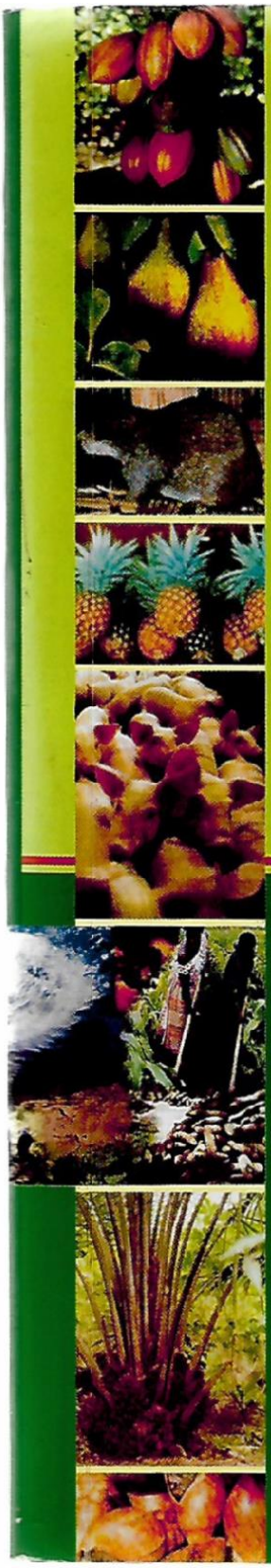

Blueprint for Sustainable Management and Utilization of Nigeria's Bioresources

Edited by
Christie Oby Onyia, B. O. Solomon, A. M. A. Imevbore & O. T. Ogundipe

Federal Ministry of Science & Technology

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The mono-cultural nature of the Nigerian economy which is about ninety-five per cent dependent on crude oil; has blinded our planners to the richness of the country in bioresources. This is in spite of the fact that over seventy per cent of the Nigerian populace derive their livelihood from subsistence farming while most of the rural poor depend on wild species of biodiversity.

This blueprint therefore seeks to define a roadmap for the conservation, management and utilization of Nigeria's bioresources such that it can combine her profile's current developmental needs and aspirations, even as it upholds the country's biodiversity and her ecological environment.

It will no doubt provide a useful guide to conservationists, manufacturers, researchers, bio-pharmacists, the academia and students of environmental sciences and related disciplines.

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BIORESOURCES AND ENVIRONMENTAL STUDIES

ISBN 978-8406-29-7

Concept Publications

Chapter 2

Status of Bioresources in Nigeria

by

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2.0 Ecosystems

2.1 Introduction

NIGERIA is characterized by a strong climatological gradient north to south, which defines the country's ecological zones. According to Adejuwon (1976), the original climatic vegetation zones were:

(i) Tropical Rainforest,
(ii) Tropical Deciduous, and
(iii) Tropical Xerophytic Woodlands.

Human activities have resulted in tropical rainforest giving rise to mangrove, freshwater swamp, forest re-growth and derived Savannah. The tropical deciduous forest gave rise to southern Guinea savannah and northern Guinea savannah while tropical xerophytic woodlands gave rise to Sudan savannah and Sahel savannah. Adejuwon, (1976), also hypothesized that the natural environmental systems under human agricultural

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activities in the rain forest, deciduous forest, xerophytic woodland and desert could give rise to a growing breakdown of original natural vegetation to much simpler vegetation types of reduced biodiversity and finally to permanent cultivation of crops adapted to the zone, except in desert areas where no changes in vegetation occur.

The major ecosystem classification in Nigeria has been discussed in detail in chapter 1.

Before dealing with the characterization of those ecosystems, there is need to observe the functions which the different ecosystems perform for the benefit of man and their respective biodiversities and elements. Ecosystems function dynamically to regulate or render the environment more suitable for the survival of living things. But when there is vegetation damage or habitat destruction, or even the extinction of some species of organisms from each ecosystem, there is a corresponding reduction in the number of nature of services derived from the ecosystem.

There is also no doubt that the higher the species diversity in each ecosystem, the more likely it can perform many of the ecosystem functions. For this reason, it is beneficial to conserve the plant species in each ecosystem. Thus, in most ecosystems in Nigeria where there has been much impact of human activities, many species and services provided by the ecosystem are no longer achievable and, even where they are, they no longer function at the same level when the system was not disturbed. Such services or functions provided by the ecosystem range from air and water purification to detoxification and decomposition of wastes. Services also include partial stabilization of climate, disposal of seeds and nutrient translocation.

It is also necessary to point out that the humid tropical ecosystem with its high species diversity, high level of rainfall and moisture and high temperature all the year round, is more useful in carbon dioxide sequestration and control of ozone layer depletion and the provision of a wide spectrum of non-timber products than the tropical savannah or temperate forest ecosystem. Similarly, the wetland ecosystem is much richer in aquatic products, some species of widelife such as crocodiles,

hippopotamus and fowls than any of the dry land ecosystems. The savannah ecosystems when not degraded or disturbed are richer in ungulates and do not protect the soil from the sun's radiation as the rainforest ecosystem.

