos 1992).

During stock surveys, each tree enumerated is given a number which runs serially through the compartment and is inscribed into the bark of the tree with a scribing knife. The parameters recorded for each tree are species name, stem diameter (at dbh or above buttress) and co-ordinates for the location of the tree in relation to a cut transect. The data are used to

produce a stock map representing a bird's eye-view of each compartment and its trees. In addition to the stock map a stand table is prepared showing the tree numbers recorded according to species and diameter classes. The stand table provides the stem numbers needed for the yield calculation and the stock map helps in yield selection.

The advantage of using the survey map to determine yield is that it gives an indication of species richness, density and distribution for different concessions in the same forest type and for different forest types. A properly executed stock survey generally enhances sustainable management of the forests.

Annual Yield Regulation

The annual amount of wood to be exploited may be expressed in terms of forest land area, volume or basal area per unit area. When yield is regulated in terms of land area, it is often not possible to pre-determine the actual quantity of wood. However the assumption is that equal areas within the same forest type will supply similar amounts of wood. This has the tendency to over-supply or under-supply the local log market depending on the stocking level of the site that is due for exploitation. If the method is not properly applied, timber depletion and forest degradation are very likely to happen. The area method is currently being used in Nigeria and Cameroon. In Nigeria the annual yield for concessionaires may vary from one to several hundred hectares.

When the yield is prescribed in volume or basal area it usually entails calculations using specifically evolved equations. The yield equations may be derived from the total stand increment, individual species increment, total standing stock and individual species stocking. Some equations used are modifications of the Brandis method (as used in the Far East) and a combination of the Hufnagl and von Mantel yield equations (used in Central Europe). These equations have been used in Ghana and Nigeria by the colonial forest administrations. Unlike the area method these formulae give the amount of timber in volume, or basal area or number of stems per species per unit area. The accuracy of the formulae is greatly affected by the growth and mortality statistics. For instance when a diameter growth of 8 mm per year and a 20% mortality over 25 years were used in Ghana for commercial timber trees, a lot of over-mature trees were retained (Adam 1989) necessitating salvage felling between 1972 and 1987.

Recent Experience with Growth and Yield Modelling

Current attempts to improve the yield equations have also been constrained by the paucity of growth and mortality data. It is believed that the most effective way of addressing yield calculation is through simulation models (Alder 1991; Vanclay 1993). But even for such models growth and mortality data are indispensable as input variables to ensure accurate predictions of yield (Foli 1993). Foli also evaluated the sustainability of the current yield formula in Ghana compared with an alternative iterative spreadsheet model suggested by Alder (1992) for calculating yield in tropical high forests. A sensitivity analysis of mortality rates used as variables in these models showed that outputs from the spreadsheet method remained stable for mortality rates up to 2.7%, after which yields declined. This shows that such a model becomes sensitive to mortality changes when the rate is high enough for the entire residual stock to die off before the next felling cycle (Alder 1995), and underscores the importance of mortality data in the determination of sustainable yield.

Okojie (1995) has reviewed the methods of multi-variate analysis which have been tried for growth and yield modelling in Nigeria. They are either distance dependent models (primary unit-single tree parameters) or distance independent models (primary unit-stem parameters).

Stem Diameter Distribution Models

The diameter distribution information of a stand is as important as the information on total volume. But special techniques are involved in summarising information on diameter distribution. Many probability densities other than the normal distribution are in use. These include the uniform distribution, the log-normal distribution, the gamma distribution, the beta distribution and the Weibull distribution.

The Weibull distribution is flexible and characterises different actual distributions simply by differences in its parameter values. Okojie (1981) employed the cumulative density function (cdf) of the 3-parameter Weibull distribution to characterise stem-diameter distribution in some mixed plantations of indigenous Meliaceae in Sapoba. The cumulative density function of the Weibull distribution used was of the form:

$$F(x) = 1 - \exp\left(- \{[x - \mathbf{a}]/\mathbf{b}\}^{\mathbf{c}}\right)$$

where $F(x)$ measures the area under the curve, x is the random variable, diameter, and exp( ) is the exponential function. The shape of the Weibull distribution is dependent on the value of

parameter **c** while **a** and **b** represent the location and scale parameters respectively. The values of the Weibull parameters have biological interpretations (Okojie 1981). The relationships between the Weibull parameters and stand attributes were examined. From the selected stand attributes multiple linear predictive models were obtained for *Lovoa trichilioides*, *Khaya ivorensis* and *Entandrophragma cylindricum*.

Distance independent, single-tree non-linear models were also developed for diameter increment in these stands of indigenous Meliaceae (Okojie 1981). These models were used to determine the expected number of stems in defined diameter classes in the stand, at given future dates. Increment values were small (0.48-1.46 cm/annum) and variable. Skewness indices derived from the Weibull parameters were used to determine the level of tolerance of the species examined. *E. cylindricum, K. ivorensis* and *L. trichilioides* were in that order in the level of tolerance.

Growth Models

Bada (1984) employed a modification of the generalised Chapman-Richard growth function based on von Bertalanffy's growth model to examine growth data from a Permanent Sample Plot in Usonigbe Forest Reserve in Nigeria. The predictive basal area growth model is:

$$BA\ (1 \ldots 7) = (n/k) - c[\exp(-\{1-m\}kt^{(1/[1-m])})]$$

where *n, k, c* and *m* are growth coefficients, and *t* is the age of the stand in years (1 … 7).

In addition Bada used the Markov Model to assess tree population changes and future stand structures in the untreated natural forests. He observed that there were great variations (2.1 m^2 – 8.1 m^2/ha) in basal area values from one plot to another. As in most untreated natural forests, the mean annual increments for the Meliaceae were small (0.45 cm). The tree population structure was also highly variable. Bada obtained, through an iterative procedure, a general solution model for predicting basal area of eleven selected species. It is as follows:

$$B = (n/k) - (\exp(-(1-m)kt))^{(1/(1-m))}$$

where *n, k* and *m* are growth coefficients and *t* is the age of the stand in years.

Basal area ranged from 2 m^2/ha to 5 m^2/ha for all species examined at the beginning of the study, but they ranged from 3.8 m^2/ha – 8.2 m^2/ha at the end of the study.

Matrix Models

Osho (1988) applied matrix models to study the population dynamics of trees in Idanre Forest Reserve. He used the population growth matrix model to predict long-term growth of the untreated natural forests. Of particular interest was the stand density and basal area growth. It was also possible to determine the stability of the forests using the dominant eigen-value. Bada (1984) used the value of the dominant latent root to examine the stable state of distribution of the population in the untreated forests of Usonigbe. He observed that most members of a given size class remained in the respective size class at some future date because of the slow growth rate. In addition, the population of the lower size classes was zero at the Stable State Distribution (SSD). Osho developed a linear programming approach to determine the maximum sustainable yield in the forest of Idanre. He also developed a stochastic matrix model for simulating secondary succession in the untreated forests and was able to project the composition of the stand using the current species composition. The studies involved estimates of recruitment and mortality rates. Osho concluded that increased growth rate (30-40%) was required to reach a stable state in the forests. In respect of recruitment an improvement of 500% was required. The implications for disturbed natural forests are therefore very serious. Ojo (1990) used the matrix modelling procedure to project the compositions in Oban, Omo, Owan and Sapoba Forest Reserves. He investigated the stable structure and obtained the stand table projection using the matrix multiplication sequence. Patterns of growth varied from species to species in these forests. Species showed no net change in the number of stems during the measuring periodic intervals. In some cases the species decreased in density. However, he indicated that most of the forests will reach a stable state in 80 years.

OTHER MEASURES FOR REGULATING HARVESTS

Felling Cycle

Felling cycle is defined as the period between two successive commercial harvests in the same forest stand. The optimum felling cycle is one that ensures complete forest recovery and sufficient stem recruitment into the exploitable diameter class. The length of the felling cycle is directly related to the intensity of logging which is also affected by factors such as species composition, stem diameter distribution, total stocking, silvicultural characteristics of desirable species, cost of exploitation and financial needs of the land owner.

The felling cycle in Cameroon is 30-60 years and 50 years in Nigeria. The felling cycles in Nigeria and Cameroon are estimated using a method similar to that in Ghana, using the time of passage for individual species and the total growth of the entire forests to establish a more ecologically acceptable frequency of cutting.

Generally shorter cycles are used when felling intensity is low and longer cycles when felling is intensive. Shorter cycles may be used as biological controls to remove diseased or infested trees as well as salvage mortality if the affected sizes are merchantable. On the other hand, longer cycles allow for increased volume per unit area harvested. This in turn reduces logging cost per unit volume as there will be more volume per unit area to absorb fixed cost. According to Osmaston (1968), the length of the felling cycle often used in selective felling may amount to one-quarter or even more than one-third of the exploitable ages of many of the species. In West Africa where exploitable ages have been estimated between 70-200 years (Alder 1989), cutting cycles ranging from 15-100 years have been applied. For instance under the modified selection system in Ghana a 25-year cycle was used from 1960-1985. This represented half of the estimated time for 50 cm dbh trees to grow to the minimum felling diameter of 90 cm. A recent analysis in Ghana has necessitated a revision of the felling cycle from 25 to 40 years (Alder 1992).

Diameter Limit

Since the age of trees is difficult to determine in the natural forests, maturity is usually defined by stem diameter. However, the size of trees to be harvested may be determined by the total stocking and diameter distribution of a stand, general morphology of the species, forest site condition for growth and, very importantly, end use and processing technology. Several species grow to tree sizes of 25 cm dbh and over. Many of these species are also noted to grow above 50 cm dbh. However, the maximum diameter and height for any given species vary with forest types (Hall and Swaine 1976, 1981). This tends to constrain exploitation if one level of minimum felling limit is adopted for a species which occurs in several ecological zones within a particular country. It has also been observed that wood deterioration in standing trees is strongly related to site. To fix the minimum limit for sawn and veneer logs, it is more realistic to relate the stem diameter to wood quality. This helps to retain more immature trees while providing for the salvaging of over-mature ones. Felling limits between 50 cm and 110 cm dbh are being used in West Africa as shown in Table 3. The bases for fixing these

limits are not well documented. In Ghana, however, it is supposed to indicate a point in the species diameter distribution where the average national stocking shows a sharp decline.

Table 3. *Felling diameter limits in four West African countries.*

	Minimum Felling Diameter (cm)			
Species	**Cameroon**	**Ghana**	**Côte d'Ivoire**	**Liberia**
Khaya grandifolia	80	110	60	100
Khaya anthotheca	80	110	60	70
Khaya ivorensis	80	110	60	–
Pericopsis elata	100	110	50	–
Triplochiton scleroxylon	80	110	60	90
Lophira alata	60	70	60	80
Mansonia altissima	60	70	50	60
Guarea cedrata	80	70	60	80
Guarea thompsoni	80	70	–	80
Lovoa trichilioides	80	70	60	70
Afzelia bipindensis	80	–	–	–
Afzelia africana	80	70	60	70
Afzelia pachyloba	80	–	–	–
Diospyros crassiflora	50	–	–	–
Terminalia ivorensis	60	70	60	70
Terminalia superba	60	70	60	70
Milicia excelsa	100	110	60	80
Entandrophragma candollei	80	110	60	90
Entandrophragma utile	80	110	60	100
Entandrophragma angolense	80	110	60	90
Entandrophragma congoense	80	–	–	–
Entandrophragma cylindricum	100	110	60	90
Nesogordonia papaverifera	50	70	50	60
Tieghemella africana	60	–	–	–
Tieghemella heckelli	–	110	60	100
Aningeria spp.	60	110	50	–
Turraeanthus africana	60	70	60	80
Mitragyna ciliata	60	70	–	80
Guibourtia ehie	60	70	60	60
Sterculia rhinopetala	60	70	–	–
Distemonanthus benthamianus	60	70	60	–
Canarium schweinfurtii	60	70	60	80
Antiaris africana/toxicaria	60	70	60	60
Nauclea diderrichii	60	110	60	–
Piptadeniastrum africanum	60	90	60	80
Ceiba pentandra	60	110	60	90
Celtis zenkeri	60	70	60	–
Alstonia boonei	60	110	60	70
Daniella ogea	60	90	60	70
Albizia ferruginea	60	70	60	–
Pycnanthus angolensis	60	70	60	70
Pterygota macrocarpa	60	110	60	60
Amphimas pterocarpoides	–	60	70	–
Mammea africana	60	70	–	60
Bombax brevicuspe	–	70	60	–
Heritiera utilis	–	70	50	60
Antrocaryon micraster	–	50	–	–
Brachystegia leonensis	–	–	–	90

Data assembled for this report

A basic premise of uneven aged or selection forest management is that the stand should contain trees of all age and size classes (Avery and Burkhart 1983). As mortality is high in the smaller size classes, it is desirable to have more small trees to be able to obtain sufficient large ones, a structure that gives a J-shaped distribution curve.

In an unregulated selection forest the diameter distribution may be found to be irregular. There may be a disproportionate number of stems in some diameter classes. It has been suggested that when trees are to be marked for felling (either silvicultural thinning or logging), cutting should concentrate on the diameter class with high stem numbers. This, however, depends on the marketability of the stem size. In this situation, the adoption of a minimum felling limit may not allow the removal of smaller diameter classes in case they predominate.

Growing Stock

The amount of wood to be cut generally depends on the growth or increment of the stand. It has therefore been suggested that an optimum reserve stock should be maintained after every logging so as to optimise the increment (Avery and Burkhart 1983). This is based on the fact that the total growth or increment is a function of the stocking. It is expected that the higher the stocking the greater the total growth. This is, however, dependent on the diameter distribution. The residual stock should therefore be composed mainly of stems that are in the productive class instead of those in their senescence. The composition and density of the residual stock that can give the maximum increment for a site needs to be investigated.

Species Composition of Yield

Though the natural forests contain many species, only few are harvested as timber. Its economic value in terms of commercial timber per unit area as compared to plantation forests is therefore low. Where attempts have been made to extract timber based on total forest growth, the tendency has been to remove all the increment from only a few species. This leads to the depletion of those species. Some measures used to maintain a good species composition have been to spread the yield proportionally among all species present. This measure has not been very successful because loggers also have to fell to meet the market demands. Trees that cannot be sold are thus not felled. According to Parren and de Graaf (1995), only about 30% of the allowable yield are actually felled by concessionaires. The population of such lesser used

species continue to build up while the number of desirable species decline. A marketing strategy that sells timber by wood categories instead of single species might help to correct the future species composition of the natural forests.

