

Tropical Forest Conservation and Management Options

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## Introduction

Tropical forests are among the most diverse and complex systems in nature (Amusa, 2014). They are also one of the most productive and most threatened of biological communities on earth (Ghazoul and Sheil, 2010). Several authors have given some vivid accounts and descriptions of the tropical forests (Richards, 1996; Singh, 2004; Ghazoul and Sheil, 2010). They occur near the equator, within the area bounded by latitudes 23.5° N and 23.5° S. One of the major characteristics of tropical forests is their distinct seasonality; only two seasons are present (rainy and dry). Usually, the length of daylight in tropical forests is 12 hours and varies little. Average temperature is 20-25° C and only varies slightly throughout the year. The average temperatures of the three warmest and three coldest months do not differ by more than five degrees. Precipitation is evenly distributed during the year, with annual rainfall exceeding 200 cm. Soil is nutrient-poor and acidic. Decomposition is rapid and soils are subject to heavy leaching. Canopy in tropical forests is multilayered and continuous, allowing little light penetration. The plant population is highly diverse. An area of a square kilometer may contain as many as a hundred different tree species. The trees grow up to 25-35 m tall, with buttressed trunks and shallow roots, mostly evergreen, with large dark green leaves. Plants such as orchids, bromeliads, vines (lianas), ferns, mosses, and palms are typical of tropical forests. The animals found in them include numerous birds, bats, small mammals, and insects.

Tropical forests are sub-divided on the basis of the seasonal distribution of rainfall. Accordingly, a tropical forest could be: (i) evergreen rainforest (no dry season); (ii) seasonal rainforest (short dry period in a very wet tropical region) - the forest exhibits definite seasonal changes as trees undergo developmental changes simultaneously; but the general character of vegetation remains the same as in evergreen rainforests; (iii) semi-evergreen forest (longer dry season)- the upper tree story consists of deciduous trees, while the lower story is still evergreen, and (iv) moist/dry deciduous forest (monsoon)- the length of the dry season increases further as rainfall decreases (all trees are deciduous). All tropical forests display a variety of ecological characteristics including high diversity and density of plant species, complexity of flowering and fruiting regimes, specificity of microsites for successful regeneration and growth of plants, and the labile response of population structure to the level of recruitment (Peters, 1996; Turner, 2001).

Given their extreme species-richness, tropical forests contain a large number of timber and non-timber resources such as edible fruits, nuts, oilseeds, medicinal plants, thatch, latexes, gums and resins. Most of these economic species, however, occur at densities of only one or few species per hectare. In terms of the timing, duration and intensity of their flowering and fruiting, tropical plant species also vary greatly, although the phenologies of most species exhibit a marked seasonality. Species sharing the same pollinator frequently stagger their flowering times. The great majority of tropical trees rely on animals (insects, birds, bats etc) to pollinate their flowers. In spite of the large distance between con-specific trees, most species are obligate out-crossers. Temporal or spatial separation of staminate and pistillate flowers within a tree, dioecy, or genetic incompatibility mechanisms are the main strategies employed to avoid self-pollination. Seed dispersal is primarily by biotic vectors (birds, bats, primates and rodents) and there is much wastage. A large proportion of seeds die before germination due to predation. Many tree species have evolved chemical defences or rapid germination to escape excessive seed predation. A number of species produce seeds with well-developed dormancy. Despite this, mortality is still extremely high following germination (due to predation); and over ninety percent of the new seedlings may die before becoming established.

Again, each tree species in tropical forests possesses specific regeneration niche within which seedling establishment and growth is enhanced. The regeneration niches of many species are linked to the occurrence of tree fall gaps. Based on the gap requirement and shade tolerance of different species, three regeneration guilds can be recognized. These include: early pioneer species, late secondary species, and primary species. The establishment, growth, reproduction, longevity, and management potential of the species within these guilds are markedly different.

The population structure or size-class distribution of tropical trees can be described by three basic types, often dubbed types I, II and III. The type I size-class distribution displays a greater number of small trees than large trees, and an almost constant reduction in numbers from one size class to the next. This type of population structure is characteristic of shade-tolerant canopy trees that maintain a more or less constant rate of recruitment. There is a high probability that the death of an adult tree will be replaced by the growth of individuals from the smaller size classes. A type I structure is considered by many authors the ideal of a stable, self-maintaining plant population.