2.1.1. Characterization of Nigeria's Major Ecosystems

(i) Savannah

The Sahel savannah is found mainly in the north-east and along the northern border with Niger Republic. In addition to the grasses, shrub species (*Combretum Spp.*) and the acacias predominate. Forest cover rarely exceeds 10, except along seasonal water courses. The savannas contain similar species to the Sahel zone with a greater frequency of *Acacia albida, Tamarindus indica, Schelocarya birrea* and forest cover of up to 20% of the land surface. The Guinea savannah is found in the middle belt of Nigeria, and is typified by open woodland with tall grasses and fire-resistant trees. African mahogany at one time was an indicative species of this zone; they have disappeared today, being a favourite species for local wood products like mortars. Tree cover here varies between 15 and 25% in undisturbed areas. The derived savannah is found further south and is a broad band that borders the remaining forest zone, and is continuing to spread south as more forest land is degraded into agricultural uses. Tree cover in this zone is as much as 30%. Although savannah tree species are not as valuable for timber as those found in rainforest, a few species are commercially harvested. Many other trees are cut for fuel-wood by residents in these areas or cleared to make room for agriculture.

Desertification is also making the borders of the drier savannah types to move southward. These lines of definition between all the various savannah types are vague and overlapping, and continually influenced by fire, drought and anthropogenic factors. Only a small amount of natural savannah has been protected in Nigeria, and the many large savannah animals often found elsewhere in Africa have become greatly reduced in number and range.

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(ii) Natural Forest Types

Nigeria has six main types of natural forestlands namely: (i) lowland rainforest, (ii) freshwater swamp forest, (iii) savannah woodland, (iv) riparian forests, (v) mangrove forests, and (vi) montage forest. The savannah woodlands mentioned earlier and riparian forest occurring in watercourses in the central and northern parts of the country also contribute to the nation's natural forest resource base. In addition, there are increasing areas under oil palm and rubber plantations. Planted agro-forestry species also contribute to the resource, but not significantly.

(iii) Lowland Rainforest

Lowland rainforest once covered much of the southern terrestrial areas of Nigeria, where an abundant rainfall regime favours the development of this ecosystem type. Unfortunately, excessive exploitation of timber, agricultural encroachment and other anthropogenic changes has greatly reduced these forests in extent. Although rainforest patches are still found in a belt in southern Nigeria from the western to eastern borders of the country, the largest remaining tracts of rainforest are primarily found in Cross River, Bendel and Ondo States (FAO, 1981) contiguous with the rainforest in neighbouring Cameroon.

Nigeria's lowland rainforests are characterized by a great variety of plant species arranged in a complex vertical structure of forest canopies. Some economically important rainforest trees include mahoganies, African walnut (*Lovoa*) and Mansonia, and a number of others that are increasingly endangered by illegal and legal logging activities. Many NTFPs (Non-Timber-Forest Products) are extracted from these forests and have important values as food items, medicinal and other domestic used by local residents.

(iv) Freshwater Swamp Forest

Freshwater swamp forests are found in Southern Nigeria, on the landward side of the mangrove belt, where salinity decreases beyond the tolerance of mangrove species. Swamp forests are dominated by species of Raphia, Pandanus, Calamus and

Alchornea, with a canopy that sometimes is as high as 15 metres tall (Anest, 1991). The swampy forests that are further inland are only seasonally flooded and are characterized by climbing palms (rattan) and a variety of other species that make the forest nearly impenetrable.Although some NTFPs are collected, large tracts have been relatively untouched by commercial ventures. A bigger threat to swamp forests is the intrusion of saltwater into many areas due to the development of navigational canals, primarily to enhance activities of the oil industry.

(v) Riparian Forest

Riparian forests consist of forest types found on narrow strips bordering water bodies. Many of these forests have been spared from agricultural influences due to difficult access and periodic flooding regimes (Beak Consultants *et al.*, 1999). These forests are important to the protection of watersheds, and when they are destroyed, siltation and degradation of the water courses become severe. These forests also have a role to play in the migration and movement of many animal species, forming corridors of connectivity between different forest patches. The riparian forests of the Jos Plateau are also known to contain a unique assemblage of species, including a number of endemic plants and a few endemic birds and mammals. These forests are under intense threat and only small amounts still remain.

(vi) Mangrove Forests

Mangrove forests in Nigeria range along 708km of coastline with an extent of from 16 to 90 km from the shore to inland, encompassing 5,591 km^2 of land (Isebor and Awosika, 1993). Mangroves survive in marine and brackish habitats and are replaced further inland by freshwater swamp forests. Nigerian mangroves are dominated by red mangroves (*Rhizophora sp.*) and also include white mangroves (*Avicennia sp.*) and a few other mangrove species. The mangrove understory includes a thick undergrowth of other salt-tolerant plant species.