MANAGEMENT OF RESIDUAL STAND

The general management objectives of the natural forests as prescribed for most forest management working plans in the West and Central African sub-region deal with:

- Sustainable supply of timber and non-timber forest products;
- Protection of rivers and streams;
- Maintenance of environmental conditions necessary for the growth of agricultural crops; and
- Conservation of biodiversity.

However, it is usually the first management objective that is being vigorously pursued in most countries. This is probably because it deals with production (revenue generation) whereas the others are more geared towards conservation of forest resources.

Generally, species diversity is lower in logged-over sites compared to mature and unlogged natural forests (Ashton 1978). Since logging has considerable impact on forest structure and species composition and may lead to loss and fragmentation of forests (Foahoam and Jonkers 1992), logging activities should be carefully planned and executed if sustainable forest management is to be achieved. The following are some of the points to be considered in the development of strategies for sustainable exploitation:

- The number of trees that can be sustainably removed;
- The frequency with which a forest stand can be exploited without losing biodiversity or productivity;
- Consequences of exploiting a greater range of species; and
- Steps to be taken to protect the rarest species and ecosystems under threat (Hawthorne and Musah 1993).

In an attempt to derive maximum benefit from the forests, while at the same time ensuring sustainable utilisation of the forest resources, especially timber, most countries have tended to encourage the exploitation of a broad base of species. More lesser-used species are now being exploited with the attendant problem of increased canopy opening leading to changes in species composition and tree mortality (Swaine and Hall 1988). According to

Agyeman *et al*. (1995a), these microclimatic changes vary with the manner and intensity of logging operation which normally influences the rate of recovery of the forest after disturbance.

Three aspects of logging are considered under the management of the residual stand. These are logging disturbance, logging damage and recovery or regeneration after logging.

Logging Disturbance

Most disturbance caused by felling trees creates small gaps. For example, about 75% of all gaps created after felling in the Bura Forest Reserve in the moist semi-deciduous forest of Ghana were less than 300 m^2 corresponding to an irradiance of 50% (Agyeman *et al.* 1995b). Canopy gaps account for 50% of the total disturbances caused by logging with skid trails and haulage roads accounting for 38% and 12% respectively. The incidence of large gaps in logged forest is low, but the extent of its influence is quite high.

Large gaps created as a result of logging are important as they provide a regeneration habitat for many pioneers (Hartshorn 1980; Putz 1983). It is therefore not surprising that regeneration following logging comprises mostly pioneers. However, the number of pioneers decreases exponentially with time (Swaine and Hall 1988). This exponential decrease in numbers of pioneers is at such a low rate that even 30 years after severely opening up a forest canopy under TSS treatment, Okali and Ola-Adams (1987) observed that forest stocking comprised mostly pioneers only. The problem facing forest managers is that pioneers generally have lower economic value compared to non-pioneers, thus indicating the potential long-term deleterious effects of uncontrolled logging.

The area destroyed by felling a single tree varies considerably depending on species and mode of felling. For example, Owusu-Bi (1989) observed that between 200-300 m^2 of area are destroyed by felling each mature tree. Adam *et al*. (1994) recorded a range between 350-600 m^2, while Agyeman *et al*. (1995b) noted a wider range between 350-1800 m^2.

The extent of logging damage generally increases with logging intensity (Hendrison 1990). For example, felling 2.6 trees ha^{-1} at the Bura Forest Reserve in Ghana, resulted in a logging disturbance of 13% (Agyeman *et al*. 1995b), whereas felling 5.7 trees ha^{-1} at the Sapoba Forest Reserve in Nigeria resulted in almost 50% of the total area being cleared (Redhead 1960). Therefore the intensity of logging that any given forest type can support should be determined before logging of that area is permitted. However, the problem is that

changes in forest composition after disturbance have not been monitored long enough for accurate projection of the logging intensity a particular forest can withstand and still ensure sustainable regeneration. It is also uncertain whether a single sharp logging shock is better than multiple medium/low-shock entries into a given compartment or annual coupe. However, the general hypothesis is that if a regrowth suffers renewed disturbance, the composition of the new regrowth must in part be determined before renewed disturbance.

Logging Damage

Logging damage is generally moderate in African rainforests. However, Hawthorne (1993) observed that logging activities in Ghana resulted in a loss of up to 30% of the forest cover in the logged-over site depending on the intensity of logging and the site of operation. Mabberley (1983) also noted that in most tropical countries between 10-30% of the forest area is destroyed through logging. In South-east Asia, about 33% of the total area and 33-67% of the residual trees are damaged after logging.

Most damage is caused to small trees, most of which are killed. Large trees are more likely to have their bark stripped. There is generally little difference in the pattern of damage caused by felling gaps, skid trails and haulage roads. However, increasing logging intensity causes disproportionate increases in damage and area of forest affected.

Investigations on the effects of mechanised and manual logging in the tropical rainforests in Nigeria have been carried out (Fasehun and Adeberu 1979; Ola-Adams in press). Comparison of structure and composition of forests subjected to varying logging intensities is illustrated by an example from Omo Forest Reserve (Table 4) showing differences in density, basal area and volume. However, Table 4 also shows that the disturbed stand has the greatest biodiversity, and that as the stand approaches maturity the number of species diminish, probably as a result of the disappearance of most pioneer species. The greatest amount of damage occurred in the 30-40 cm diameter class (Table 5). The trees in this category suffered the highest amount of crown damage.

Trees with branch or stem damage may be able to grow better than those with crown damage although they may be exposed to pests and diseases. Branch, stem and crown damages can reduce diameter growth. Affected trees are mostly those located along the tracks and around the harvested trees. This was quite an unnecessary waste as the affected trees were not put to any

used but were left to rot. Moreover, the impact of the fallen trees may retard natural regeneration. The growth of the undamaged trees may be retarded because of habitat changes.

Table 4. *Comparison of structure and composition of undisturbed, disturbed (recently logged) and secondary forests.*

Measure	Undisturbed Forests	Disturbed Forests	Secondary Forests
Density (trees/ha)	190.9	108.7	104.9
Basal Area (m^2/ha)	28.9	14.3	11.6
Volume (m^3/ha)	791	343	184
Number of tree species	70	126	63
Number of families	29	40	28

*Based on an inventory by Sutter (1979).

Table 5. *Tree damage in a five-month-old logged-over forest in Omo Forest Reserve (Compartment 169) by diameter class.*

	Number of trees damaged by dbh class (cm)					
Type of Damage	10–20	20–30	30–40	40–50	50+	Totals
Crown damage	16	11	21	5	10	63
Branch damage	-	3	1	3	-	7
Stem damage	1	-	1	-	4	6
Felled	4	1	11	15	20	51
Undamaged	102	109	74	76	182	543
Totals	123	124	108	99	216	670

Source: Ola-Adams (1995)

Recovery after Logging

Liberation thinning, climber cutting and coppice management have been undertaken in the post-exploitation logging treatments. The aim of liberation thinning is to reduce competition, increase growing space for younger plants especially seedlings and saplings in the gaps, and

to help damaged trees develop new shoots through coppicing. In some countries, especially Ghana and Côte d'Ivoire, the working plans prescribe recovery operations in disturbed areas such as loading bays, skid trails and hauling roads. The recovery operations involve refilling of loading bays with top soil and planting with composite pioneer species.

Logging Gaps and Regeneration

Even though the regeneration of many species is gap dependent (Swaine and Whitmore 1988), medium-sized gaps and skid trails result in a greater regeneration of economic timber tree species than other gaps. Small gaps (resulting from branch falls or small-tree falls) and large gaps (resulting from multiple-tree falls, haulage roads and loading bays) result in reduced regeneration and a decline in the economic value of the forests. Greater regeneration on skid trails (medium irradiance) compared to small felling gaps (low irradiance) and haulage roads (high irradiance) was also observed by Hawthorne (1993) in a regeneration study after logging at the Bia South Forest Reserve. Skid trails also had a higher proportion of the presently exploited timber tree species regenerating. This underscores the importance of gaps in regeneration (Hartshorn 1978; Whitmore 1984).

CHAPTER 3
MANAGEMENT CONTROL SYSTEMS

Management control systems are strategies for ensuring uniformity in the methodology of forest operations and adherence to regulatory measures for the protection and sustainable management of forests. In West Africa management controls exist mainly in the form of working plans and manuals of procedure which deal with harvesting regulations, concession acquisition, revenue collection and disbursement, and forest product quality control and marketing.

The effectiveness of the control systems vary among the West African countries. The variations are related to factors such as:

- System of government;
- General economic situation in the country;
- Availability of trained manpower;
- Commitment of forestry staff;
- Co-ordination and co-operation among forestry sector institutions; and
- Co-operation between forestry service and the local communities or land owners.

The general laxity in forest management control systems in the sub-region is leading to the degradation of very rich forest estates. In Liberia, ineffective exploitation control has encouraged destructive and wasteful logging and milling methods (Koffa 1988).

During periods of political instability and economic depression, forest controls break down resulting in forest encroachment by farmers and loggers. This has been observed in Ghana, Nigeria and Liberia. Another general malady preventing effective control systems is the lack of qualified personnel. For instance in Sierra Leone about 66% of the established posts were vacant in 1981 (Allan 1988).

MANAGEMENT PLANS

The preparation of working plans for the management of natural tropical forests has now become a pre-requisite for marketing of tropical timber on the world market. Thus management plans have become one of the criteria for sustainable forest management. The current state of affairs paints a gloomy picture for the region's future share of the world market for tropical timber. Most forests do not have working plans and those that do, have outdated plans.

Writing of forest working plans in the region started in the 1950s. The working plans for Bobiri Forest Reserve in Ghana were written in 1955 (Anon 1960) and in Nigeria about 974,115 ha were under working plans by 1960 (Kio *et al.* 1993). These working plans and several others have not been revised since they were first written. Consequently routine management practices have generally been based instead of site-specific prescriptions as would have been provided by a working plan. In Liberia no working plans have ever been produced, and although plans have been developed for several forests in Cameroon this has only been done recently (Tropenbos 1992). Difficulties in writing or revising working plans are attributed to several factors, paramount among which are:

- Non-availability of up-to date forest stocking statistics;
- Lack of qualified trained manpower;
- Lack of adequate knowledge about the forest growth dynamics; and
- Lack of well-established silvicultural and management systems.

Some improvements have, however, occurred in the last ten years as a result of externally funded forest resource projects. The U.K. Overseas Development Administration (ODA) is funding a forest inventory and forest resource management project in Ghana (Howard 1989) to help prepare new working plans. The ODA is also carrying out a similar project in the Cross River State of Nigeria. In Cameroon the Tropenbos Foundation is providing training for personnel and logistics to undertake research for the development of natural forest management systems. Since management plans are necessary for sustainable forest management, national and state governments need to develop procedures to ensure regular revision and up-dating.

INVENTORIES

The application of forest inventory techniques to describe the forest structure, composition and quantification of the timber resources is an essential component of forest management control systems (Baidoe 1970; Redhead 1971; Gatter 1984). However, the high cost of the operation and the requirement for highly trained personnel and special equipment have made it difficult for all the Anglophone West African countries to wholly finance the prodecure. Most countries have therefore had to rely on external funding to support national forest inventories.

The two main inventory techniques which have been used in the sub-region are:

- Static enumeration using either stratified or systematic sampling; and
- Continuous forest inventory using Permanent Sample Plots (PSP).

Static Enumeration

The first forest inventories in Ghana (1960), Nigeria (1966) and Liberia (1971) applied static enumeration procedures essentially to provide stocking statistics for determining timber yields. Due to lack of adequate taxonomic knowledge, these inventories also covered trees above 10 cm dbh for well-known economic species and 30 cm dbh for the lesser-used species (Anon 1995). The unidentified and non-economic species were sometimes bulked as 'all others', thus having a significant number of species unaccounted for. The results of these inventories could not be used to revise the old working plans, hence the need to carry out new inventories in the late 1980s.

Recent inventories in Cameroon (1987) and in Ghana (1989) have been extensive and covered all tree species from 5 cm dbh and above (CENADEFOR 1988; Blackett 1989). Their results have given a better picture of the composition and structure of the timber resources of the two countries. However, as in previous inventories no mention was made of NTFP which are potential resources that can sustain the interest of local communities towards the protection of the forest estates.

Continuous Forest Inventory

Studies on forest dynamics through continuous forest inventories have not received wide application in the sub-region. For instance in Nigeria only fifty PSP were supposed to have been laid in the tropical moist forests by 1985 (Kio 1978). In Ghana the 700 PSP established in 1970 were located in one forest type (moist semi-deciduous forest). These plots were also treated according to the Leading Desirable Tree concept, which looks at few selected species and only 50 stems per hectare instead of all trees (Baidoe 1969). This design does not afford a good interpretation of growth dynamics in the tropical mixed forest since growth is affected by interaction amongst all plant species on a given site (Alder 1991). To develop better growth models and prescribe effective management, PSP in the tropical mixed forest have to consider all species and all stems of tree sizes (Alder and Synnott 1992). About 500 new PSP were established in Ghana between 1989 and 1992 to replace the old ones using the approach suggested by Alder and Synnott.

The usefulness of inventory results for the tropical mixed forest can be enhanced by intensifying research in forest inventory methodology (Kio 1973). For instance, the sample intensity that can provide acceptable estimates for individual species stocking above 70 cm dbh is one issue for further research, as the 100% enumeration of timber size trees is considered expensive and unnecessary (Alder 1990). Again the current emphasis on total forest resources evaluation requires inventory methods that will take account of NTFP.

HARVESTING CONTROLS

Natural forest management practices in the various countries have led to the development of varied control measures for the harvesting of forest produce. Harvesting controls have been designed to ensure the following:

- Ecologically and silviculturally acceptable logging practices;
- Effective and efficient way of assessing and collecting forest revenue; and
- Quality control of raw materials.

These control measures may form part of the working plans or regulations provided under legislative instruments.