A type II size-class distribution on the other hand, is characteristic of species that show discontinuous or periodic recruitment. The actual level of seedling establishment may be sufficient to maintain the population, but its

infrequency causes notable discontinuities in the structure of the population as the newly established seedlings and saplings grow into the larger size classes. This type of diameter distribution is quite common among late secondary species that depend on canopy gaps for regeneration.

The final size class-distribution, type III, reflects species whose regeneration is severely limited for some reason. Most of the individuals in the population are more or less the same size or age, and although many of them may be reproductively active, no seedlings have been successfully recruited. Type III distributions are frequently encountered among light-demanding, early pioneer species that require large canopy gaps for regeneration. In the absence of such a disturbance, these species may temporarily disappear from the forest, the former population represented only by the seeds lying dormant in the soil. In general, all the size-class distribution types correlate well with the regeneration guild of a species, although a single species may exhibit any of these types depending on the environment and level of recruitment.

By and large, there is a cause-and-effect relationship between the ecological processes occurring at any of the life cycle stages of given species and sustainability of tropical forest management. Thus, given that more than one half of tropical forests have already been destroyed, a greater understanding of the ecology of tropical forests may enhance the potential for achieving a truly sustainable system of resource extraction within the forest ecosystem.

### **Importance of Tropical Forests**

Tropical forests are of great importance from ecological and economic viewpoints. Although they cover less than 10 percent of the Earth's land area, they contain the vast majority of the world's plant and animal genetic resources. These forests help stabilize the natural environment in areas where they occur and make it possible for life to persist under varying circumstances through maintenance of essential ecological processes and life support system. Tropical forests perform certain ecosystem services functions. Some of these include: protection and regulation of water resources, stabilization of soil, moderation of nutrient storage and cycling, pollution breakdown and absorption; and general resilience of the ecosystem. They play a major role in the global carbon cycling and in regional climatic patterns. They maintain very high rates of moisture and energy exchange with the atmosphere. They also absorb the vast majority of incoming solar radiation, and thus have a very low albedo- reflectivity of solar radiation (Thomas and Baltzer, 2002; Amusa, 2002).

Forest removal naturally results in an increased albedo, which can alter patterns of tropical and even temperate zone precipitation. Loss of tropical forest vegetation also results in reduced evapotranspiration, thereby reducing water cycling between the land and the atmosphere. Thomas and Baltzer (2002) showed that in Amazonia 50-80% of the water vapour entering the atmosphere via evapotranspiration is retained regionally, recycling as rainfall. Tropical deforestation also leads to a large net flux of carbon into the atmosphere. Studies have suggested that primary tropical forests act as globally important carbon sinks. Thus, tropical deforestation results not only in the release of carbon stored in biomass and soils, but also in the loss of carbon dioxide that would have been taken up by the intact forest (Thomas and Baltzer, 2002).

The world's tropical forests constitute a capital asset with great potential for yielding sustainable benefits. They provide livelihood opportunities to the local people. They provide income and jobs for hundreds of millions of people in small, medium, and large industries. They encompass over half of the world's standing timber, and could potentially produce as much as 75% of the world's wood products (Burslem *et al.*, 2001; FAO, 2014). Uses of tropical timbers range from industrial round wood, sawn wood, fuel wood, wood based panels and pulp and paper. There are also many valuable tropical forest products other than timber, in particular food products and pharmaceuticals. Tropical forests contain many wild relatives of modern food crops and domesticated animals. The developed world relies on many foods and other products derived from native tropical plants such as the shea-butter, different array of nuts, oilseeds, latexes, gums, resins, rattan and vanilla.

Tropical forests serve as insurance to meet the challenges of response to new technologies and biological changes including the development of resistant varieties to pest, diseases, as well as environmental stresses. They also offer opportunities for increased productivity and nutrient contents. For thousands of years humanity has known and exploited the curative and therapeutic effects of many tropical plant species and they have been used to manufacture medicines. Despite enormous progress in synthetic chemistry and biotechnology, pharmacy is still largely based on plant substances. Homeopathy- a complementary disease-treatment system in which a patient is given minute doses of natural substances, and similar practices have enjoyed a certain renaissance in western countries, while plant remedies are still the basis for the primary health care of most people in the developing world. Globally, at least 35,000 plant species are used for medicinal purposes (GTZ., 1997; FAO, 2014). With the tremendous diversity of species yet to be described, future cures for many diseases await discovery, particularly in the form of natural chemicals derived from tropical plants, fungi and microorganisms.