Local residents also use mangrove for firewood, for drying their fishing nets; they also collect a number of NTFPs from the understory. As mangroves are cut for firewood or opened

up for navigational canals, villages, and oil company operations, they are gradually being replaced by Nypa palms which do not provide the same extensive ecological services provided by native mangroves.

(vii) Montane Forest

In Nigeria, montane forests are found primarily on the highlands that form the south-eastern borders between Nigeria and Cameroon. Although some of this high altitude area consists of grassland, shrubs and rocky outcrops, there are some patches of montage forests along the eastern, southern and western sections that merge gradually into lowland rainforest at the base. Due in large part to their geographical isolation and unique microclimate, they contain considerable biodiversity and many of the plant and animal species found here are endemic to these areas. Two types of montane forests can be discriminated, the moist forests with a diversity of moss and epiphytic species and uneven canopies, and drier forests higher up, where dwarf and stunted trees occur. The Jos Plateau is another highland area that once contained tracts of montage forests. This area has been highly modified by anthropogenic factors and now only remnant patches exist.

Major threats to Nigeria's forest resources are unsustainable uses and poor management of existing forested land, including lack of enforcement. The derived savannah zone described above is an excellent example of these effects. The primary forest is overexploited and gives way to agricultural land or secondary forest with species that are of lesser economic value and importance for biodiversity conservation. Lack of affordable access is the only reason today why the montage forests in the south-east and the freshwater along the coast and in the Niger Delta still exists. Table 2.1 shows the estimate of forest cover in Southern Nigeria.

Table 2.1: Estimates of Natural Forest Cover in Southern Nigeria

Forest Type	Estimated Area (ha)	% in Forest Reserves
Lowland forest	1,700,147	20.7
Freshwater swamp forest	1,611,360	4.9
Savannah woodland	392,321	2.3
Riparian woodland	84,355	0.1
Mangrove forest	5.314	-
Montage forest	3,847	-
Total	**3,797,344**	**28.0**

Adopted from: Beak Consultants et al., 1999 – USAID, 2002

2.2 Bioresources Groups: Plants, Animals and Microbes

2.2.1 Introduction

Bioresources encompass all living things in the biosphere in addition to those substances formed by living organisms in association with non-living things which exist wherever living things have grown and have been in existence for varying periods of time (Okigbo, 2005).

The biodiversity (uniqueness of plants, animals, microbes and environment) forms the bioresources (biological resources) which are living resources consisting of plants, animals and micro-organisms. Collectively, they have unquestioned importance for human survival, industry, commerce and trade since they produce goods and services (Ola-Adams, 2002).

The bioresources of any nation can be classified into plants, animals, fishery and micro-organisms. Plant bioresources comprise agricultural crops and forestry, while animal bioresources consist of livestock and wildlife resources. Fishery consists of fishes while micro-organisms comprise the smallest entities, the viruses, which can be seen only with an electron microscope, as well as those seen by eye and with the light microscope. The protists include the single-celled bacteria, protozoa, algae, fungi, yeast and some multicellular species of

algae and fungi which are large and conspicuous such as seaweeds and mushrooms.

The conversion of products (raw or semi-processed) of these bioresources provides a variety of goods and services which are inexhaustible. Traditional people, who reside mostly in the rural communities, have survived by applying crude technology to sustain them without any scientific knowledge or background.

Among the plant bioresources, agricultural crops have had the greatest benefits of conversion through the application of technology (scientific innovations), especially chemistry-based technology. This is reflected in Box 2.1.

Box 2.1: Plant Products in Agriculture

1. Food and related products consumed by humans
   Cereals, Roots and tubers, Starchy fruits, Grain legumes (pulses)Miscellaneous seeds, Fruits and vegetables, Nuts, Oils and fats Sugar and Sweeteners, Beverages (Non alcoholic and alcoholic)Species, condiments and flavourings
2. Feed consumed by animals
   Fresh green forage and fodder, Hay, Silage, Concentrates, cereals and oil seed cakes, By-products (bagasse, fruit pulp)
3. Medicines
4. Fumitories (tobacco, India hemp)
5. Masticatories (e.g. kola)
6. Fibres and textiles (cotton, sisal, ramie, piassava)
7. Wood and miscellaneous raw materials for-
   Timber for construction, Paper-making, Rubber, Cork, Household goods (baskets & utensils), Rayon, Plastic, Explosives, Lacquer, Cellophane, Photofilms
8. Fertilizers: Green manure, Covercrops and shrubs, Decomposed crop/plant waste (compost), Mulch
9. Fuels-charcoal Fuelwood, Alcohol, Methane
10. Industrial oils
11. Essential oils

12. Perfumes
13. Dyes and colouring material
14. Gums
15. Resins
16. Tannins
17. Insecticides
18. Fish poisons
19 Aesthetic beauty products:Florist crop flowers and foliage·Landscape crops:nursery plants turf grass, ground covers, deciduous and evergreen shrubs and trees.