Logging Practices

In all the Anglophone West African countries logging is carried out by registered timber companies who operate either on permit or concession basis. Parcels of forest lands are given out to the companies by the state for log production. In Ghana felling permits are issued for areas below 250 ha for a period of one year or for a small number of trees to be exploited within four weeks. Concessions on the other hand are granted on short- and long-term leases. For instance in Ghana short-term leases are up to three years and cover not more than 1,000 ha whereas long term leases covering anything above 1,000 ha last for 15-50 years and, exceptionally, for as long as 99 years. In Cameroon concession areas vary from 250-25,000 ha for a lease period of five years depending on the company's demand for wood. In Liberia forest concessions granted in 1957 covered up to 41,000 ha for a period of 40 years and with the option of extending for another 20 years. Currently concession areas have been increased to 180,000 ha but only for a period of 25 years (Parren and de Graaf 1995). One general view among foresters in West Africa is that the concession period should be the same as the felling cycle. This will imbue the concessionaires with a feeling of security and motivate them to as-

sist in silvicultural operations and to invest in sustainable management of the forests. In Ghana where the felling cycle is 40 years, a lease period of 40-80 years has been suggested.

One important consideration in harvesting controls is to minimise logging disturbances. Though unavoidable, the disturbances can be minimised through the use of appropriate machinery and working methods (Hendrison 1990). Some countries, for example Ghana and Liberia, have established standards for logging, road layout and construction (Gatter 1984). However, the regulations in Liberia are less strict because salvage felling for up to one mile is allowed along the hauling road. This is a major cause of forest land degradation (Gatter 1984). Another consideration to reduce logging disturbance is the re-entry period. To safeguard the regeneration that normally follows after gap creation, re-entry into logged compartments has been restricted. In Ghana, for instance, re-entry is prohibited for three consecutive years within a felling cycle.

The location of an annual logging area within a production forest is indicated on a logging schedule. The schedule specifies the compartment or number of compartments to be felled by a given concessionaire at various periods within the felling cycle. Such an arrangement helps to identify the various coupes for re-entry when the cycle recommences. Felling in compartments which are found unhealthy or to be still in convalescence could be rescheduled within a felling cycle. In this way each compartment would be given ample time to recover from the logging disturbance.

Payment of Forest Revenue

Methods estimating forest revenue differ among the West African countries. In Nigeria timber royalties are charged per unit of forest area logged. This method encourages loggers to remove as many trees as possible so as to maximise their income per unit area, thus leading to serious over-exploitation. In Ghana royalties are charged per tree and the value is estimated at 6% of the FOB price per cubic metre of the round log multiplied by the average tree volume of the species at the minimum felling diameter, or at a 2% deduction on local log sales or log and lumber exports. The logger's royalty liabilities are assessed from the yearly log production statistics collected by both the forestry department and the Forest Products Inspection Bureau (FPIB). Payment is made directly to the forestry department. In Cameroon timber royalties are charged per unit log volume, and the collection of such revenues has been contracted to a private company. In Nigeria the money is paid up front to the state forestry departments.

Quality Control of Logs

The general feature of log quality control methods in the sub-region is the application of minimum felling diameter. As noted, the felling limit represents the mature size at which the species is expected to give good quality timber. Felling limits are generally prescribed under legislative instruments making it an offence to fell undersized trees or sell logs produced from them. However, due to the decline in stocking of trees like *Milicia excelsa, Entandrophragma* and *Khaya* species, loggers are now felling undersized trees which have higher proportions of sap and juvenile wood as against good quality heartwood. In a survey to estimate the extent of undersized tree exploitation in Ghana, 46% of 4,000 butt-logs examined were found to have been produced from undersized trees (Adam *et al.* 1993).

Before the imposition of log export bans in Nigeria, Ghana and Cameroon, exports were graded based on the number and extent of defects. The tendency to bring only defect free logs to the market results in increased logging residue (Ofori *et al.* 1993), even though most defects may be superficial and the logs could still produce good quality lumber or veneer (Agyei-Boakye 1994).

CHAPTER 4
BIODIVERSITY AND THE CONSERVATION OF NON-TIMBER FOREST PRODUCTS

INTRODUCTION

This chapter focuses on the necessity to maintain the biodiversity of the existing forest ecosystems not only as an end in itself but as a major requirement in the conservation of NTFP which play an increasingly important role in the social and dietary needs of the rural and urban populations. Issues affecting biodiversity, based on the work by Oguntala (1995), and the economics and dynamics of NTFP with particular attention to options for future generations, as discussed in a paper by Okojie (1995), will be reviewed here.

Biodiversity is a vital resource because it is the gateway to better and faster supplies of matter and energy to humans. Diversity is directly proportional to the naturalness of an ecosystem — the less disturbed an ecosystem the richer its species (Lal 1991). It follows that to conserve this resource, the species richness in an area must be determined as a first step in the sustainable management of the genetic and natural resources of that area. Therefore, biodiversity must be treated more seriously as a global resource to be indexed, used and, above all, preserved. Three circumstances make it imperative for this to be given an unprecedented urgency, particularly in West Africa. Firstly, increasing human population is degrading the environment at an accelerating rate in the sub-region. Secondly, new uses for biodiversity that help to relieve human suffering and decrease environmental destruction are being discovered. Thirdly, occurring more in Africa than elsewhere, much of the biodiversity is being irreversibly lost through extinction caused by the destruction of natural habitats. In particular, attention is urgently needed on the tropical moist forest ecosystems, among all the major habitats, because they have the richest species composition and face the greatest danger of being destroyed (Wilson 1988).

FEATURES OF BIODIVERSITY

The ecological principles of biodiversity have to be understood before they can be applied effectively, particularly in the management of forest resources. The fundamental principles according to Lal (1991) are:

- The greater the diversity of an ecosystem, the more stable it is.

The West African forestry practices in the past selectively paid more attention to some selected commercial species at the expense of others. This led to the conversion of the forest ecosystems to monoculture plantations, thus reducing their stability.

- The diversity of an ecosystem increases, as a function of time, from an initial state where it has a minimum value to one of maximum value, when the ecosystem is called a climax community.

  Most of the natural forests in West Africa are not climax but rather seral communities which have been continuously disturbed by human activities. Climax forests are now rare in West Africa. If human interference in these ecosystems is stopped or controlled, the ecosystems will evolve towards greater species diversity, although during this process their immediate economic value will decrease.

- The biomass/productivity ratio of an ecosystem is proportional to its biodiversity. For a given biomass, productivity decreases as diversity increases.

  Man-made forests or disturbed natural forests, though poor in species, are more productive than more mature forests. Productivity of environment, nevertheless is as important as its stability. Monocultures are, however, fragile and susceptible to environmental disturbances. It is therefore necessary that forests serving as genetic pools should be identified and destructive human interventions should be excluded.

- Species diversity is dependent on the stability of environment.

  Communities which evolve in stable environmental conditions, or which have suffered only regular or foreseeable fluctuations, show the tendency to decrease in species diversity.

- Ecosystems rich in diversity exploit ecosystems poor in diversity. In other words, mature, climax communities remove matter and energy from immature communities. For example, mature forests attract epiphytes like orchids, wildlife and other rare species. They also store water and nutrients removed from more disturbed areas.

MAINTAINING STRUCTURAL AND FUNCTIONAL DIVERSITY

Preserving biodiversity in West Africa requires the maintenance of all successional stages. Since early successional stages are typically well represented, a major concern is preserving or recreating the mature forests. Such mature forests typically contrast sharply with early successional stages in composition, structure and function.

Most West African forests are disturbed forests that have developed after logging or silvicultural treatments. Due to human pressure, the composition and structure of these forests have changed in comparison with the original forests. The mahogany dominated forests of Sapoba Forest Reserve in Edo State of Nigeria, for instance, have been taken over by other species previously regarded as uneconomic.

Functional differences between mature and young forests are often qualitative rather than quantitative. That is, forests at all stages fix and cycle energy or carbon, regulate hydrologic flows and conserve nutrients. Mature forests present a very large crown surface and occupy an extensive volume of space because dominant trees are commonly taller than 35 m. Such forests are particularly effective at gleaning moisture from clouds and fog which can substantially increase precipitation (Harr 1982). In addition the mature forests provide several important sites for nitrogen fixation (e.g. epiphytic lichens) and decomposing wood which are more limited or absent in earlier stages of succession. Mature forests and the organisms and processes that they represent are an essential aspect of global biodiversity at risk. Thus preserving or recreating mature forests should be a key objective of any conservation programme. Such efforts would be timely in West Africa since there are still opportunities to retain some mature forest ecosystems and to allow younger forests including man-made plantations to develop into mature forests.

RATE OF CHANGE IN TROPICAL FOREST AREAS

The rate of change in tropical forests has been discussed in depth by Lanly (1982) who made an effort to document the rate of increase of secondary forests (by reforestation, afforestation and natural regeneration) as well as of the rate of forest loss. Other attempts usually emphasise conversion or modification of mature forests with little or no analysis of recovery (Myers 1980). Lanly showed that of the 11.3 million ha of mature tropical forest lands deforested annually, 5.1 million ha are converted to secondary forest fallows. He estimated that the total area of this forest type is 409 million ha and almost 1 million ha of secondary forests is created annually on unforested lands through natural regeneration or human intervention (Lugo 1988). Such large forest areas cannot be dismissed as irrelevant to the conservation of species diversity because they support extensive biota and because under certain conditions they are capable of supporting more complex biota than the mature systems they replace (Ewel 1983). Lanly (1982) also showed that deforestation rates are higher in closed than in open forests. Within closed forests a large fraction of the conversion involves logged forests that have previously been modified by

human activity. Moreover, recovered secondary forests are potential foster ecosystems for endangered species and their role in species conservation must be considered.

Of the total land area of 2,236 million ha in Africa, only 568 million ha were forests in 1980. In 1990 only 527 million ha of forests were left, representing an annual reduction of 4.1 million ha or 0.7%. Comparative annual rates of deforestation in Latin America and Asia were 7.4 and 3.9 million ha respectively (FAO 1993).

The tropical rainforests in Africa occupy 118.5 million ha, compared with 306 million ha in Asia and 522.6 million ha in Latin America. Deforestation is also happening in the dry and very dry zones. According to FAO (1993), the total land area of these zones in Africa is 823.1 million ha, with a forest cover of 151.2 million ha or 18% of the area. The annual deforestation rate is 1.1 million ha or 0.7%.

Lanly (1982) also estimated that the total amount of operable productive forests in Africa was 169.2 million ha with only 2.0% of these forests being under an organised management system. Studies of the growing stock of productive forests in some selected African countries were carried out by FAO in 1984, and Table 6 presents the estimated current and projected values of growing stock in these countries. According to the projections, three countries – Côte d'Ivoire, Nigeria and Senegal – would have nothing left in their closed productive forests by the end of the century.

It has been reported that Nigeria has been losing an average of 23,000 ha of gazetted forest estates per annum through government de-reservation alone. It is estimated that well over 350,000 ha of forests and savanna woodlands are destroyed each year through clearance for farming, uncontrolled fires or conversion to some other forms of land use. The cumulative effect of all these activities in Nigeria is a tremendous loss of its forests. In 1897, Nigeria had 60 million ha of forests and woodlands, but now it has only 9.6 million ha of forest reserves, much of which is degraded and only 2.4 million ha are in the forest zone. This represents a reduction of over 50 million ha in less than 100 years. Between 1981 and 1985 closed forests were being converted at the rate of 5% per annum in that country (World Resources Institute 1987).

Table 6. *Estimated growing stock in selected closed productive African forest (million m^3)*

Country	1980	1990	2000	Change 1980–2000
Angola	270	222	173	–97
Ghana	198	165	132	–66
Guinea Bissau	25	16	8	–17
Côte d'Ivoire	766	99	0	–766
Liberia	220	145	70	–150
Nigeria	492	44	0	–492
Senegal	2	0	0	–2
Cameroon	4,645	4,434	4,223	–422
Central African Republic	1,102	1,086	1,070	–32

Source: FAO. 1984.

CONSERVATION AND BIODIVERSITY ISSUES

Some common issues to be considered in any biodiversity strategy (ODA 1991) include the following:

- A common agreement on what is valuable should be reached. An ethno-botanical survey seeking the views and cultural values of the local inhabitants should be carried out and incorporated into the agreement. The views of the government officials alone are insufficient.
- It is important to recognise that biodiversity objectives will differ among the various communities to whom the forests in their localities have become their heritage. For instance, deforestation is quite rampant in Omo Forest Reserve in Ogun State while more conservation efforts are seen in the Taylor Creek Forest Reserve in Rivers State and Ehor Forest Reserve in Edo State in Nigeria. It follows that the values placed on these forests are different.
- The objectives of biodiversity conservation must be precise to be useful. For example, the objective 'to maintain as much diversity as possible' is vague and unhelpful to forest managers. A precise definition of goals and measures of biodiversity needs to be set for the management of each forest reserve. Depending on the species composition and structure of the forests, the emphasis may be on shrubs, climbers or herbs rather than on trees.

The wider objective of any biodiversity programme is generally to maximise the conservation and use of biodiversity in order to provide sustainable social and economic benefits of the people. For example, the most deserving habitat or forest reserve in one country might be a very low global priority, but the reverse could also be true as in the case of turning the Strict Nature Reserve in Omo Forest Reserve Nigeria into a World Biosphere Reserve. This has saved the most mature forests in Ogun State from destruction, while various adjacent plots have been seriously tampered with.

Although the humid forests in West Africa are rich in plant and animal species, they have traditionally been protected for timber production. These forests are also sources of other products, collectively grouped as NTFP, which have been defined as all the biological materials that may be extracted from forest ecosystems and are utilised within households, or are marketed, or have social, cultural and religious significance. NTFP include food, medicines, oils, resins, tannins, materials for making furniture (e.g. rattans), household equipment and implements, building materials, fuelwood and bushmeat. The collection, processing and marketing of NTFP is done by members of the family and these products constitute a major source of household income for the rural communities.

USES OF NON-TIMBER FOREST PRODUCTS

These rural communities which make up over 70% of West Africa's population depend on NTFP for a variety of uses. The majority of NTFP have multiple uses. In general, these can be grouped into foods, medicines, fuelwood, household equipment, utensils and support/auxiliary uses, but it should be noted that to the typical rural users, these classifications are relatively arbitrary.