## Loss of Tropical Forests and Drivers of Change

Tropical forests are being lost at an alarming pace, particularly in South America and Africa (FAO, 2015). The largest forest losses over the past decade have been mostly in the Amazon Basin, where large tracts of tropical rainforests have been cleared for cattle ranches and soybean plantations. In absolute terms, there has been more clearance of tropical forests in Brazil than in any other nation of the world (Ghazoul and Sheil, 2010; FAO, 2015). Nigeria has the dubious honour of having the highest annual deforestation rate of 4.5% in the African continent, representing an annual loss of about 410,000 ha/annum. On the average, tropical forests are disappearing at up to 130,000 km<sup>2</sup> a year, representing a loss of about 50 football fields a minute (FAO, 2015).

The tropical rainforests (also termed tropical moist and humid forests) are receiving the greatest attention, because they are being destroyed so rapidly and because they are the most biologically diverse of all terrestrial biomes. Of the roughly 16 million km<sup>2</sup> of tropical rainforest that originally existed worldwide, less than 9 million km<sup>2</sup> remains as at 2005 (MEA, 2005). With different estimates, the current rate of rainforest loss is debatable but alarmingly high.

Rates of rainforest destruction vary considerably among geographic regions. Of the world's three major tropical regions, Southeast Asian forests are disappearing most rapidly in relative terms, while the African and New World tropics have somewhat lower rates of percent-annual forest loss (Sodhi et al., 2004; FAO, 2015). Such averages, however, disguise important smaller scale variations. In the New World tropics, for example, the Caribbean, Meso-American, and Andean regions are all suffering severe rainforest loss, but the relative deforestation rate for the region as a whole is buffered by the vastness of the Amazon. Likewise, in tropical Africa, forest loss is severe in West Africa, montane areas of East Africa, and Madagascar, but substantial forest still survives in the Congo Basin (FAO, 2015).

Other tropical and subtropical biomes have suffered even more heavily than rainforests. Tropical dry forests (also known as monsoonal or deciduous forests) have been severely reduced, in part because they are easier to clear and burn than rainforests. For instance, along Central America's Pacific coast, much less than 1% of the original dry forest survives. Losses of dry forest have been nearly as severe in Madagascar and parts of Southeast Asia (Mayaux et al., 2005).

Prior to the late 1980s, deforestation in the tropics was generally attributed to rapid human population growth coupled with government policies for rural development. These included agricultural loans, tax

incentives, and road construction. Such initiatives, especially evident in countries like Brazil and Indonesia, promoted large influxes of colonists into frontier areas and often caused dramatic forest loss. However, the fundamental drivers of tropical forest destruction have changed in the past decades (Rudel, 2005; Butler and Laurance, 2008). More recently, the impacts of rural peoples on tropical forests seem to be stabilizing. Although many tropical nations still have considerable population growth, strong urbanization trends mean that rural populations are growing more slowly, and are even declining in some areas (Kowero *et al.*, 2009; Kowero, 2015). The popularity of large scale frontier colonization programmes have also waned.

Globalized financial markets and a worldwide commodity boom have created a highly attractive environment for the private sector. Under these conditions, large-scale agriculture—crops, livestock, and tree plantations—is increasingly emerging as the biggest direct cause of tropical deforestation (Butler and Laurance, 2008). Surging demand for grains and edible oils, driven by the global thirst for biofuels and rising standards of living in developing countries, is also spurring this trend. In Brazilian Amazonia, for instance, large-scale ranching has exploded in recent years, with the number of cattle more than tripling (from 22 to 74 million heads) since 1990 (Smeraldi and May, 2008), while industrial soy farming has also grown dramatically.

Other industrial activities, especially logging, mining, and petroleum development, are also playing a critical but indirect role in forest destruction (Asner *et al.*, 2006; Finer *et al.*, 2008). These provide a key economic impetus for forest road-building, which in turn allows influxes of migrants, hunters, and miners into frontier areas, often leading to rapid forest disruption and cycles of land speculation.