Sources: Spedding (1979). *An Introduction to Agricultural Systems.* London: Applied Science Publishers Ltd.

Forestry bioresources, on the other hand, are so vast that scientific technological applications may take decades to complete. However, Keay *et al.* (1964) eased the burden by providing the key to classifying Nigerian trees so that selection or preferences for technology application becomes relatively easy. Some gains have been made, especially in essential oils. Okafor, while illustrating the implication of forestry bioresources and livelihoods on NABDA Policy and Action Plan, examined some case studies, especially "The Role of Conservation and Domestication of Minor Woody Forest Plants for Local Communities in Nigeria." Box 2.2 and Table 2.2 present lists of some of the more widely recognized and potentially useful products from wild and semi-wild species in Tropical West Africa. They indicate plant species and products which are potential research and development materials.

The second case study by (Okafor and Ham, 1999) was sponsored by the Biodiversity Support Programme of WWF, Washington. It showed that the use of medicinal plants is extremely important to the people of south-eastern Nigeria for their medicinal needs. A list of 55 medicinal plants and their uses identified through discussions and interaction with farmers and traditional healers in the study area is presented in Table 2. Verification, processing and packaging of remedies of serious ailments such as diabetes, malaria, high blood

pressure, insomnia, impotence in men, stomach ulcer, prostate problems, rheumatism, diarrhoea, etc., could be researched into by biotechnology outfits.

The third case study was on Indigenous Woody Plants of Nutritional Importance in Traditional Farming System of the Nigerian Humid Tropics (Okafor, 1994). This case study, which was delineated into three periods 1967-1970, 1970-1989, and 1990-1993, has been most useful in providing practical illustrations of R&D strategies and methods on the vexed issues of improvement of food supplies and environmental conservation.

Box 2.2: Commercial Products

A number of food products that could be produced commercially from lesser-known tropical fruits have been documented (Okafor, 1991; Okafor and Ham, 1999). These products include:

(i) *Jams and Jellies:* Suitable species include *lrvingia gabonensis, Chrysophyllum albidum, Dalium guineense, Ficun sycomorus, and Soleroonryn barren,* (Okafor, 1973; Okafor and Okonjo, 1974).

(ii) *Fruit Juice:* The following species are suitable: *Dailium guinecuse, farlnarl curatellifolia, Tamarindus indica, Darkia biglobosa.*

(iii) *Confectioneries:* Breadfruit flour, processed from *Treculia Africana,* can be used to produce a variety of baked foods (Anazonwu-Bello, 1981).

(iv) *Beverages:* Ejiofor *et al.* (1988) have prepared a non-alcoholic beverage from powdered *Treculia africana* seeds that was found to be acceptable when taken without milk and sugar. Various fruits are also suitable for brewing alcoholic drinks, including *Spendias mombin, Selerocarrya barren, Uapaca kirkiana, Diospyros mespilifornis.*

(v) *Composite Seasoning:* Several indigenous seeds can be blended into composite seasoning. Suitable species include: *Afrostyrax lepidophyllus* (country onion),

Monodera brevipes, *M. myriatica*,*Piper guineense* (bush pepper), *Tetrapleura tetraptera* and *Xylopia aethiopica* (Ajayi, 1986).

(vi) *Fats and Oils:* The high fat and oil content of the fuits *of Dacryodes edulis, Elaeis guineensis, Vitellarin paradoxa, Daillonella texisperma, Irvingia gabonensis, and Rioinodendron heudelotii* indicates their suitability for commercial production of cooking oil and margarine, manufacture of soaps and pharmaceutical preparations, etc. (Okafor, and Okonjo, 1974; Udeala, et al. 1980, Omoti and Okiy 1987).

(vii) *Agbono Cubes:* The kernels of *Irvingia gabonensis* known as agbono (ogbono), are widely used in West and Central Africa as a thickening agent in soups. Ejiofor *et al.,* (1988) have confirmed that the kernel residues (after defattening) can be cubed or packaged in any other form and used more conveniently locally or exported to other countries.

(viii) Others have identified industrial potentials of *Irvingia gabonensis, Treculia africana, and Pentaciathra macrophylla* as spice crops.