Foods

These are diverse forest plants which are eaten whole or in parts and contribute to an enriched diet of the rural communities. They supplement staple foods and are consumed in times of food scarcity especially during the dry months. Okafor (1981) recorded 171 indigenous woody plants of nutritional importance within the forest zone in Nigeria. They are eaten as leaves, nuts and seeds, fruits, roots, tubers and mushrooms. Some tree species with edible fruits and seeds include *Annona muricata, Artocarpus communis, Canarium schweinfurthii, Chrysophyllum albidum, Cocos nucifera, Cola acuminata, C. gigantea, Dacryodes edulis, Dialium guineense,*

Dennettia tripetala, Garcinia kola, Irvingia gabonensis and *Xylopia aethiopica* (Okafor and Fernandes 1987). Most of these are eaten as snacks, condiments in soup or as dietary staples (e.g. *Artocarpus communis*). Many of them are also sources of minerals and vitamins. *Dialium guineense* is rich in Vitamin C while *Spondias mombin* has a lot of vitamins A and C.

Rural farmers prioritise food as one of the most important reasons for retaining some tree crops on their farmlands. In a survey by Adeola *et al.* (1994) over 170 tree species were identified on farmers' plots in the humid lowlands of Nigeria. Eight of their ten most important tree species were kept for their food values. These include *Irvingia gabonensis, Dacryodes edulis, Chrysophyllum albidum, Vernonia amygdalina, Garcinia kola, Dennettia tripetala, Treculia africana,* and *Ocimum gratissimum*. *Irvingia gabonensis* (var *excelsa*) was ranked highest of all. Some are eaten as leafy vegetable (*Vernonia amygdalina, Ocimum gratissimum, Ficus* spp., *Netum* spp., *Ceiba pentandra*) while others provide nuts (*Elaeis guineensis, Cocos nucifera and Ricinodendron* spp.).

Mushrooms are also highly valued in the rural diet. A lot of them are picked from the forests and consumed as meat substitutes (FAO 1989b). They are usually gathered by women and children who market them to supplement family incomes. Another category of food derived from the forests is wildlife meat (bushmeat). For rural communities with woodlands around them, wild animals play a major role in their diet (Federal Department of Forestry 1987). Ajayi (1971) estimated that over 80% of the people in southern Nigeria eat bushmeat and this constitutes about 20% of the animal protein consumed. The most common bushmeat are grasscutters and small antelopes (Martins 1978). Guinea fowl is also widely consumed (Akande 1979; Ayeni 1980).

Medicine

Forests provide materials for medication for a large majority of rural and urban dwellers. Parts of forest plants are used in various combinations to treat a variety of ailments ranging from common colds to serious cases like cancer. The importance of herbal cures in Nigeria has led to the popularity of traditional medical clinicians who claim a large degree of success in their cures (Adekunle 1992). While these claims cannot be firmly ascertained there is agreement amongst researchers that the use of plant medicines is on the increase in view of the rising cost of modern health care (Adekunle 1992). Some medicinal species listed by Okafor and Fernandes (1987) include *Cajanus cajan* (measles), *Garcinia kola* (snake repellent), *Irvingia gabonensis, Kigelia*

africana (sores), *Napoleona imperialis* (anti-emetic) and *Tetrapleura tetraptera* (after birth healing).

Plant parts used are usually gathered from the forests, fallow and communal lands. Some of the plants have become very scarce and involve travelling long distances for collection. Adekunle (1992) has therefore called for the genetic conservation and propagation of medicinal plants in Nigeria.

Fuelwood

Fuelwood is the major source of energy for rural households and the main source of cooking fuel in urban areas of Nigeria. Fuelwood and charcoal provide the energy needs of small-scale processing enterprises like palm oil production and fish smoking. Most plant species are used for fuel especially their dead trees and fallen branches. Even *Irvingia gabonensis* (which is highly valued) is used as fuel but only when dead or when it becomes a threat to homesteads in the home garden system. Other species listed by Okafor and Fernandes (1987) include *Artocarpus communis, Cajanus cajan, Dialium guineense, Hannoa klaineana, Nauclea latifolia, Parkia biglobosa, Tetrapleura tetraptera, Vitex doniana* and *Xylopia aethiopica*. Women and children are the major gatherers and this activity is most prevalent during the farming periods when the bush is cleared, raked and burnt.

Other Uses

Some non-timber trees or shrubs are used for animal feeds either as browse or in a cut and carry manner. Most Fulani cattle herdsmen graze their herds in the south especially during the dry season. In the process a lot of trees are browsed. Even species like *Gmelina arborea,* recorded as eaten by goats, is in fact preferred in the Esa-Oke farm settlement of Osun State in Nigeria (Adeola 1993). Species commonly used for fodder (especially for small ruminants) in the humid lowlands of Nigeria include *Albizia lebbeck, Artocarpus communis, Treculia africana, Baphia nitida, Anthonotha macrophylla, Cajanus cajan, Ceiba pentandra, Daniellia oliveri, Ficus* spp., *Dacryodes edulis, Gliricidia sepium* and *Leucaena leucocephala* (Okafor and Fernandes 1987).

The uses of *Leucaena leucocephala* and *Gliricidia sepium* have been documented in alley farming (Kang *et al.* 1991) and in intensive feed gardens (Atta-Krah and Sumberg 1988). There are many other indigenous browse species. Multiple purpose trees in the forests can also be used to improve the soil. They provide stable environmental conditions on which sustainable

production depends. For some Nigerian communities (Mbaise people of Imo State), the forests provide the only means of soil fertility restoration through fallows (*Gliricidia* and *Leucaena* spp.). The forests represent the single largest storehouse of genetic diversity, a resource of great importance of future agricultural production (FAO 1989b). They improve the microclimate, reduce wind damage, protect soil from erosion, restore productivity, improve water quality and aid water availability downstream, and also serve as sources of recreational opportunities.

Other auxiliary roles played by non-timber forest trees/shrubs include provision of fences, stakes for yam, shade, utensils, etc. Some of the species and their uses are:

Acacia auriculiformis	shade for cocoa
Acioa barteri	yam stake
Baphia nitida	live fences, chewing sticks
Hildegardia barteri	fibres for rope

Availability of fuelwood, foods and other NTFP are affected by the changes in the forest ecosystem. Scarcity of fuelwood has led to purchase of more expensive, alternative fuel sources, thereby putting a strain on the family budget. The time needed for collection has also increased significantly (FAO 1990). Women now have to track long distances to gather fuelwood, thus reducing the time they have available to earn incomes from other activities. Destruction of habitat due to land clearing, over-utilisation of some resources, damaging methods of harvesting and deforestation practices have threatened the extinction for many non-timber tree species in Nigeria.

The damaging uses of the forests result in poor habitats for wildlife, loss of biodiversity, fuelwood shortages, poor soils, reduced food crop yields, loss of edible fruit trees and vegetables, changes in fruiting habits of plants and loss of income by rural families who depend on NTFP for their livelihoods. This in turn may lead to a reduced quality of lifestyle in the rural communities. Research activities on NTFP must be intensified to address the situation.

MARKETS FOR NON-TIMBER FOREST PRODUCTS

Besides augmenting rural dietary needs and thereby releasing financial resources which would otherwise have been spent on purchases from the market, NTFP also supplement rural incomes. An example is the provision of bushmeat. Martins (1978) noted that the prices of bushmeat (grasscutters especially) had been on the increase since 1970. Some sell for as high as N500/kg (N is the symbol used here for naira, the local currency of Nigeria). These prices are much

higher than the prices for beef and mutton in the market. Gathering of forest foods is a very important activity especially during the dry season. Fruits are usually sold at profitable prices in the local markets. Most fruits are obtained from protected trees even though some farmers are now beginning to plant the cultivated varieties of wild plants like *Irvingia gabonensis* and *Dacryodes edulis*.

Seeds of *Irvingia* and *Garcinia* are taken to as far as Lagos and Kano for sale (Aiyelaagbe *et al.* 1994), but in general NTFP are sold at big markets closest to the sources of collection or production. Prices of the products are higher at the end of the season than at the middle (Okafor 1979; Aiyelaagbe *et al.* 1994). Vegetables from the forests are also marketed. These vegetables command higher prices in eastern Nigeria compared with cultivated fresh vegetables. Palm wines are commonly marketed throughout southern Nigeria. The demand is very high and recently some research institutions and private organisations have started pilot commercial production to meet the high demand. Okafor (1979) showed that returns are lucrative since the wages earned from palm wine tapping are higher than the Nigerian minimum daily wage. There have been isolated studies to determine the value of NTFP in the high forest zone of Nigeria, but generally the forestry sector's contribution to the nation's GDP is low because NTFP are not included in the calculations.

OPTIONS FOR DEVELOPMENT AND SUSTAINABLE USE OF NON-TIMBER FOREST PRODUCTS

A shift in emphasis from timber production to the NTFP is needed if the value of the forests is to be appreciated by present and future generations. The following should be considered in this respect.

- Increase the use of the forests for their recreation and eco-tourism values:

  Records indicate that the annual recreational value for Okomu Wildlife Sanctuary in Edo State is about N2.5 million at prevailing prices. If properly organised and advertised many forest estates can provide these services.

- Debt-for-Nature Swap:

  Many non-governmental organisations (NGO) now offer this service. Essentially, they pay developing countries the value foregone for not destroying their forest estates. Madagascar and Costa Rica have benefited from this swap and it has assisted them in off-setting some of their external debts since such payments are made in hard currencies.

This option will enable the forests to recuperate their resources and at the same time allow the countries to earn the necessary incomes for their economic development.

- Sustainable management of the forests:

  The basic concept of sustained yield would have to be extended to all products and services including NTFP. This will have to be complemented with improvements in technology for harvesting, processing and the use of forest products.

- Reduction in the rate of use of fuelwood for energy:

  The use of fuelwood for cooling, heating and processing agricultural products has contributed to the high rate of deforestation in West Africa, and threatens the sustainability of NTFP. Alternate sources of energy (natural coal, petroleum products, solar energy and nuclear energy) and more efficient ways of using fuelwood must be explored.

- Patents:

  Present initiatives to secure the patent rights for extracted active ingredients from NTFP should continue. Such rights must include benefits to forest resource owners from the turnover value of companies that use them. They must also include the exclusive rights to own and protect the resources. This may provide adequate financial resources to support more efficient management of the humid forests on a sustainable basis.

- Value addition to NTFP:

  More value must be added to NTFP through processing, better packaging and exports. For example, the humid forests have many species which are used as spices and condiments. These have potential export value. About 30 local species of NTFP have been listed by the Nigerian Institute of Horticultural Research (NIHORT) as spices. The processing of hides and skins of legally cropped wildlife will also enhance their export values. Other NTFP which can be exported include resins, concentrates from forest fruits, seeds and sweeteners.

- *Ex situ* conservation:

  At the current rate of deforestation, *ex situ* conservation methods must be employed to enhance the sustainable production of the NTFP. These will include special spice gardens, orchards of forest fruit trees, village woodlots for species used for stakes, fencing materials and botanical gardens. The compound garden system would be necessary in the rural communities.

- Use of natural resource accounting to promote sustainable forest management:
  Environmental services such as the net value of carbon-fixing amenities, biodiversity protection, soil stabilisation and watershed protection which, although not marketable, have values that can be estimated. Such estimation will provide basic data for comparative analysis with other forms of forest land uses for policy enunciation. Natural Resource Accounting (NRA) is one way to explicitly incorporate environmental and resource information into an accounting framework designed to measure resource stocks and flows. The ultimate goal of NRA is to improve economic management of natural resources by facilitating the integration of economics and environmental information, and providing an effective means for its presentation to the decision makers.

CHAPTER 5
INTER-GENERATIONAL ISSUES IN SUSTAINABLE FOREST MANAGEMENT

Forest management programmes in the sub-region aimed at arresting forest depletion and degradation have been unsuccessful because of a lack of support for their sustainable implementation. In part, this can be explained by insufficient attention being given to inter-generational and technical issues.

INTER-GENERATIONAL ISSUES

Investments in Natural Forest Management

Investments in forestry may be considered as inputs into protection and management activities which may come from the private or public sector. Though differences in financial and economic returns on these two investments have not been well studied, it is known that public funding for forestry research in particular is declining world-wide compared to private investments. Specific areas in forestry which require priority attention in terms of investments include protection, production, research and extension.

Generally, investments in forestry come from two broad sources, namely internal and external forest industry funds. The internal funds arise out of distribution of revenue generated from harvesting, processing and trade of forest products. The external sources of investments come from funding arrangements, such as grants, which might be used to intervene in the timber markets. Though these investment avenues exist, the development of self-financing sustainable forest management systems in the sub-region has not been possible due to low timber prices and strong competition from timber products and materials from other countries. The availability of funds for investment in forestry activities is affected by land ownership and administrative procedures in the sub-region.

Equitable Distribution of Costs and Benefits

The formula and mechanism of distributing forest revenue is generally skewed in favour of central governments because of their assumed forest protection and management roles. Despite the substantial forest revenue, governments are reluctant to reinvest significantly in forest management activities because of increasing budgetary constraints that have limited their

funds which can be allocated to forestry. Also, forestry is not viewed as a priority sector by most governments. At present, all forestry institutions in the sub-region are poorly funded. As a result, the privatisation of all forestry programmes and activities have been suggested. Institutional reforms in several countries especially Ghana (funded by the ODA, U.K.) are looking at the possibility of changing and privatising the forestry sector to increase its efficiency. The current approach to forest protection and management may have to be reviewed in the light of the following:

- Funding structure — increasing private participation in protection and management;
- Ownership structure — protection and management may be privatised; and
- Decision making structure — involvement and participation of private individuals in decision making.

Currently, the costs of forest protection and management are realised only in terms of stumpage or royalty for timber and non-timber products. However, the costs of other environmental effects (intangible costs) that cut across boundaries are yet to be accounted for. The current view on the distribution of costs and benefits of sustainable forest management tends toward making all those who want the services of the forests pay for the actual costs of producing these services.

Forest Revenue Collection

Forest revenue is generated mainly in the form of royalties, stumpage and rental fees. Stumpage fees and royalties were determined principally by chiefs during the colonial period. This resulted in variable royalties and fees for similar products from different areas. The high level of heterogeneity in prices of wood commodities made the successful implementation of forest tariffs difficult. At present, in Nigeria, royalties and stumpage fees are determined by the individual states resulting in variations in the market prices of wood across the country. On the other hand, in Ghana and Cameroon the determination of the stumpage fees and royalties are the prerogatives of the respective governments. Even though this latter system has the advantage of ensuring uniformity of prices for similar products within the country, the rates set are so low that they do not adequately reflect the status of the available resources and economic costs of production and investment. Such low pricing of forest products is the major reason for over-exploitation of forest resources and degradation of land resources especially in unprotected areas.