### Conservation and Sustainable Management of Tropical Forests

Safeguarding the world's tropical forests should ideally not preclude their use or development in whatever manner that best serves human needs. Such use and development must, however, be sustainable. When forests are properly managed and utilized, they generate many renewable benefits. The International Union for the Conservation of Nature and Natural Resources (IUCN) have identified two main methods of conserving forests and biodiversity in general. These are *in situ* (preservation and protection of forest resources in their natural habitat) and *ex situ* (preservation and maintenance of forest resources outside their natural habitat) methods.

*In situ* method of forest protection usually involves the establishment of a network of protected areas representative of the particular ecosystem that is to be preserved. If certain endangered species of a climax vegetation do not regenerate naturally and cannot be cultivated with present

knowledge, *in situ* conservation will prove the most appropriate. For instance, most of the constituent species of the climax vegetation of the Nigerian tropical forest ecosystems are not domesticated; hence their continued existence depends on the persistence of the ecosystems in which they occur. Strict Nature Reserves, Game Reserves, National Parks and Managed Nature Reserves are means of protecting tropical forests and their constituent species in many countries.

On the other hand, *ex situ* method of forest conservation serves to preserve and maintain forest resources outside their natural habitat where it may not be possible to maintain an adequate genetic base for any particular endangered species in the ecosystem in which it occurs. Seed storage, pollen storage, establishment of clone banks and the use of tissue and meristem techniques are some of the approaches used under *ex situ* conservation method.

Obviously, as far as forests are concerned, the best management practice would be to leave them untouched. However, with the current demand for forest products, and with rapidly increasing human populations in tropical regions, this is an unlikely prospect for the majority of large tracts of forest. For most, some sort of management will be required to prevent their complete demolition. There are a wide variety of forest management opportunities, often with differing and even incompatible goals. It is therefore, important to examine some of the management options applicable in tropical forestry:

### 1. Management for ecosystem and genetic resources protection

Forest management for ecosystem and genetic resources protection comes under the *in situ* method of conserving forests and biodiversity. Designation of protected area is always the preferred approach with this method. The IUCN (1994) has developed a classification system for this, which is widely used. These include:

Category I- Protected area managed mainly for science or wilderness protection. This is further divided into: (I (a) Strict Nature Reserves, and I (b) Wilderness Areas);

Category II- Protected area managed mainly for ecosystem protection and recreation (National Park); Category III- Protected area managed mainly for conservation of specific natural features (Natural Monument);

Category IV- Protected area managed mainly for conservation through management intervention (Habitat/Species conservation area);

Category V- Protected area managed mainly for landscape/seascape conservation and recreation (Protected Landscape/Seascape) and;

Category VI - Protected area managed mainly for the sustainable use of natural ecosystems (Managed Resource Protected Area).

Tropical forest protected areas are designated to prevent deforestation and thereby secure conservation of biodiversity. Protected areas are usually established in recognition of the uniqueness of biodiversity of an area. The management usually comprise a cycle of planning, implementation and evaluation (consisting of a series of stages). The Rapid Assessment and Prioritization of Protected Areas Management (RAPAM) methodology provides a series of questionnaires and simple scoring tools to assist in the process of evaluation. It was developed by the World Wildlife Fund (WWF) and World Bank Alliance. Also, Margules and Pressey (2000) identified six main steps to be followed in addressing effectiveness of the system. These include:

- i. compiling data on the biodiversity of the area at hand (reviewing existing data and carrying out new field surveys if necessary);
- ii. identifying the conservation goals by setting quantitative conservation targets for species, habitat types, the minimum size and connectivity of habitat patches;
- iii. reviewing the current conservation status and assessment of threats;
- iv. selecting the conservation areas and extent;
- v. implementing conservation actions in the areas selected and;
- vi. maintaining the required values of the conservation area and monitoring progress towards these goals using appropriate indicators.

Nevertheless, the effectiveness of protected areas has often been undermined by limited capacity to withstand pressures for forest conversion and degradation (Bruner *et al.*, 2001). Tropical forest protected areas are most vulnerable to degradation and encroachment at their accessible edges, where biological edge effects and human activities interact. This has necessitated the development of buffer zones around protected area boundaries. The buffer zones are meant to safeguard against encroachment, often by allowing local people limited low-impact resource uses such as the collection of fruits and nuts, medicinal plants, weaving materials, or animal fodders.