Source: Okafor, 1994

Table 2.2: Some of the More Widely Recognized, Actually and Potentially Useful Form of Wild and Semi-wild Woody 'Minor' Species in Tropical West Africa

Product	Species
Food cropFood supplements Condiments (used in soups) Fruits	*Treculia Africana. Dacroyodes edulis, Pentaclethra macrophylla. Irvingia gabonensis, Parkia biglobosa, Prosopis Africana, Adasonia digitata, Chrysophyllum albidum, Denneltia tripetala, Dialium guineense, Dioscorephyllum. cumminisii, Irvingia gabonensis,*

	Landolophia owariensis, Maesobotrysa barteri, Monodora myristica, Synsepalum dulcificum, Tamarindus indica.
Fruits and beverages, including alcoholic drinks Edible seeds,Leaves/ vegetables *Garcinia kola,*	*Diallum guineense, Elaeis guineensis, Hibiscus sabdariffa, Raphia hookeri, Tamariandus indica.* *Cola acuminate* (mostly semi-wild), *Adansonia digitata, Afzelia bella,var. bella, Ceiba pentandra, Gnetum africanum,G. buchholziianum, Gongronema lalifolim,Heinsia crinata, Myrianthus arboreus,Pterocarpus mildbraedii, P. santalinoides, P. Soyauxii, Vernonia amygdalina, Vitex doniana.*
Animal fodder	*Acioa barteri, Baphia nitida, Dialium guineense, Elaeis guineensis, Ficus spp., Moringa oleifera, Parkia biglobosa, Treculia Africana.*
Fats and oils	*Dacryodes edulis* (pear oil), *Elaeis guineensis* (palm oil and kernels). *Irvingia gabonensis* (dika butter), *Panda oleosa, Poga oleosa, Plukenelia conophora* (conophor oil), *Vitellaria paradoxa.*
Chewing sticks/ toothbrushes Fibre	*Baphia nitida, Fagara spp., Garcinia kla, G. manni, Homalium spp.* *Adonsonia digitata, Ceiba pentandra, Hildegardia barteri, Raphia spp., Sida spp., Triumfetta spp., urena lobata.*
Pulp for paper-making	*Treculia Africana*

Source: Okafor, 1994.

2.2.2 Indigenous/Lost Plant Bioresources

Roche observed that people in many tropical countries, especially in West Africa, are obviously not suffering from pronounced malnutrition. He attributed this to the significant

but unrecorded amount of protein and carbohydrates which are harvested from the wild, including various forms of wildlife – the so-called indigenous or lost crops and animals. Thus, a sizeable proportion of the populace in West and Central African countries receive significant nourishments from natural forests, especially from indigenous perennial plants (Appendix 2: A).

The contribution of wild fruits, nuts, seeds and vegetables to the African diet and their potentials in overcoming or ameliorating the food problems of inadequate supply and nutrient deficiencies have been indicated by various workers (Okigbo, 1977, 1978; Okafor, 1975b, 1980a,b, 1989), among others. These edible plant products are sources of relatively cheap plant protein, and other essential nutrients such as minerals and vitamins. They are obtainable at strategic periods of the year when cultivated annual staples, that are in any case difficult to store, are available or very scarce. These traditional sources of food are usually used to supplement the annual staples. They thus contribute significantly to the food basket of rural people, especially during famine.

Although some of the exotic (introduced) food crops such as cassava, maize, rice and, potatoes have been widely adapted and naturalized, and have assumed great importance in the Nigerian food basket, there is indeed a need to address the indigenous wild forest products, otherwise known as traditional food sources, for the following reasons:

(i) They are generally neglected, underutilized and their habitats are under severe pressure of simultaneous destruction and modification. iIt is noted that;

(ii) The introduced staples, fruits trees (mango, oranges, paw-paw *(papaya),* coconut, etc); vegetables (lettuce, cabbage, tomatoes, onions, etc. and a host of others, have received and are receiving greater attention in research, development, extension and utilization, often in designed institutes and generally by the Ministry of Agricultural and Rural Development and its agencies.

(iii) Some cultivated indigenous tree crops such as palm tree *(Elaeis guineensis),* kola (*Cola accuminata*) and vegetables

such as *Amaranthus spp., Corchorus spp; Talinum triangulare,* are also receiving reasonable attention.

(iv) The indigenous crops are ecologically well adapted to our environment and sustain the vast majority of Nigerians, especially in rural areas, and during most seasons; they are also sources of substantial income, e.g *Irvingia, gnetum,* etc.

It is obvious therefore that these bioresources are important in the food, medical, industrial, social and cultural requirements of man, but have been neglected or in fact threatened with extinction. These include algae, fungi, roots, vegetables, tubers, fruit trees, culinary plants and plants of pharmaceutical value and others. Many of these bioresources exist in Nigeria and have been used for centuries but are now little appreciated (Table 2.3).

These lost resources have been so classified for various reasons, including:

(i) Deforestation, including forest clearance for cultivation, urban and infrastructural development, over-grazing and bush burning;

(ii) Over-exploitation of the resources because of their high economic or commercial value. Rate of exploitation exceeds rate of natural regeneration;

(iii) Endemism – restricted in their habitat or ecological range. Destruction of such areas endanger the survival of such species;

(iv) Genetic erosion – which is the loss of genetic diversity, including loss of individual genes and the loss of combination of genes. The main cause of genetic erosion is the replacement of local varieties or landraces by improved and/ or exotic varieties and species such as the gradual replacement of African rice (*Oryza glabberima)* by the Asian rice (*Oryza sativa)* and *Trichosantis sp.* (snake tomato) by *Lycopersicon esculentum* (Table 2.3 on page 77).