One reason that may account for the low revenue generation is the inability of the forestry sector to value the forests and forest products in real financial and economic terms. Another reason is the general policy of classifying forests into protected (reserved) and unprotected (non-reserved) areas. This has led to the loss of significant revenue through the destruction or illegal exploitation of timber on farmlands which continue to supply large quantities of raw materials. A further explanation for the low generation of revenue is the inadequacy of forestry departments to monitor forest resource exploitation. There is, therefore, the need to involve local communities in forest revenue collection.

Natural Forest Resource Valuation

Timber is recognised as the most important forest resource in the sub-region. Other uses or values, namely NTFP and intangible benefits, are not appreciated by national planners. However, non-timber products contribute more to the income of local communities than timber products. There is a need for comprehensive forest resource valuation to address the present deficiencies.

At present, no consensus on the most appropriate approach to valuing natural tropical forests is available. However, it is generally accepted that the total economic valuation concept can be used effectively. Total economic valuation requires proper measures of economic welfare which implies the need for data on community demands. The total valuation considers the quality (price) and quantity of all forest products and services expressed in value terms. It includes the following:

- Use values (instrumental values):

  These incorporate direct values (e.g. timber products, non-timber forest products, ecotourism, etc.), indirect values (e.g. nutrient cycling, watershed protection, carbon sequestration) and option values (e.g. biodiversity, future uses or insurance premium where changes are irreversible).

- Non-use values:

  Though potentially quite significant, particularly for unique and endangered resources, these values are difficult to measure. Non-use values include existence values, bequest values which are usually for future users and social and cultural values.

Very few comprehensive studies on forest resource valuation have been undertaken in the sub-region. Prices of forest products are therefore fixed arbitrarily without considering the

true economic costs of logging. Lack of comprehensive resource valuation is one of the major reasons why forest products are grossly undervalued in the sub-region.

A case study of the application of the total economic valuation concept to the Korup Rainforest Project (sponsored by the World Wildlife Fund) in Cameroon concluded that there was a true net benefit for conserving the national park (Ruitenbeek 1992). Governments or forestry departments in the sub-region should be encouraged to undertake such studies and base royalties, stumpage fees and other forest revenues on their results.

Marketing Strategies To Promote Sustainable Forest Management

The primary cause of deforestation in most Anglophone West and Central African countries is not the timber industry but the farming sector (particularly shifting cultivation) followed by domestic consumption of fuelwood and charcoal. Timber consumption accounts for only about 10% of all wood harvests in the sub-region while the remaining 90% is attributed to fuelwood and charcoal consumption. Controlling timber harvesting alone will not lead to sustainability. It is clearly necessary for the sub-region to vigorously pursue fuelwood plantation development and small-scale planting on farms to satisfy domestic demand for wood.

Despite the small proportion of wood consumed as timber, the timber industry contributes to deforestation indirectly by providing access (logging roads) to previously relatively undisturbed and inaccessible areas (Eastin 1996). Reliance on a small number of tree species for timber means that a large area of forest must be opened up each year in order to provide a given harvest volume. For example, only four species account for about 75% of all timber exports in Ghana.

The timber industry can therefore contribute towards the search for a sustainable system by broadening the base of exploitable species. This requires an active marketing policy and marketing strategies aiming at the following:

- Large-scale production leading to lower production costs;
- Increased access to market information;
- Greater market access and orientation;
- Developing more effective business strategies and linkages;
- Developing standards to meet certification criteria;
- Creating markets for lesser-used and known species and NTFP; and
- Encouraging the processing of value-added products.

Certain factors limit the competitiveness of wood products from the sub-region for foreign markets. They are:

- Over-capacity of sawmills given the available wood supply leading to low economies of scale and under-utilisation of capital and other fixed costs;
- Low efficiency of machinery and slow processing capacity leading to low profitability of the industry;
- Price of timber resources determined administratively rather than through market forces. Price differences are therefore largely a function of species rather than kiln drying or processing. Market prices do not therefore reflect their full economic costs; and
- High wood residue and waste generation.

Another issue gaining in importance relating to the export of wood products is product certification. Consumers, especially those from the developed countries, are increasingly being influenced by environmental considerations in their choice of products. Many consumers insist on product certification. The certification process is based on establishing an audit system to ensure that products marketed originate from sustainably managed sources. For certification to be effective, it should be at the forest or concession level and not the country level.

TECHNICAL ISSUES

Technical structures needed to maintain sustainable forest management are discussed below. These include harvesting operations, monitoring of forest resources, control of exploitation and human influences.

Harvesting Controls

To many people the obvious value of the forests is the products harvested from them, i.e. the direct consumptive value. This value or the right to harvest the forests is difficult to withhold and, if not monitored and controlled properly, it can lead to deforestation and/or forest degradation. Several countries in West and Central Africa are grappling with illegal and excessive exploitation of their forest resources. The bulk of the produce harvested is timber. During harvesting operations the equipment used can cause extensive damage to the soil and residual trees if not well controlled. As a result of uncontrolled logging, countries such as Côte

d'Ivoire and Nigeria, by the early 1980s, had almost logged out their forests and have accordingly been listed among countries with critical level of deforestation (FAO 1989a).

The world-wide concern about the environment, and the tropical forest ecosystem in particular, has brought pressure on governments to ensure sustainable resource management. In response to the mounting pressure, several initiatives have been taken in the sub-region within the last decade to:

- establish a performance control system for stakeholders to whom forest utilisation contracts have been granted; and
- create a conducive environment to promote sustainability of the tropical moist forest.

The legal framework governing timber harvesting in West African countries is generally enshrined in relevant sections of the forest legislation dealing with resource allocation. Under these sections, the functions of public authorities responsible for all aspects of forest utilisation are provided. In addition, provisions for exercising controls and checks on timber harvesting are outlined to give the granting authority a legal basis for its functions.

Harvesting controls are to ensure orderly and efficient logging practices resulting in the maximum use of felled trees and minimum damage to the rest of the forest (Dykstra and Heinrich 1996). The general conditions embodied in harvesting control systems cover the following:

1. Inventory of the resource
2. Harvestable material (yield)
    - volume, or number of trees, size of tree
    - type of species
3. Frequency of harvesting
    - felling cycle
4. Location of felling area (restriction and ecological considerations)
5. Harvesting procedure
    - road layout
    - infrastructure development
6. Machinery

The execution of these control systems is affected by several factors, but the major one is institutional co-operation. The institutional framework for effecting the control measures are different in the various countries. However, the forest service is, in all cases, involved at

the forest level operations, but the forestry staff are generally rendered impotent by the lack of logistics and, above all, by an apathetic legal system that delays action on cases of infringement upon forest regulations and awards non-punitive penalties.

To ensure a more effective control system the following are recommended:

- Revision of existing forest legislation to reflect trends in harvesting technologies; and
- Revision of penalties to make them more deterrent.

Resource Monitoring

Global climatic changes and local activities such as logging, road construction, agriculture and fires are affecting the size and health of the tropical forest ecosystem. The type and extent of damage caused by these factors and activities need to be known in good time in order to plan and execute corrective measures. The extensive coverage of the ecosystem and its remoteness generally prevent a quick reconnaissance on the ground. The use of remote sensing techniques therefore affords the opportunity for more efficient and timely monitoring. The areas of application include:

- Delineation of forest cover from disturbed areas, or monitoring of changes over time;
- Estimation of standing volume of wood;
- Monitoring of phenology and seasonal dynamics of vegetation over extensive areas and provision of opportunity for early warning of possible disaster; and
- Estimation of ecological parameters such as net primary productivity at regional and national levels.

Monitoring, or the periodic observation and measurement of surface phenomena, is a vital part of forest management. The application of various silvicultural treatments require periodic observation or measurements to establish their success or failure. Forest fire risk monitoring is essential for successful establishment of plantations and the protection of natural forests. Logging roads within protected forests need to be closely monitored to avert excessive road construction per unit area.

Remote sensing methods have been used in the sub-region for the management of forests. In 1976 the UNDP/FAO assisted Nigeria in the use of a Side-looking Airborne Radar (SLAR) to map the vegetation and national land use patterns. In Ghana satellite imageries were employed to stratify the forests for sample plot location in the 1987 national forest inventory sponsored by the ODA. Again, limited overlapping sets of digital imagery (taken in

1986, 1989 and 1990) have been used in Ghana in an attempt to estimate the rate of forest loss in some forest reserves in the dry forest zone. In collaboration with Le Direction et Controle des Grands Travaux (DCGTx) in Côte d'Ivoire, SODEFOR employed Landsat TM digital data to classify the nation's remnant forest lands into intact forests, degraded forest, plantation areas and wetlands.

The application of remote sensing, though capital intensive in terms of cost of equipment, materials and trained personnel required, is cost-effective for forest resource monitoring, survey, mapping and quantification. However, it cannot replace some conventional ground methods, such as permanent sample plots used for monitoring vegetation succession and growth of individual species and stems. Remote sensing is therefore complementary to ground-based systems.

CHAPTER 6
SOCIO-ECONOMIC FACTORS INFLUENCING SUSTAINABLE FOREST MANAGEMENT

INTRODUCTION

This chapter discusses some of the important social and economic factors and issues which have relevance for and do influence sustainable forest management in the West Africa. They include:

- Population and its growth rate;
- Community participation in forest management;
- Land, tree and forest tenure, and land use patterns;
- Capacity building for sustainable forestry, and
- Economic policies for sustainable forest protection and management.

POPULATION, SUSTAINABLE FOREST MANAGEMENT AND UTILISATION

The human population of a country is essentially a valuable and economic resource; however, it can become a source of great social and economic concern when the population is allowed to grow at a rate faster than resources available to it. In most of West Africa, rapid and uncontrolled population growth has caused social, economic as well as environmental problems, in the face of the rapidly diminishing forest and related natural resources.

Goods and services derived from the forests, especially the NTFP, support the livelihood of rural communities, as discussed in Chapter 4. These goods and services meet critical social needs for food, clothing, housing and health care, and in many areas, the forests provide the main sources of economic income for a majority of the households (Falconer 1992). Since a great proportion (60-90%) of the population in West Africa lives in rural communities and depends almost entirely on the forests for basic necessities and requirements, the need to exploit and use these resources is even more critical.

High population growth rates have several other detrimental effects on efforts to protect and manage forests sustainably. The population places a heavy demand on agricultural lands and, because of unsustainable agricultural production systems, transfers these pressures in the form of encroachments into the natural forest and resources. In Ghana, for example, it has been noted that unsustainable farming systems have resulted especially in the degradation

of non-reserved forest lands. Further, illegal logging and encroachment on the forest reserves and resources in Nigeria have led to de-reservation of 21% of the reserved forests in some states. The annual deforestation rates in West Africa range from 0.5 to 1.4% of the total forest lands (Table 7). Strict policies and regulations to contain shifting cultivation and other unsustainable land use systems, though important, are not the only solutions (Agyeman and Brookman-Amissah 1987).

Westergren (1995) says that "*poverty forces people to use available resources to the limit and often beyond (it). When survival is at stake, it may be perfectly rational to consume capital (stocks), that is, future productive capital (e.g. forests and their resources*)". In many areas of Africa poverty and overpopulation are exerting pressure on the remaining forests, and this is likely to continue. Deforestation has its roots in poverty, rapid population growth, unsatisfactory and unsustainable agricultural systems, as well as unsustainable logging practices in order to earn the much needed foreign exchange.

Still, given the vast size of the present population, what are the answers to its negative and detrimental effects on sustainable forest management? What are the solutions to population pressures on forest reserves and the ecology generally? It is easy to say that steps should be taken to control population growth rates, but population excesses alone do not explain negative attitudes toward forest management. Even if populations are small, unsustainable management can still persist if these attitudes remain unchanged. Several views have been expressed on these issues and they shall be examined in the following section. Bojang (1995) also has suggestions for the evolution of sustainable land use and agricultural systems to increase food production without harm to the ecology.

COMMUNITY PARTICIPATION

The extent of degradation of forest resources in West Africa is so widespread that the government forest services cannot rehabilitate the degraded areas alone. For example, the rate of reforestation in the sub-region is alarmingly less than the rate of deforestation (Table 7). It is therefore high priority to involve local communities in forest management and protection schemes.

Table 7. *Annual rates of population growth, deforestation and reforestation in selected West African countries.*

Country	Annual Population Growth (%)	Annual Deforestation Rate (%)	Annual Reforestation Rate (%)
Cameroon	2.8	0.8	0.04
Côte d'Ivoire	3.8	1.0	0.04
Gambia	3.0	0.8	0.02
Ghana	3.4	1.4	0.02
Liberia	3.2	0.5	0.04
Nigeria	2.5	0.8	0.04
Sierra Leone	2.4	0.6	0.01

Rural communities are the major and direct consumers of the goods and services taken from the natural forests, especially NTFP. Concomitant with this, they are also the major and direct cause of deforestation and other forms of ecological and environmental damages. The benefits derived from the forests by the local communities are so considerable and their development and overall welfare so closely linked with the forests, that it is in their own interests to participate in the protection, management and utilisation of the forests. In this respect, rural communities must see themselves as important stakeholders with a "self-image of trustees" of the forests and resources.

The benefits of community participation in forest management are reduced costs to the government, generation of income and employment within the local communities and better maintenance, protection and exploitation of natural forest resources, especially NTFP. Despite the immense benefits of community forestry, very few programmes have been successful in West Africa. This is probably because most forestry development projects are aimed at increasing timber exports with little local community focus and minimal emphasis on NTFP, the primary concerns of the communities.

Another problem hindering the success of community forestry programmes is that farmers are usually not prepared to use their lands for tree crops at the expense of food crops when their resources are scarce. In most communities, land is viewed as productive only in terms of agriculture. Community participation in forestry can only be successful if the majority of the rural communities are involved in the planning, execution and monitoring stages of

forestry programmes. The input of such programmes should, to a large extent, be provided by the local communities and the output should primarily benefit them.