## 2. Management for sustainable timber production

The management of forests for sustainable timber production is done through selective logging and sustained yield principle. Selective logging is by far the most important forest management practice in the tropics at present, and it is often allied with sustainable forestry practices. Sustainable forestry has been touted as a way to reconcile the demand for tropical woods with preservation of forests. By carefully removing only as many of the trees or other products as can be replaced relatively quickly and leaving others untouched, and in addition, planting tree seedlings of desirable species, it is thought that forest ecosystems can be maintained so as to provide many crops of timber or other forest products. After an initial harvest, the forests

would be left alone for an extended period of time, following which they could again be harvested for valuable products. In order for this system to be effective, there are several imperative preconditions: One, that the populations of species being harvested in the forest are able to produce a reproductive surplus; two, that there be adequate relatively undisturbed habitat; three, that soil fertility be maintained; and fourth, that erosion, runoff and road construction be kept to a minimum.

In selective logging, management of regeneration ranges from allowing natural processes to occur unimpeded, or cleaning up the site (raking and burning the slash), or preparing the soil for growth of seedlings – either natural or planted. Generally, however, selective logging results in ancillary damage, particularly when mechanized logging is involved. Many smaller trees and non-timber trees sustain damage or are killed when trees are felled on them, or when bulldozers enter to retrieve cut trees. Road construction during logging operations also cause erosion and runoff, damages vegetation other than trees, greatly compacts soil, and removes topsoil and seedlings. Climbing plants such as strangler figs and lianas are also damaged, or more often, deliberately cut to reduce the probability of pulling down other trees. Yet, these plants are essential components of the forest, providing food and shelter for canopy-dwelling species and supporting larger trees.

The detrimental effects of selective logging on stand structure, biodiversity, and forest soils can be reduced substantially through the adoption of Reduced Impact Logging (RIL) guidelines. This is a systematic approach to planning, implementing, monitoring and evaluating forest harvesting (Enters and Durst, 2002). It has been developed and refined over several decades while new practices and thinking continue to emerge. RIL seeks to reduce the impact of timber harvesting through a series of improved management interventions which include a well-trained workforce, careful harvest planning, cutting of climbers and lianas before felling, directional tree felling to minimize impact to the surrounding forest, the establishment of buffer zones along water courses, and using improved technologies to reduce soil damage and compaction during log extraction (Putz *et al.*, 2008). Nevertheless, while RIL reduces forest damage, it is not clear whether the long-term recovery of forests, their associated biodiversity, or their potential to sustain economically competitive future harvest can be achieved. There are also a number of constraints resulting in its infrequent uptake. These include high initial costs and insufficient awareness of its benefits, dearth of appropriate forest management policies and incentives, a lucrative illegal timber market and an absence of longer-term tenure necessary to encourage investment (Ghazoul and Sheil, 2010).

### 3. Management for environmental services

The forests provide a wide array of environmental services, some of which are now being successfully commercialized, thereby increasing financial benefits. The most commonly recognised forest ecosystem services are carbon sequestration for global climate regulation, watershed functions (including provision of clean and regular flow of water as well as flood control), biodiversity and the aesthetic beauty of the landscape (which is linked to revenues from tourism). In particular, the potential role of forests and forestry in sequestering carbon to reduce the build-up of greenhouse gases in the atmosphere is well-known. Forests have always sequestered carbon, but this ecosystem service went unnoticed and uncompensated.

Forest management for carbon sequestration is associated with a relative increase in stock of carbon held captive in the forest ecosystem over what would have occurred in the absence of such focused management. Increases in the stock of carbon could be accomplished as a result of an increase in the forest biomass and/or as a result of an increase in forest soil carbon directly. Managing forests to reduce carbon dioxide emissions and to increase carbon sequestration is possible through a number of approaches including:

- i. afforestation- converting non-forest lands to forests (i.e. tree planting on lands previously used for marginal crops);
- ii. reforestation- planting trees on lands previously used in forestry (e.g. re-planting quickly after a fire);
- iii. forest preservation- keeping forests as forests and;
- iv. forest management practices- implementing strategies such as thinning or increasing the length of rotations (the period of time between harvests) to minimize the risk of catastrophic fire.