Table 2.3: Priority list of Under-Utilized and/or Fast Disappearing Economic Woody Food Plants Needing Immediate Attention

Forest Zone	Savannah Zone	Other Crops (cultivated)
1. *Beilschemedia mannii*	1. *Adansonia digitata*	1. *Digitata exilis*
2. *Bligia sepia*	2. *Afzelia Africana*	2. *Grain amaranths*
3. *Chrysophyllum albidum*	3. *Annona senegalensis*	3. *Diascorea spp*
4. *Cola acuminate*	4. *Balanites aegypticaca*	4. *Celosia spp*
5. *C. lepidota*	5. *Borassus aethiopum*	5. *Citrullus lanatus*
6. *C. pachycarpa*	6. *Ceiba pentadra*	6. *Vigna subterranean*
7. *Cacryodes edulis*	7. *Detarium microcarpum*	
8. *Dennettia tripetala*	8. *Ficus capensis (F.sur)*	
9. *Dialium guineense*	9. *Grewiwa mollis*	
10. *Dioscoreophyllum cumminsii*	10. *Irvingia smithii*	
11. *Eleis guineensis*	11. *Moringa oleifera*	
12. *Garcinia kola*	12. *Parkia biglobosa*	
13. *Gnetum spp*	13. *Phoenix reclinata*	
14. *Gongronema latifolium*	14. *Prosois africanata*	
15. *Irvingia gabonensis*	15. *Raphia sudanica*	
16. *Monodora myristica*	16. *Pterocarpus santalionides*	
17. *Myrianthus arboreus*	17. *Syzygium guineense*	
18. *Ocimum gratissimum*	18. *Tamarindus indica*	
19. *Pentaclethra macrophylla*	19. *Vitellaria paradoxa*	
20. *Piper guineense*		
21. *Pterocarpus spp*		
22. *Raphia hookeri*		
23. *Spondias mombin*		
24. *Synsepalum dulciticum*		

25.*Tetracarpidium conophorum* 26.*Thaumatoccuus daniellii* 27.*Treculia Agricana* 28.*Vernonia amygdalina* 29.*Xylopia spp*		

Source: Adapted from Gbile *et al.*, 1978; NNBSAP, 2006

2.2.3 Animal Bioresources

2.2.3.1. Mammals and Birds

Nigeria has a very rich and diverse mammalian fauna. The 1992 report by FEPA indicated that 247 mammalian species are known to occur in Nigeria. Since no thorough survey has been undertaken, it is likely that more species may be found, especially in the montane and forested regions. There are also about 900 species of birds in the country. According to the Federal Ministry of Environment, the population levels of these birds and mammals are very low and many of these (species) are found only in protected areas, where they are still threatened due to lack of adequate protection.

Some larger species such as giraffes, various antelopes, ostriches, vultures, etc., which may be common in other African countries, are fast disappearing in Nigeria due to a combination of habitat destruction and severe hunting pressures. The most endangered sub-species of gorilla on earth- the Cross River gorilla (*Gorilla gorilla diehli*), is found in a restricted part of a National Park and holds on with 250 or les animals remaining in the population which is broken into two separate isolated groups. Most of Nigeria's birds and mammals, however, are also found in other countries in Africa with similar habitats; but a few species, known as endemic species, only occur in Nigeria.

Some important endemics include three monkey species: the white-throated monkey (*Cercopithecus erythrogaster),* Sclater's guenon (*Cercopithecus sclateri*) and the Niger Delta red colobus (*Plecolobus pennantii epieni);* and three birds: the Anambra waxbill (*Elstrilda poplipara),* the Ibadan malimbe (*Malimbus ibadenensis)*

and the Jos indigo-bird (*Vidua maryae).* In addition, some birds and mammals are near endemics and found in some habitats shared with the neighbouring countries. The Gulf of Guinea forests of south-eastern Nigeria, Western Cameroon and Bioko Island of Equatorial Guinea are one such area with an exceptional number of near endemic primate species.

2.2.3.2 Reptiles, Amphibians and Fishes

Nigeria has a high diversity of reptiles, amphibians and fish, but these are not nearly as well known or studied as the birds and mammals. There are about 135 reptile species, 109 amphibian species and 648 fish species reported in the 1992 country studies as existing in Nigeria. Reptiles are the most studied and those that are hunted for food, like turtles and tortoises, are known to be rapidly disappearing in Nigeria. Over 230 fish species are said to be found in inland waters and many more found in coastal and marine habitats. The best known fish species are those with commercial value, but many others that are less obvious, smaller and found in restricted and specialized habitats, have not been recorded. There is also no good record regarding the level of endemism of reptiles, amphibians and fish in Nigeria. A snake species, (*Nahelya egbensis*) and five amphibians are reported as endemic to Nigeria.