The extent of community participation in forestry and the success of these programmes are influenced by factors such as land, tree and forest tenure, forest policy and capacity building.

LAND, TREE AND FOREST TENURE

Land Tenure

Land, in most West African states before colonisation, meant the soil itself as well as the subsoil and anything under the soil, such as minerals. It did not include things on or attached to the soil, such as trees, houses and other permanent fixtures. Thus a distinction exists between interests in the land itself and interests in objects attached to the land (Klutse 1973). The characteristic feature of this tenurial system was the absence of the concept of land as a marketable commodity (Olawoye 1995). Land was communally owned with common control, management and utilisation (Osemeobo 1993) due to the combined efforts of acquisition, mostly through wars, and could therefore not be sold. Absolute ownership of land was vested in the chiefs or community leaders in trust for the community as a whole. The basis of land acquisition within any community in those periods was settlement or simply through occupation and use by individual family members.

However, the emergence of modern states in West Africa has brought about a modification in the land tenure system. Almost all lands have been placed under state control (especially in Nigeria and Côte d'Ivoire). The changes in land tenure systems, due to nationalisation of all lands, have resulted in less active participation of local communities in forest protection and conservation programmes. It has also subjected the forest reserves to more concerted encroachment.

In Ghana, the situation is slightly different with chiefs and landowners still retaining control of the land but not of the resources on it. These resources are managed by the government in trust for the communities. Though this offers greater security of tenure than total nationalisation, it is still not effective in promoting forest protection and conservation, mostly because the landowners have no direct control over the resources which supposedly belong to them.

Tree and Forest Tenure

An important and also critical issue is the lack of clear and unambiguous legislation on tree and forest tenure, and rights to use timber and other wood resources from forests. Generally, the strength of one's right to trees may depend on his/her rights to the land. Forest laws stipulate, in almost all the countries, that no individual has the right to use the forest reserves for tree products without authorisation from the government forest service authority. Outside the reserves, however, the laws only forbid the use of commercial timber trees; but then, unless forbidden under customary laws, most trees may only be used by members of the landowning communities. Interestingly, customary land tenure regulations often discourage tree planting by tenants, who may be strangers, because planting and owning trees traditionally entail title to the land (Westergren 1995).

The relevance and significance of tree and forest-tenure issues for sustainable forest management is that the tenurial systems, or an absence of tenure rules, could be an obstacle or disincentive for:

- Private investment in industrial forest plantations;
- People's participation in community forestry programmes aimed at production of fuel wood and fodder;
- Individuals to use land as collateral for bank credit or investment capital;
- Providing security in the absence of other property; and
- Using technological inputs in agriculture, forestry and grazing.

The absence of well-defined laws for tree tenure and user rights implies that in many communal societies, where the people live on communal land, all have free access to forest resources for agriculture and for domestic use, yet no-one assumes the responsibility to renew the resources. In a situation of steadily increasing population, this free-for-all situation places the forest lands under heavy pressure. Sudan is one example where customary rights to land have created such problems (Westergren 1995).

Generally, customary laws do not seem to restrict tree or tree product acquisition, ownership and transfer among indigenous members of the local community. However, tree tenurial restrictions appear to be greater on strangers. Customary tree tenure does not seem to influence the participation of the majority of people living in local communities. For example, indigenous peasant farmers who form approximately 60-80% of rural communities have few tenurial restrictions to land and trees (Agyeman 1994; Olawoye 1995). Strangers and tenants,

however, face stronger tenurial restrictions, probably because the long production period for trees and the lack of appropriate documentation of land ownership increase their chances to claim land rights when trees are planted. Also, the general belief that whoever plants a tree is entitled to its produce probably adds to the owners' reluctance to allow tree planting. They would not welcome former tenants returning each year for the next twenty years or so to harvest the produce especially after the tenancy has changed hands.

Although customary laws frown upon indiscriminate felling of trees, there are few customary regulations which actually prevent it. Strict government policies and laws could be partially effective in protecting the reserved forests against degradation and illegal exploitation to a certain extent. Nonetheless, strong customary laws to prevent people from degrading the natural forests should be developed.

Generally tree and forest tenurial systems are disincentives to tree planting and forest protection and conservation by local communities in West Africa. The management of trees, the right to own, plant and dispose of trees within the forest reserves is controlled by the various governments (IIED *et al.* 1993; Soladoye 1995). The lack of secure ownership to trees and the fact that landowners have to acquire permits for the use of even small amounts of forest products have discouraged the active participation of the local communities in forestry programmes. The communities want less restricted access to trees and to the forest (Agyeman 1994).

Gender Implications For Land And Tree Tenure

Olawoye (1995) has reviewed the issues of gender implications of land and tree tenure in Nigeria. The stratification and land tenure systems of a locality are important for an understanding of the management of natural resources because they allocate rights and obligations to community members (Olawoye 1993). The society also differentiates between those who have control over resources, which denotes the ability to make decisions over their use, and those who have temporary access to use the resources for a designated time and purpose determined by the "owner". In the latter case, individuals without control may be restricted to growing arable crops for one year on a plot of land, with no assurance that the same plot will be available for their use in the next season. In the fadama areas of northern Nigeria, some landowners rent out portions of their land for the dry season or wet season only, returning to use it themselves for the remaining part

of the year. For obvious reasons, such tenants would be unwilling to make long-term improvements on the land.

Permission to plant trees is seldom given to tenants or women. An account is given by Olawoye (1994: A.30) illustrating the reservations that men may have in even allowing their wives to plant trees:

> Tree planting by women is allowed only after a woman has demonstrated that she is a 'good wife' and has stayed long enough to ensure that she will not leave the household. Those who are older and have had children may be allowed to plant trees in the compound for shade or for the fruits. The *Lawan* stated that it is dangerous to have a young wife plant a tree in the compound, because if she leaves, she may later come back to demand the fruits of her tree and cause problems for the husband. On land that the woman owns, however, she can plant whatever she wants.

Resolving the issue of socially imposed land and tree tenure restrictions for rural women will not occur through legislation or confrontation. Sustainable development strategies must work within the framework, not seek to destroy the cultural identity. Nevertheless, it is recognised that in most rural communities, each individual woman cannot get long-term control over land, nor be given permission to plant trees. Groups of women, on the other hand, have often had the collective ability to obtain long-term user rights to communal lands, and are often given lands for their groups' agricultural activities without restrictions on their uses. For women to plant a few trees around their compounds or on the family farms, however, will still require educating the male decision makers of the communities about the advantages to be gained.

Multiple Land Use: Issues and Conflicts

One important land-related factor which may also threaten and confront sustainability of forest management, protection and production systems is the issue of multiple land uses and the conflicts they pose. Natural forest lands have many alternative uses including:

- Agriculture-food production and for development of pastures for grazing;
- Civil construction works and for development of towns and cities for housing; and
- Building of dams, lakes and irrigation projects.

In West Africa, all of these alternative uses exist and demand attention. Agriculture is the most important and poses a greater threat to sustainable forest management. Agricultural expansion and development programmes almost invariably result in deforestation. This can be explained in the light of the unsustainable traditional farming system of shifting cultivation. This form of cultivation is always on existing lands, and when it returns to the same plots too frequently, it does not allow the forests enough time to return to its former condition.

What are the solutions? In terms of land for agricultural production, the solution should lie in making agriculture sustainable and permanently more productive. This implies that the farmers should adopt more improved technologies in their traditional farming systems. This has further implications for a system of credits and subsidies for farm land improvement schemes to be undertaken by the farmer on his own.

In a competitive and open market economy, people (and farmers in particular) may find that the value of future gains from allowing forests to stand on prime lands suitable for agriculture or other uses is lower than present-day gains from deforestation, i.e. the present gains from deforestation (for agricultural purposes) may be greater than future gains to be derived from keeping the forests intact (Persson and Munasinghe 1995). If it is more profitable to deforest (i.e. use forest lands for alternative purposes) than to reserve, protect and manage forests sustainably, then the market forces of demand and supply will settle prices in favour of agricultural and other uses, as against forest reservation, protection and conservation. If society deems the forests as both a present and future asset, it seems that intervention by governments in the market place is required to protect and manage them sustainably.

The Human Factor

The value of forests to individuals and communities is seen as a behavioural pattern controlled or influenced by man's perception, learning, memory, thinking and motivation as well as attitudes in communication. The influences of these attributes are also amplified with time and mode of leadership. For any forest management model to be acceptable and successful, it must first be tested against the background of general human behaviour. The search for a sustainable forest management system should go beyond technological and biological approaches, and examine sociological, psychological and anthropological issues as well.

Traditionally, forestry in the sub-region has excluded the local people from management decisions. This has resulted in an antagonistic relationship between foresters and local

communities. While the foresters see the local communities as a threat to the permanency of the forests, the local people also perceive foresters as preventing them from utilising their own resources. These conflicts have arisen because the human factor has largely been ignored in most management decisions. The development of a mechanism to ensure positive local community thinking and perception about forestry is important in any programme designed to ensure sustainable forest management.

CAPACITY BUILDING FOR SUSTAINABLE FOREST MANAGEMENT

Capacity building for sustainable forest management should be examined holistically taking into account the various associated factors as well as the various "actors" or agencies that have an assigned forestry role. This means evaluating quantitatively and qualitatively capacity building in terms of physical and material infrastructures as well as in terms of the human resource capacity development.

Capital and resource endowments raise the productive levels of production factors. The successful implementation of sustainable forest management programmes can depend considerably on the quality and quantity of the human or management factor. Given the situation prevalent in much of West Africa where the governments face rising and severe budgetary constraints, and calls for public expenditure cuts, many governments can barely cope with the costs required to build the capacities of their forestry services or departments to the desired levels and standards.

In view of the numerous financial constraints, some governments have launched forestry sector rehabilitation/reforms with the assistance of the World Bank and other foreign governments. In Ghana, this is exemplified by the World Bank/Government of Ghana Forest Resource Management Project which started in 1989.

CHAPTER 7
POLICIES AND LEGISLATION

INTRODUCTION

In West Africa there are three major phytochoria (centres of endemism). The first is the Guinea-Congolia Centre of Endemism, a forest habitat which is estimated to support 8,000 plant species of which 80% are believed to be endemic, representing over half of all species of the Agrotropical Realm (Stuart *et al.* 1990). The second center of endemism comprises the derived savanna and guinea savanna which is described as the Guinea-Congolia/Sudania Regional Transition Zone. The third phytochorium is the Sudanian Regional Centre of Endemism. This stretches from Senegal in the West to the Ethiopian highlands. It was originally thought to have been dry forests, much of which now has become severely degraded and is becoming increasingly characterised by open woodlands. Wetlands are also typical of the zone. There are about 2,750 plant species in this zone of which at least 30% seem to be endemic to the region.

Of these three zones of vegetation, it is the first, the Guinea-Congolian high forest region, which captures the imagination. Since this is also the richest belt in terms of timber products, the tendency has been to relate the forest policies and legislation of the West and Central African sub-region to the events occurring in this zone. This attitude has its origin in its colonial history with unfortunate consequences for the management and conservation of forest resources in the sub-region. Until quite recently, the complementarity between the high forest belt and the savanna in drawing up national forest policies and management strategies was not recognised. Thus in most countries of the sub-region the aim of forest policy is to achieve self-sufficiency in wood products and to retain a viable foothold in the export market where wood is a major source of foreign exchange earnings.

The link between economic development and the state of natural resources, *vis-à-vis* between poverty and environmental degradation which prevails in the whole of Africa (Kowero 1995) has added a new dimension to the consideration of policy objectives. As an example, in Nigeria policy objectives include consolidation and expansion of the forest estates, and their management for sustained yield; forest conservation and protection of the environment; forest regeneration at a greater rate than exploitation; reduction of waste in utilising the forest and forest products; protection of the forest estates from fires, poachers, trespassers and unauthorised graziers; encouragement of private forestry; creation of man-made forests for specific end uses;

increase of employment opportunities; development of national parks and game reserves; development of secondary forest products which are significant in the local economies, and encouragement of agroforestry; co-operation with other nations in forestry development; and development of more efficient use of wood energy.

In this chapter (based on Adeyoju 1995), an attempt is made to review forest policies and legislation in Anglophone West and Central Africa, consider the requirements for effective national/regional forest policies and indicate strategies which may be adopted to ensure that policies are translated into activities leading to sustainable forest management and conservation.

REVIEW OF FOREST POLICY AND LEGISLATION IN ANGLOPHONE WEST AFRICA

With the exception of Cameroon and Liberia, the Anglophone West African countries share nearly identical administrative and resource development experiences. The four countries (Gambia, Ghana, Nigeria, and Sierra Leone) followed the same reservation procedure, type of area to reserve and national forest reservation target. This is because the British Colonial Office exercised a tight control and standardisation of the treatment of issues encountered in the territories.

Although each country had peculiar cultural factors which militated against a speedy reservation process and extensive acquisition, the same issues characterised the forest policy enunciation. The main issues in every policy document included reservation, wood production, government involvement in and control of forest industries, management of savanna areas for multiple purposes of wood production and grazing, conditional provision for fuelwood and pole plantations near the urban centres, and protection of watersheds and vegetation along river courses. Essentially, wood was the only acceptable valuable forestry good. Other forest resources were grouped together as "minor forest produce" including wildlife. Environmental values and biodiversity were accorded low priority, though some efforts were made to establish "inviolate forest plots".

For nearly 150 years of its existence, Liberia has never been a colony and therefore lacks a forest management practice imposed from outside. For a very long time, it was the respective foreign companies prospecting for timber which acquired large tracts of forest areas with exclusive liberty to do their own thing as they deemed fit with no thought for a national viewpoint. However, soon after the establishment of the professional training programme in 1965 at the

University of Liberia, a gradual direction was initiated toward establishing a forest service, curtailing the extensive commercial interests of concessionaires, enacting a forestry law, and experimenting with the co-existence of two parallel institutions, i.e. a forest service charged with plantation development, silvicultural treatment and yield control, and the Wood Development Corporation charged with the responsibility for exploitation, revenue and sales (including exports). The inspiration for forestry reconstruction in Liberia is derived largely from the experiences of the other Anglophone countries.