A number of countries and jurisdictions have adopted some sorts of forest-related climate laws that create incentives for managing forests for environmental services. There are also payment schemes that reward forest owners who promote management for maximal carbon sequestration. Many corporate institutions in Europe are already benefiting from carbon trading by investing in tree planting in some parts of Africa. Carbon trading also offers opportunities for indigenous companies and in particular Small and Medium Enterprises (SMEs). Markets for carbon sequestration have been adopted in Uganda, Tanzania, Malawi and Madagascar (Landell-Mills and Porras, 2002). The market for environmental services from forests is growing rapidly around the world, often facilitated by national and regional policies as well as international conventions and agreements (Scherr *et al.*, 2004). Certain segments of society that are able and willing to pay for these services are creating opportunities for the forest owners.

#### 4. Management for ecotourism

Many nature-based tourism and ecotourism activities revolve around forests, establishing a strong cause-and-effect relationship between ecotourism development and forest use. Ecotourism provides a means by which people can use forests and its resources, especially the wildlife, without extracting resources or degrading the environment, and draw income from it. This non-extractive aspect presents a strong incentive to protect the resource. In the early 1990s to the early 2000s, ecotourism grew 20% - 34% per year (International Ecotourism Society, 2006). In a study assessing tourists flow and revenue generation in Kainji Lake National Park, Nigeria, a total of 39,138 tourists and ₦40,135,223.85 revenue was generated between 1999 and 2009 (Adejumo *et al.*, 2014). Bhandari (1999), shows that average annual tourist entry in the Masai -Mara National Park, Narok, Kenya, is around 200,000, with attendant huge revenue generation. However, the capacity of ecotourism to generate income and employment for surrounding communities depends on how well it is managed, and in particular on the systems set up for planning and benefit sharing (FAO, 2005).

Despite the non-extractive nature of ecotourism, it is still not entirely free of detrimental environmental impacts. Activities such as tree felling and road construction for development of tourist facilities and infrastructure have obvious implications the forest ecosystem. The intensity of tourism development and use, long-term versus short-term tourism planning, and the extent of modification an area undergoes affects the amount of environmental damage incurred. Disease transmission from humans to wild animals may also lead to local extirpation of certain animal populations. Therefore, it is important to exert caution in order to ensure that the very features that provide the basis for attracting tourists are not damaged or destroyed in accommodating visitors' physical needs and comfort.

The concept of carrying capacity, with its physical, social and ecological components has found application in the design and management of forests for ecotourism. Strengthening local institutions for forest management and developing information, through research on multiple uses of forests and new products of potential commercial value, also creates investment opportunities for both the scientific community and the private sector. The increasing demand for nature-based recreation has indeed induced a dynamic private sector involvement in the management of game reserves and parks in Kenya, Namibia, South Africa and Madagascar.

#### 5. Management for non-timber forest products

Non-timber forest products (NTFPs) are goods of biological origin other than commercial timber derived from forests, other wooded lands and trees

outside forests. They comprise plant parts, fungi, and other biological materials harvested from within and on the edges of natural, managed or disturbed forests. NTFPs include fungi, moss, lichen, herbs, vines, shrubs, or trees. Plant parts harvested include the roots, tubers, leaves, bark, twigs and branches, fruit, sap and resin, as well as the wood. These products have been classified into several major categories including culinary, wood-based, floral and decorative, and medicinal and dietary supplements (Chamberlain *et al.*, 1998; Amusa, 2014).

Some culinary non-timber products in Nigeria's tropical forests include *Artocarpus altilis*, *Beilschimidia mannii*, *Crassocephalum crepidioides*, *Irvingia gabonensis*, *Piper guineense*, *Treculia africana*, and edible mushrooms. Wood-based NTFPs are produced from trees or parts of trees, but not timber sized trees. Some of the more important wood-based NTFPs include *Garcinia manni* and *Massularia acuminata* stems for chew-sticks, rattan (cane and willow) for furniture, and *Prosopis africana* for carving. Many forest species are harvested and used in the floral industry as compliments to flower arrangements. The leaves of *Galax urceolata* (Galax) an evergreen herbaceous perennial are collected and exported to Europe for background foliage. The numbers of plants from tropical forests with high medicinal value are also enormous. For instance, Amusa (2014) reported monetary values of ₦248, 400.00 and ₦765, 000.00 ha<sup>-1</sup> annum<sup>-1</sup> for *Annickia chlorantha* and *Piper guineense* respectively in Omo Forest Reserve, southwestern Nigeria. Other medicinal plants of great importance in Nigeria are: *Bucholzia coriaceae*, *Hippocratea indica*, *Kigelia africana*, *Piptadeniastrum africanum*, *Tetrapleura tetraptera*, and *Zanthoxylum zanthoxyloides*.