2.2.3.3 Invertebrate Species

In 1992, FEPA's Country Study indicated that values for invertebrate species, excluding insects, are made up of data for molluscs and bivalves (77), annelids (10), echinoderms (5) and zooplankton (134). About 301 species of insects out of a total of about 20,000 are found in the aquatic ecosystems. There has been no systematic study of this class of organisms, though a few economically important invertebrates, such as various prawns and molluscs have been so studied. Various insects, including ants and butterflies, have been studied in certain habitats, and it is estimated that there are around 1,000 species of butterflies in the Cross River National Park alone.

The exact number of species of all classes of animals in Nigeria has been difficult to determine due to inconsistency in nomenclature and inadequate investigation.

2.2.4 Microlivestock

Nigeria is richly endowed with a high population of different microlivestock species (under-utilized animals) which, if carefully studied and intelligently harnessed, could bridge the yawning gap between the demand and supply of animal products within a short period. According to the National Research Council, "microlivestock" is a term coined for species that are inherently small and are seldom considered in the broad picture of livestock development. In most cases, many of these "microlivestock" are undomesticated such as the grasscutter (*Thryonomys swinderlanus*), the giant rat (*Cricetomys gambianus*), the snail (*Achatina marginata*), the hare *Lepus europus/capensis*), and the quail (*Coturnix coturnix)* or semi-domesticated species like the guinea fowl (*Numida meleagris*), rabbit (*Oryctolagus cuniculus*) and guinea pig (*Cavia porcellus*).

A review of livestock improvement efforts by the Nigerian government in the 20th century shows that although a number of breeding and multiplication programmes had been tried, none had passed the back-cross stage. The few visible improvements in live weight or growth rate and productivity of the offspring were largely due to heterosis arising from the enormous genetic distance between the exotic and indigenous parents. Back-crossing in any direction was not viable because in the direction of the exotic parent, the offspring succumbed to poor environment and disease while in the direction of the native parent, the preponderance of survivor genes limited productivity. In these "breeding" programmes, homozygosity was either assumed or ignored, and so in effect, the efforts were only a shade superior to the indiscriminate matings in the wild. Examples of some of the programmes include:

(i) Importation of live animals for multiplication and breeding,
- Friesians,
- Borans,
- Short horn, Brown swizz,
- White Leghorn,
- Landrace, Large white,
- Black pigs – all stations and university farms.

(ii) Hatcheries – government and private,
- importation of parent stock,
- production of F1 commercial stock.

(iii) Ranches - government and private ranches

(iv) Poultry Foundation Stock – NAPRI mandate

(v) Upgrading of Friesian and White Fulani, Large White.
- Landrace or Large Black and Native pig,
- Nubian goats and WAD goats,
- Boran Cattle and Ndama,
- R.I.R. (Rhode Island Red) and Native Chicken,
- Starcross and Native Chicken.

(vi) Poultry Multiplication Centres.

It is evident that these programmes involved mostly cross-breeding at flock level with little or no selection. Equally, the animal bioresources status in Nigeria is indeed very complex and in fact difficult to articulate due to insufficient studies and lack of data.

2.3 Plant Genetic Resources

Plant Genetic Resources for Food and Agriculture (PGRFA) consist of the diversity of genetic material contained in traditional varieties and modern cultivars grown by farmers as well as crop wild relatives and other wild plant species that can be used for food, feed for domestic animals, fibre, clothing, shelter, wood, timber, energy, etc. These plants, seeds, or cultivars are maintained for the purposes of studying, managing, or using the genetic information they possess. As a term, "genetic resources" carries with it an implication that the material has or is seen as having economic or utilitarian value.

Modern crop and animal improvement practices depend on genetic stock from natural ecological systems. Breeders and farmers depend on genetic stock from natural ecological systems. They rely on the genetic diversity of crops and livestock to increase yields and to respond to changes in environmental conditions. For example, genetic material for the improvement of the world's major food crops, such as corn, wheat and soybeans, are sourced from the wild.

However, despite the importance of biodiversity to the survival of present and future generations of Nigerians, the country is experiencing a high rate of biodiversity loss. Among the issues that pose a collective threat to biodiversity protection in Nigeria are:

(i) Exponential increase in population accompanied by intensifying industrial activities for economic development;

(ii) Dependency of the rural population (which accounts for 70% of the total population) on biodiversity resources;

(iii) Lack of clear consistent national policy;

(iv) Poor co-ordination among relevant institutions;

(v) Failure to establish a mechanism for sustainable funding;

(vi) lack of government commitment to adequate funding of institutions, programmes and activities that conserve biodiversity.

Hence, in order to guarantee the conservation of Nigeria's biological diversity, and in line with the recommendations of the Convention on Biodiversity, the Federal Ministry of Environment initiated the Strategy and Action Planning Process.