Over the last thirty years of independence in Gambia, Ghana, Nigeria and Sierra Leone, a significant shift from the long-term pursuit of policy objectives to inconsistent and erratic management is witnessed. While each country has launched a series of periodic plans with specific targets, nevertheless, development objectives have oscillated wildly in defiance of normative guidelines. The characteristic pattern is the conspicuously enlarged forestry revenue contributions which are matched by low local investments. In virtually all the countries the sustained yield principle has been jettisoned, thus effectively negating forest policy prescriptions. Also, the situation has worsened through political instability arising from continual military interventions and civilian unrest.

Forest legislation is an important institutional element for the development and expansion of the sector. It provides the structural framework within which national forest policies are set and in turn reflects their objectives and priorities. Consequently it should incorporate provisions that pertain to forestry and biodiversity resources.

Some important aspects of national forest policies and laws are summarised in this chapter.

Acknowledgement of Resource Management Objectives

Current forest laws contain major departures from the narrow perspective of timber harvesting and felling controls toward planning and management of forest lands. For instance in Cameroon, the purpose of the law is to guide the conservation, exploitation and development of forests, wildlife and fisheries. Also, forests include lands capable of producing wood and other non-agricultural produce and of providing an indirect effect on soil, climate or water regime.

In Ghana the reasons for constituting forest reserves include to maintain or re-establish forest vegetation in order to safeguard water supply, to aid the well-being of forests and agricultural crops grown on the land or the vicinity, and to secure the supply of forest produce to villag-

ers. Integrated management of resources is of concern to the Forestry Commission which is charged with reviewing national forest management and forest policy formulation.

Liberian forests are defined as a major economic resource to be devoted to the most productive use for the permanent good of the nation. Their conservation and utilisation are to be undertaken in accordance with such restrictions to ensure perpetual benefits.

In Nigeria, the respective state (regional) forest legislations emphasise the wood supply values of the forest. However, the national forest policy sees it as a resource rich in vegetative and soil contents and needs to be conserved diligently. It should be noted that there is no national forest law as such.

The policy in Sierra Leone distinguishes between national forests, national production forests and protected trees. They are intended to be managed to achieve the greatest combination of benefits in the form of production, protection and non-forest uses.

Forest Land Use

New legislation or amendments provide for a more systematic and rational apportioning of forests among the major land uses. This is in response to the expanding agricultural requirements for food production *vis-à-vis* the need to retain adequate land area for continuous timber production, environmental protection and communal forest development.

Long-term Management Practices

The future production of the high forests depends mainly on the utilisation of additional trees and those of lower diameter classes remaining in the forests after the first exploitation. In support of this type of extensive forestry, the prescription of minimum diameter limits, the prohibition of erratic returns to over-logged areas and the determination of some form of annual allowable cut are the most immediate and legal requirements that may be imposed on the operators.

Sustained Use of Forest Resources

Ghana, Cameroon, Liberia and Sierra Leone have made efforts to improve their legislation in order to provide the necessary instruments for introducing long-term management practices and to support more consistently a rational utilisation of the forest resources. However, it should be admitted that the need to adjust the annual harvesting volumes to long-term forest potentials has not yet found full acceptance in the various laws and regulations. It is therefore imperative while

formulating future revisions of legislation to include specific operational provisions in support of sustainable use of forest resources.

Wildlife, National Parks and Protection of Biodiversity Resources

The growing awareness of the importance of wildlife management and nature conservation has led to the adoption of legislative provisions related more specifically to biodiversity values. For instance, the forest laws of Cameroon, Liberia and Sierra Leone incorporate regulations which provide the framework for the utilisation and management of natural resources based on a multiple use concept. The laws in these three countries provide for the establishment of national parks, fully protected nature reserves, protected wildlife areas and buffer zones around such areas, game reserves and game sanctuaries.

For a very long time, Ghana has had a separate Department of Wildlife with its own independent mandate. In recent years, Nigeria has created three agencies charged with the responsibility for particular aspects of natural resource protection and development. These are the Natural Resources Conservation Council, the National Parks Board and the Federal Protection Agency (FEPA) with overlapping mandates and are now being rationalised *vis-à-vis* the inalienable functions of state and federal forest services.

APPROACH TO NATIONAL AND WEST AFRICAN FOREST POLICIES

Current understanding of forestry functions tends to suggest that the overall objective of national and international forest policies should encompass strategies to protect the environment. Unfortunately, few forests are managed to provide the full range of goods and services including the protective functions which could be derived from them. Most forests are managed for one dominant use established by the manager (in this case the respective governments). It seems, therefore, that the ideal approach to national and (regional) West African forest policies would involve the following steps:

- Determination of the variety of goods and services required by the local population at different points in time;
- Estimating the aggregate requirements of each good and/or service by local population;
- Evaluation of biological potentialities of local forests to provide the goods and services;
- Analysing the investment requirements to foster appropriate production levels of local forests for the domestic market;

- Assessing real and potential substitutes for conventional, occasional and aesthetic uses of forest resources;
- Charting an interim forest products balance sheet as an indicator of total requirements, supply and deficit status over a given period;
- Outlining the feasibility of plural ownership of forest resources and the variety of incentives to foster free market enterprise in all aspects of the forestry sector;
- Succinctly indicating the interdependence of the supply regime of each forest product within national geographical regions and across international boundaries; and
- Enumerating the imperatives for national co-ordination of forestry activities and the parameters for harmonisation of international forest policies.

Of major relevance to future collaboration between countries in the sub-region is the unique opportunity for marketing institutions to prospect across national boundaries. To that extent, there is a need to evolve a mechanism for sharing information on production costs and marketing strategies. This would not only improve competition, it would also enhance complementarity of programmes between the countries.

POLICY DIRECTIONS FOR SUSTAINABLE FOREST DEVELOPMENT

The inability of the forest service to provide adequate quantities of needed goods and services, to maintain the integrity of the forest estates, to access sufficient qualitative resources for pressing tasks and meet new challenges is being boldly acknowledged by most forest managers. This in itself is a positive development underlying the potentialities of alternative and/or complementary investment strategies. Policy directions in support of sustainable forest development are summarised under five sub-headings as follows:

Forest Ownership

For too long, forestry in West Africa has been beleaguered by the over-bearing role of single ownership, single manager and single seller, all of which deny the enterprise of competition, commodity development and resource inputs. Undoubtedly, other types of ownership have been at work in other parts of the world with tremendous advantages to the sector. There is a strong case for plural ownership of forest lands consistent with the current commercialisation trend. In other words, strict technical prescriptions have to be attached to the management of forest reserves that mainly serve local rather than the larger societal/national needs. They have to be

handed over to communities that are ready and capable of responsibly pursuing objectives and obligations of an efficient forest owner.

Forest Management

Arising from the circumstances of forest reservation primarily for the single objective of wood supply, the forest administration conferred upon itself the exclusive rights of forest management even when the Reserve Settlement Court of Nigeria and the gazette announcement of the Governor-in-Council decisions recognised the rights of communities in enclaves and neighbourhoods to certain privileges. There is no provision for the involvement of forest and local communities in the various stages of management, i.e. when and what regeneration strategy to apply; when and what type of forest tax to impose; who shares and what proportion from the forestry proceeds; etc. Until about twenty years ago the only financial concession to Nigerian forest owners for the loss of their lands to perpetual forestry enterprise was through payment of royalties. In the last two decades, state governments have denied the communities their legal entitlements. This is one important reason for the profound state of hostilities between the public and forest services.

In an analysis of the forest fee system in Ghana, Sargent *et al.* (1994) showed that:

- forest fees had been too low in absolute terms to protect the resource or slow down exploitation;
- the system had resulted in an inadequate market incentive differentiation between species, thus leading to over-exploitation of highly desirable timber species and under-exploitation of abundant but less-desirable species;
- the system was highly inequitable – the low proportion of stumpage value amounted to a 'gift' from society to industry and other users; and
- the system was inefficient as a mechanism for recovering stumpage value, thus promoting wastage both in the forests and mills.

The authors suggested that forest fees could be used as fiscal incentives. The first is to create conditions in which sustainable forest management is more attractive to the manager/user than deleterious practices. The second is to ensure that sufficient funds are raised from utilisation of the forest resources to cover the full costs of sustainable forest management and protection.

Creation of New Forests

Many countries have legal provisions for new forest land acquisition. However, because the present forest administrators are unfamiliar with the exercise of such provisions, hardly any new forest reserves have been constituted since political independence. Yet, the opportunities still exist to augment the total forest estate through:

- acquisition of small to medium forest estates in certain locations;
- persuasion of the livestock agencies to develop ranches with high-grade pastures as the inevitable development phase;
- developing a support package for individuals, communities and institutions who are inclined to grow short rotation crops in woodlots, estate perimeters, windbreaks; and
- instituting appropriate training for senior forest managers to enable resolution of land use conflicts.

By the same token, the procedure for de-reservation should be strengthened such that the government alone cannot exercise unilateral de-reservation powers without proper environmental impact assessment and objective public debate of the suitability of the alternative forest land use being proposed.

Development of New Products

A careful observer of tropical forest policy would no doubt be confounded by (a) the gigantic waste accumulating at exploitation sites, gantries, sawmills, plank markets and joinery shops, and for which there is no feasible effort to utilise; and (b) the continuing neglect of the investment opportunities and potential multiplier effects of actualising a fraction of the resources left on the ground. Needless to say that at this point in time, less than 40% of the biomass content of each tree felled reaches the sawmill. Again each log at the sawmill yields less than 60% of its contents as sawnwood while the remaining 40% ends up as off-cuts, bark slabs and sawdust. Although there has been a general increase, in the last fifteen years, in the recovery rate of the cellulose content of each tree or sawnwood at each stage of further processing, the point must be made that the 60% left in the forests and the waste proportions accruing in other places constitute a grievous loss of opportunity.

The implications of this situation summarised are that:

- with appropriate technology, more wood, semi-wood products and substitutes for sawnwood can be made available to the market;

- with a significantly increased variety of wood products in the market, there would be less pressure on the standing forest resources, and consequently the immature under-sized trees would be spared untimely exploitation;
- with more wood products being obtained from each tree, the rate of illegal felling would decline;
- the limited and regulated entry into the forests would lead to healthier and more productive forests; and
- the utilisation of wood waste would create a more friendly forest and wood processing environment.

Already, the Forestry Research Institute of Nigeria has developed a small-scale technology, virtually independent of electric energy for the production of floor tiles, wall tiles, partitioning panels and roofing sheets. For each product, at least 90% of the raw material comes from wood wastes. Because of its backward integrative effect on the quantity and quality of the nation's standing timber, this processing plant deserves a vigorous commitment from all quarters.

Technical Support

It is clear from the foregoing discussion that forestry can no longer be pursued as an exclusive government enterprise with members of the public as consumers of whatever forest goods and services are delivered to them. Therefore governments need the co-operation of all would-be wood producers for the sustainability of sectoral benefits. However, because it is a long-term business and one which competes for land that has attractive short-term uses, there is a clear case for technical support for the emergence of a truly efficient sector. Governments have the unique duty to provide technical support as a social service to the sector. Specifically, technical assistance is required for:

- facilitating accessibility of land to private and corporate wood growers as painlessly as possible. The drawing up and processing of vital documents for freehold or leasehold can be accelerated with the support of the forest service. This would be a major first step to enlisting the much needed mass participation in this sector.
- if private and corporate bodies are to be encouraged to transfer their lands to long-term forestry goals, then the state should execute variants of financial inducement and protection such as:
    - tax relief on private forest areas;

- differential interests on loans from agricultural and commercial banks;
- differential duties on forestry regeneration tools and equipment;
- subsidies on seed and planting stock; and
- special insurance schemes against forest fire and blight.

A further area of substantive technical support is for the development of non-forest products which are critical to many local economies.

CHAPTER 8
STRATEGIES AND INCENTIVES FOR SUSTAINABLE FOREST MANAGEMENT

STRATEGIES

The biological richness and complexity of the tropical forest ecosystem give it immense social, economic and scientific values of global significance. Therefore, nations are morally obliged to sustain these values through judicious utilisation of the resources in these forests. Countries with tropical resources are thus required to adopt strategies (e.g. consumption behaviours, technologies and economic policies) that will ensure the sustainability of tropical forest resources. To encourage the adoption of these strategies, priority actions for implementation should be clearly listed. In Anglophone West and Central Africa, the problems of forest conservation and management highlighted earlier should be addressed in the priorities for action.

The first priority is to re-establish the organisational capacity that will ensure responsible management of the forest estates. The administration of forestry within the sub-region is complex. The current economic situation does not allow for adequate manpower and financial capabilities to address all aspects of tropical forest ecosystem research and development. Therefore, these countries need to pool their human, material and financial resources together to address issues relating to sustainability. Since little or no collaboration exists among forest sector institutions, duplication of efforts and uneconomic use of resources may result. The sub-region will have to develop regional integrated and collaborative programmes. Institutions, especially research organisations, could then be assigned specific studies (within a larger programme) that they can deal with better. The cost and benefits of such a programme will thus be shared among the participating countries.

The second priority is to re-establish the integrity of the forest estates. This entails their restoration and maintenance. The inability to protect the forest estates is not only due to the deficiencies of the law, but also reflects the failure of forestry authorities to apply the law and the non-involvement of the local communities in the maintenance of these estates. Insufficient funding of the forestry services is one cause, but the lack of transparency in managerial capacity also adds to the problem. To redress this issue, efforts should be made to resettle the encroachers, starting with those found in the most valuable forest reserves, particularly in re-

serves that have suffered the least damage. Acceptance of encroachment on whatever pretext, may lead to the loss of the whole forest reserve.

Ghana's efforts to reduce serious encroachment in some forest reserves in the western region, dubbed "operation halt," have largely failed due to the encroachers' violent/armed responses to their eviction. The government's reaction in sending in the military was only partially successful because the forestry department failed to provide the logistical support to carry out eviction. Likewise, Côte d'Ivoire's approach by forming forest communities comprising encroachers, forestry department staff and government officials to see to the gradual eviction of encroachers over a period of time was also not a total success. It is necessary both to find a solution acceptable to all in order to reduce cost and to ensure efficiency.