The market demand and the interest in managing forests for NTFPs have grown tremendously. Some of the NTFPs are marketed and consumed with little or no processing (e.g. mushrooms, fruits and berries etc.), while many more are sold as raw materials to be later processed. Others are supplied for furniture and crafts (e.g. rattan furniture). In forestry socio-economic context, marketing of NTFPs in combination with efficient processing and resource management, provide a means of meeting the needs of people whose livelihood depends on these products. The commercialisation of NTFPs transpires at three levels (locally, nationally, and internationally) and targets different niche products. However, commercialising NTFPs of high value has been acknowledged to enhance the sustainability of species involved. Consequently, it is important that adequate attention be paid to sustainable harvesting, production and optimal marketing of high value NTFPs.

## Conclusion

Tropical forests are unique ecosystems with multiple benefits. However, these priceless ecological units are being lost at a disturbing rate. The fundamental drivers of tropical forest destruction have moved from rapid human population growth to large-scale agriculture involving crops, livestock and tree plantations. Other anthropogenic activities, especially logging, mining, and infrastructural development, are also playing a critical but indirect role in the destruction of these forests. *In situ* and *ex situ* have been identified as two main approaches to safeguarding the world's tropical forests and its biological diversity. Given the demand for tropical forest products, some sort of management options will be required to prevent complete destruction of the forests. Some of the management options and goals applicable in tropical forestry have been enumerated. For all of these management options, however, there has been lack of confidence in applying them fully in tropical forestry. This could be attributed to lack of defined objectives, and management plans to carry out these objectives. Thus, tropical forest management in most developing countries generally exhibits a lack of professionalism. It is hoped that this will be addressed in the bid to safeguard our fragile ecosystem.

## References

- Adejumo, A.A., Amusa T.O. and Adamu H. (2014). Assessment of Tourists Flow and Revenue Generation in Kainji Lake National Park, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*. Vol. 6(2): 35 - 47. Published by the Department of Forestry, Wildlife and Range Management, University of Agriculture, Makurdi, Nigeria.
- Amusa, T.O. (2014). Income Potentials and Sustainable Management of Selected Non-timber Forest Products in Omo and Shasha Forest Reserves, South-western Nigeria. Thesis submitted to the Department of Forest Resources Management, University of Ibadan, Nigeria, in partial fulfillment of the requirements for the award of Ph.D. in Forest Economics and Management. 253p.
- Amusa, T.O. (2002). The Role of the Forests in the amelioration of the Nigerian Environment. *The Nigerian Field*. Vol. 67. Pp 31 – 43. ISSN: 0029-0076. Published by The Nigerian Field Society.
- Asner, G. P., Broadbent E., Oliveira P., Keller M., Knapp D. and Silva J. (2006). Condition and fate of logged forests in the Amazon. *Proceedings of the National Academy of Sciences of the United States of America*. 103, 12947–12950.
- Bhandari, M. (1999). Tourism Raised Problems in Masai Mara National Park Narok, Kenya. 47 Report prepared for APEC, Nepal. 14p.

- Bruner, A.G., Gullison R.E., Rice R.E., da Fonseca G.A.B. (2001). Effectiveness of parks in protecting tropical biodiversity. *Science* 291: 125-127.
- Burslem, D.F.R.P., Garwood N.C. and Thomas S.C. (2001). Tropical forest diversity – the plot thickens. *Science* 291: 606-607.
- Butler, R.A. and Laurance W.F. (2008). New strategies for conserving tropical forests. *Trends in Ecology and Evolution*, 23, 469-72.
- Chamberlain J.L., Bush R.J., Hammett A.L. (1998). Non-timber forest products - The other forest products, *Forest Products Journal* 48(10), (1019).
- Enters, T. and Durst P.B. (2002). *Introduction*. In: Applying Reduced Impact Logging to Advance Sustainable Forest Management. FAO 2002. ISBN 974-7946-23-8.
- FAO (2005). State of the World's Forests 2005. FAO, Rome.
- FAO. 2014. State of the World's Forests: Enhancing the socioeconomic benefits from forests FAO, Rome.
- FAO (2015). Global Forest Resources Assessment 2015- How are the world's forests changing? FAO, Rome.
- Finer, M., Jenkins C., Pimm S., Kean B. and Rossi C. (2008). Oil and gas projects in the western Amazon: threats to wilderness, biodiversity, and indigenous peoples. *PLoS One*, doi:10.1371/journal.pone.0002932.
- Ghazoul, J. and Sheil D. (2010). Tropical Rainforest Ecology, Diversity and Conservation. Oxford University Press, New York. 516p.
- GTZ- German Agency for Technical Co-operation (1997). Non-timber Forest Products - A key to sustainable tropical forest management. GATE - 1997 (No. 2). 52 p.
- International Ecotourism Society (2006). Fact Sheet: Global Ecotourism. The International Ecotourism Society, Washington, DC, USA. 6p.
- IUCN (1994). Guidelines for Protected Area Management Categories. Gland, Switzerland: IUCN.
- Kowero, G., J. Njuki and C.T.S. Nair (2009). Some drivers of change in forest conditions in Africa. In: Special Issue on Sustainable Forest Management. *Discovery & Innovation* 21(1):4-11.
- Kowero, G. (2015). Investing in African forestry: a few observed trends and issues to watch Nature & Faune. Vol. 29, Issue No. 2. Forests and People: Investing in Africa's Sustainable Future, 8-11. ISSN: 2026-5611. Published by the Food and Agriculture Organization of the United Nations, Regional Office for Africa, Accra. Available at [www.fao.org/3/a-i4872e.pdf](http://www.fao.org/3/a-i4872e.pdf).
- Landell-Mills, N. and Porras I. (2002). Silver Bullet or Fools' Gold? A global review of markets for forest environmental services and their impacts on the poor. IIED, London.
- Margules, C.R. and Pressey R.L. (2000). Systematic Conservation Planning. *Nature*, 405, 243-253.

- Mayaux, P., Holmgren P., Achard F., Eva H., Stibig H.J. and Branthomme A. (2005). Tropical forest cover change in the 1990s and options for future monitoring. *Philosophical Transactions of the Royal Society of London B*, 360, 373–384.
- MEA (2005). *Millenium Ecosystem Assessment*. Island Press, Washington, DC.
- Peters, C.M. (1996). The ecology and management of non timber forest resources. World Bank Technical Paper No 322. World Bank, Washington. 157Pp.
- Putz, F.E., Sist P., Fredricksen T. and Dykstra D. (2008). Reduced Impact Logging: Challenges and Opportunities. *Forest Ecology and Management* 256, 1427-1433.
- Richards, P.W. (1996). *The Tropical Rain Forest: an Ecological Study*. Cambridge: Cambridge University Press.
- Rudel, T.K. (2005). Changing agents of deforestation: from state initiated to enterprise driven processes, 1970–2000. *Land Use Policy*, 24, 35–41.
- Singh, V.P. (2004). *Tropical Forest Ecosystems-Structure and Function*. Scientific Publishers (India). ISBN 81-7233-370-6. 305p.
- Smeraldi, R. and May P.H. (2008). The cattle realm: a new phase in the livestock colonization of Brazilian Amazonia. *Amigos da Terra, Amazônia Brasileira*, São Paulo, Brazil.
- Sodhi, N.S., Koh L.P., Brook B.W., and Ng P. (2004). Southeast Asian biodiversity: an impending catastrophe. *Trends in Ecology and Evolution*, 19, 654–660.
- Thomas, S.C. and Baltzer J.L. (2002). Tropical Forests. In: *Encyclopedia of Life Sciences*. Macmillan Publishers Ltd, Nature Publishing Group / [www.els.net](http://www.els.net).
- Turner, I.M. (2001). *The Ecology of Trees in the Tropical Rain Forest*. Cambridge: Cambridge University Press.