The third priority is to bring all forest reserves under sustained yield management and to prepare working plans for them. This is already being done through support from various agencies in Ghana (ODA, World Bank, DANIDA) and in Cameroon (IDRC, Tropenbos, CIRAD-Forêt, ODA). Nigeria is seeking the support of the World Bank for a similar project. Attention should be given to a review of royalty rates to reflect the real value of wood. This would make the sawntimber industry less attractive except to the more efficient operators. Additionally, the management of individual forest reserves should recognise the stake of adjoining communities as co-owners, with the forestry department acting as trustee. In principle the communal owners should continue to receive royalties substantial enough to ensure their co-operation in maintaining the integrity of the forest reserves. Any management plan should include provision for secondary forest produce (bushmeat, wild fruits, natural gums, native sponge, browse, spices and medicinal plants) as well as timber, poles and fuelwood. It may be necessary for a new enquiry to be conducted into rights being practised within a reserve, including beneficiaries, what they are allowed to take, the needs of the local communities, and the means by which they may be regulated on a sustained yield basis.

Working plans should be formulated based on a two-stage approach. The first should be the setting up of broad guidelines on the management objectives of each reserve by the forestry department based on their technical experience. Next should be the formulation of detailed activities to achieve the management objectives by the forestry department in conjunction with the local communities.

The fourth priority is to reduce the pressure on forest reserves by introducing systems for regulating their exploitation, especially by providing appropriate substitutes for those who derive part of their livelihood from gathering secondary produce within the reserves.

A shift from timber production of a few species to one that allows for a variety of goods and services will ensure the development of more profitable forestry programmes and also lead to greater participation of local communities. Management strategies should therefore concentrate on improving the regeneration and growth of timber and NTFP using management techniques that will ensure the sustainable utilisation of both resources on the same piece of land.

Finally, the procedure for monitoring and evaluating progress in the management of forest reserves and for ensuring that targets are met should be implemented. This will include forestry extension activities within the support zones to a forest reserve. This may best be accomplished by the establishment of a forestry data bank for each country, a move which has commenced in Ghana and Cameroon. The implementation of such priority actions should be undertaken as part of an overall strategy embodied in a Tropical Forestry Action Programme (TFAP) developed for each country. As a pre-requisite for the formulation of a TFAP, silvicultural practices and policies governing multiple land use, land tenure, the forestry sector, industry and population have to be re-examined and where necessary up-dated.

Silviculture and Forest Management

The need for the conservation of biodiversity strongly favours the continued use of the Selection System in the floristically rich tropical high forest of Anglophone West and Central Africa. However, some form of silvicultural treatment must be undertaken alongside commercial logging to enhance the growth and survival of the residual crop and advance regeneration. The following actions should be considered to ensure the sustainable application of the Selection System.

- A form of improvement thinning and climber cutting is suggested. As much as possible manual thinning should be practised instead of using arboricides;
- Logging disturbance should be reduced to the barest minimum in order to maintain a healthy and productive residual crop after logging. Hawthorne (1993) recommends the removal of a maximum of 200 exploitable (>70 cm dbh) trees per compartment of 140 ha over the period of the felling cycle;

- Total disturbance due to felling should not exceed 15% of the logging area to ensure sustainability;
- The annual allowable cut should take into consideration the logging intensity and disturbance created as a result of logging;
- The annual allowable cut should not exceed the annual growth rate;
- An appropriate felling cycle and minimum exploitable girth limit of tree species should be adopted;
- Broaden the base (i.e. increase the number) of species being exploited;
- Management of the natural forests in West Africa should be species and not area oriented; and
- Use of an economic evaluation approach instead of financial analysis (Leslie 1987) to determine sustainability of silvicultural system.

Multiple Land Use Policy

A national land use policy is required to co-ordinate sub-sector policies concerning activities such as agriculture, forestry, roads, urban development and mining. The policy should provide a rational framework to resolve conflicts between these activities. A major objective of TFAP is to promote land use systems that improve natural vegetation cover and meet local and national needs for forest products. For some countries (e.g. Nigeria and Ghana) an effective land use planning institution based on a flexible multi-disciplinary approach able to sustain long-term policies is under consideration.

The multiple uses of land generally make decisions and policies affecting land extremely difficult. However, an integrated land use approach is important to harmonise land uses to obtain the maximum net benefit. Such an approach can only be achieved when a policy framework is drawn up to ensure the implementation of baseline programmes on land capability classification at both the national and district levels. Multiple land use will reduce conflicts of interest between alternative land uses and also minimise environmental degradation.

Land Tenure

In many countries, land tenure is an unresolved issue because of the constraints posed by the customary land tenure system for forestry development. The FAO target is that 25% of the

total land area of each country should be earmarked for forestry. For many countries in Anglophone West and Central Africa, the proportion ranges from less than 10% (Nigeria) to 40% (Cameroon). Changes in land use are determined by demand. As noted earlier, the demand from non-agricultural sectors is usually stronger than from agriculture and forestry due to the greater financial returns obtained per unit area of land in the short term.

Similarly, demand for forest land is complicated by competition from agricultural uses for food production. Rational land use policy must take account of these conflicting demands. There is less competition for marginal areas such as erosion sites, steep mountain slopes, fragile soils which are of little value for non-agricultural uses, and with low potential for agriculture. Such fragile ecosystems must be devoted exclusively to conservation forestry. Each country should develop policies for the conservation of these ecosystems as part of an overall strategy to secure tenure and thus contribute to sustainable agricultural production.

Forestry Sector Policy

In most countries the policy framework needs to be revised to include the involvement of communal forest owners in management decisions, sharing of forest revenue from natural forests and the modification of government claim to the harvesting of trees on farmlands and private forestry development generally. Private tree ownership should be recognised as a basis for promoting private sector plantations and agroforestry in the form of individual farm forestry, community woodlots and protection forestry.

Forest resources in the sub-region are grossly under-priced. This unrealistic pricing system contributes to the over-exploitation of forest resources and the consequent degradation of land resources. In most countries, the rates of payment do not reflect the status of available resources. As an example, the market prices of fuelwood and charcoal do not cover their full economic costs. Supplies originate from a market characterised by open access to forest. An appropriate policy on forest tariffs that take the social cost or value of the wood into account may therefore help to regulate the use of fuelwood in the long run.

As a first step, every country in the sub-region should adopt the following courses of action:

- Adopt stumpage fees close to the real value of wood;
- Introduce a pricing policy which favours the protection of highly threatened species; and

- Encourage all forms of processed wood export.

At the sub-regional level, an attempt should be made to co-ordinate a forest revenue system by conducting an inter-country survey to evaluate current systems. Guidelines for marketing and pricing of wood could then be developed to facilitate the movement of timber across national boundaries. Each country should set up a data bank on establishment and management costs, providing information which can be pooled from time to time to determine a realistic tariff system. If this strategy is adopted, inter-country movements of processed timber could reduce pressures on the forest ecosystems of the countries with poor forest resources or are overpopulated. This may also create the right atmosphere for a massive effort to mobilise private sector resources in tree planting.

Forest Industry Policy

Trade policies on timber in the individual countries have a significant effect on their neighbours since timber is an important international trade commodity. For instance, the suspension of round log exports from Nigeria, Ghana and Cameroon resulted in a high round log exports from Liberia in the 1980s (Parren and de Graaf 1995). Therefore, to be effective timber trade policies should be harmonised.

The timber processing industry is associated with high logging and mill residue generation, and consequently high resource degradation. Therefore, a downstream processing policy that ensures higher conversion rates and the development of quality products need to be implemented. The policy should address the following issues:

- The total number of mills and overall processing capacity should be guided by the national annual allowable cut;
- Processing should focus on secondary and tertiary products;
- Processing of smaller materials such as branches from mature trees;
- Utilisation of saw dust;
- Utilisation of more species;
- Total ban on round log exports; and
- Exporting lumber by mixed species according to colour, density and end use so as to remove pressure on individual or single species.

Population Policy

A correlation exists between population growth rate and land degradation. When the increase in population exceeds that of agricultural productivity, the rate of land degradation will be accelerated. Rapid population growth, a characteristic of a large part of the sub-region, can eliminate any gain in productivity despite interventions. The tendency would be the depletion instead of sustainable maintenance of forest assets. The higher the population, the quicker the rate of capital stock consumption and therefore the sooner the need to replace the assets. One possibility for increasing land productivity is through the promotion of fodder production as well as efficient use of traditional energy sources.

It is essential for the respective governments to promote and execute measures to ensure sustainable goods and services that accrue from the environment and the natural resources. Every government should adopt a 'National Policy on Population' to counter the effect of rapid population growth arising from high fertility and rapidly declining mortality.

The policy should aim at improving the standards of living and quality of life in the sub-region, promoting health and welfare, and achieving lower population growth rates through voluntary birth control methods.

INCENTIVES

The problems of forest management and the incentives needed to promote sustainable forest practices are outlined below.

Cash Incentives for Natural Forests

The reserved forests are obviously inadequate in meeting the increasing demand for forest resources, therefore, the size of the forest estates needs to be expanded. Cash inducement or development programmes/packages should be given to chiefs and local communities who agree to convert their lands to forests.

Agroforestry should be encouraged. The system is seen as a sure way of converting several unproductive cocoa and food crop farms into multipurpose forest lands in the long run. Farmers who have encroached on forest reserves and have planted cocoa or other crops should be induced to intercrop their farms with trees.

Participatory Forest Management

Traditionally all legally constituted forest reserves are managed by the Forestry Department in trust for the chiefs or landowners. However, such lands are strictly policed to the total exclusion of the rights of landowners and surrounding communities who owned and lived in them before reservation. In most cases this has fostered an antagonism between the local communities and the staff of the forestry service. The local communities retaliated by encroaching on the reserved forest lands. At present, about 4% of the reserved forests in Ghana have been encroached upon. The government has failed to evict the farmers despite several attempts involving the police and military.

One possible solution is the adoption of a collaborative or participatory approach to forest management (ODA/FD 1994) to promote sharing of products, responsibilities, controls and decision making for the unreserved forest resources (Prah 1993).

Rights to Timber

Benefits from and rights to timber originating both inside and outside reserves are skewed and are in favour of the timber industry. Farmers and communities have little incentive to protect the timber resources on their land. Therefore, local communities should be given strong but not necessarily absolute rights to specified forest products including timber to encourage their protection of the forest resources (IIED *et al*. 1993; Agyeman 1994).

Planning for Local Benefits

The reservation policy has not improved the life of the respective communities (Agyeman 1994) despite the royalties paid to them (Oteng 1994). The management objectives have not adequately addressed the needs of these communities who play an important role in the sustained management of the forest. Even the use of the forests as a source of NTFP is constrained by cumbersome methods of permit acquisition (Falconer 1992). It is thus imperative that forest management planning should first consider the needs of local communities living near the forests (FAO 1989a; ODA/FD 1994).

Control of Timber Exploitation

Monitoring of timber exploitation outside reserves has been lacking and no effective sanctions against illegal felling are available. To offset this problem, the assignment of part of the reve-

nue and other benefits of both the reserved and unreserved forests to landowners, farmers and neighbouring local communities will encourage them to monitor timber exploitation and protect the forest resources effectively. Also, salaries and allowances of the forest service staff who are responsible for monitoring timber exploitation should be seriously addressed to bring them commensurate with those of the other sectors of the economy.

Increased Revenue to Government

Another weakness of some of the management systems in West Africa is the low revenue returns due to low royalties. The forestry departments are thus incapable of undertaking any elaborate forest management or silvicultural practices that could improve the forest stand. For instance, the Tropical Shelterwood System induced adequate regeneration and growth, but was not applied extensively as a management system because the low financial returns is tied to the royalties and not to the true market value of the timber. Financial, policy, legal and regulatory incentives to sustain the forest resource base have to be developed (IIED *et al*. 1993).

Flexible Land and Tree Tenure

Land and tree tenure systems vary with different societies in West Africa, but generally families and individuals have farming rights over any piece of land their ancestors had cultivated. Despite the right to farm and to collect non-timber produce, timber trees on the land are by law vested in the state in most countries. This implies that farmers and chiefs cannot sell or even use any timber tree on their farms. Consequently, farmers also do not benefit from the revenue obtained from the trees felled on their farms. This is a big disincentive for farmers to protect the trees or forests (Agyeman 1994). It is therefore necessary to review the current land, tree and forest tenure systems, as well as the forest and timber laws, to give the right of ownership of trees to farmers who have the customary or statutory legal farming rights over any parcel of land, and to provide incentives for private investment in forestry.

CHAPTER 9
AREAS FOR FUTURE RESEARCH

Future research should be focused on work that will contribute to *Agenda 21* Chapter 11, Area A, paragraph 11.3(g) and to paragraph 12(a) of the *Forest Principles*. The former document refers to the build up of critical mass of researchers and strengthening their capabilities to undertake research on forests and forest products such as the sustainable management of forests, biodiversity and traditional uses of forest resources by rural communities. It also emphasises improving market returns and non-market values from the management of forests. In addition, the *Forest Principles* paragraph 12(a) emphasises forest inventory and assessment undertaken by national institutions with particular reference to biological, physical, social and economic variables. In this context, the following broad areas of future research are suggested.

Research for the Improvement of the Selection System

In conducting this research, attention should be devoted to the resolution of factors crucial to the successful implementation of the Selection System of Management. These factors include:

- Resource inventory (NTFP as well as wood products); and
- Yield regulation with emphasis on growth modelling, felling cycle, diameter limits, growing stock, species composition and management of residual stands.

Biodiversity Conservation Research

- Development of a conservation strategy for West Africa (identification of ecosystems under threat and mode of conservation/protection);
- Determination of minimum areas, appropriate shapes and patterns of distribution of the ecosystem patches required to conserve viable populations of interest; and
- Evaluation of species richness, distribution, behaviour phenology, germination and survival under the various intensities of the Selection System.

Policy and Socio-economic Research

Research would concentrate on the importance of the welfare of the poor/rural communities as they relate to forest resource sustainability. Major areas of focus should be on:

- Research on how to improve the livelihood strategies for rural communities living in or close to the forest resources;
- Influence of macro-economic policies and other interventions on sustainable management, and use of the natural forest resources; and
- Valuation of forest resources.

In addition, the following areas would also merit serious consideration:

- Appraisal of forest revenue systems;
- Evaluation of environmental, ecological, financial and socio-economic costs of implementing silvicultural systems;
- Ethno-botanical surveys in which views and cultural values of the local inhabitants are incorporated;
- Influence of socio-economic factors, policies and various forms of incentives on sustainable forest management; and
- Overall supply and demand trends in the region.

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