2.3.1 Nigeria and the Convention on Biological Diversity

Nigeria was among the 153 countries that signed the Convention on Biological Diversity (CBD) at the United Nations Earth Summit in June 1992. The Convention is probably the most all-encompassing international agreement on biodiversity ever adopted. It has five main aims:

- Conserving biodiversity at all levels, including genetic, population, species, habitat, and ecosystem;
- Sustainable development of biodiversity, to ensure that this diversity continues to maintain the life support systems of the biosphere;
- Fair and equitable sharing of benefits from biodiversity to recognize that social and economic goals for the use of biological resources and benefits derived from genetic

resources are central to the process of sustainable development, and that these in turn will support conservation;

- Sharing of relevant technology for sustainable development; and
- Establishment of global financial mechanism for the conservation of biodiversity.

The conservation and sustainable utilization of plant genetic resources is key to improving agricultural productivity and sustainability, thereby contributing to national development, food security and poverty alleviation. Today, the world is not food-secure in terms of access to food. Eight hundred million people are undernourished and 200 million children under five years of age are underweight.

The 1991 Census put Nigeria's population at 88.5 million. At present, it is put at approximately 140 million, growing at a rather fast rate of approximately 3.2% per annum. This poses a significant challenge to the agricultural potential of the country, especially as agricultural resources are poorly managed and are being rapidly depleted.

National self sufficiency will be impossible to achieve if we do not protect and conserve the remaining valuable genetic resources for posterity, as plant genetic resources form the basis of dynamic, diverse and adaptable agriculture, and are fundamental to national food security. With this, it is clear that conserving and sustainably using our plant genetic resources must be part of our developmental strategy.

The genetic resources saved from extinction today may provide the solutions for tomorrow's critical food or vegetational rehabilitation needs or the unexpected pests or other calamities among other problems that include economic and environmental hazards. Also, as many indigenous and edible wild plants that were previously in high demand are now almost forgotten and have been replaced by species only recently introduced, conservation of these endangered indigenous species is of paramount importance to save these plants from total extinction.

It should be known that if our future is not going to be put in socio-economic jeopardy, ways must be found to control the

changes taking place and to ensure their reversibility. Indeed, we need to maintain, for future use, collections of representative samples not only of local varieties which are now in the process of being lost or replaced but also of endangered wild species. These samples can be kept either ex-situ or in-situ.

In the light of the aforestated, it is clear that germ-plasm conservation is an inevitable tool with inestimable value and one process that will ensure any country's future. Efforts should be geared towards the process of ensuring our future strategically through the enhancement of the process of genetic resources identification, collection, conservation, documentation and controlled utilization for research and development.

In the present economic situations, budgetary approach has proved not sufficiently effective in the conservation of Nigeria's vast plant genetic resources. The need to apply a project system will be more effective.

The main objectives of conservation are:

- To maintain ecological process and life support systems;
- To preserve genetic diversity; and
- To ensure the sustainable utilization of species and ecosystems.

Genetic Resources Conservation Focal Points:

1. Ministry of Environment,
2. Ministry of Agriculture, and
3. Ministry of Science and Technology.

Ministry of Environment:

- National Parks, Botanic Gardens, Game Reserves,
- Forest Reserves.

Agriculture

- Commodity Research Institutes,
- Universities of Agriculture.

Science and Technology:

- National Centre for Genetic Resources and Biotechnology.

2.3.2 Conservation Activities

(i) In Situ Conservation

Nigeria has 12 Strict Natural Reserves (SNRs), the establishment and maintenance of which are backed by government legislation. Other forms of *in situ* conservation, e.g. botanical garden, arboreta, etc., are maintained by universities and other tertiary institutions in the country. According to government regulation, there is total ban on exploitation of these in the *in situ* conserved areas. But because of problems involved in the implementation of the government legislation, illegal exploitation and felling of forest trees are carried out in the reserved areas. While efforts are needed to ensure the protection and enforcement, it is desirable that other strict forest reserves are created.

(ii) Ex-Situ Collections

Although a large number of institutions in Nigeria maintain some forms of plant germ plasm, it soon became clear that the system being operated had series of inadequacies, some of which are:

- Only a few of the research institutes had definite projects concerned specifically with the collection and maintenance of germplasm.
- The research institutes and a few universities-based collectors tend to collect and maintain only those crop plants in which they had research interest; the genetic coverage was therefore usually narrow.
- Explorations for collection were conducted in isolation by the various interest groups without co-ordination, giving rise to wasteful duplication of efforts.
- The originators of the genetic resource materials were invariably plant breeders working in problem-solving, result-oriented research establishments and who therefore had the tendency to regard germ plasm as mere tools and not as resources to be salvaged from extinction. There was therefore the practice to select the "useful", materials and neglect the 'useless' ones, thus exposing the latter to the danger of genetic erosion.

It was with these inadequacies in the background, coupled with the need to provide centralized facilities for conservation and use of germ plasm, that the Federal Government in mid-1986 set up the National Centre for Genetic Resources and Biotechnology. According to authorization memorandum, the Centre is, *inter alia,* expected to undertake the following functions:

- Exploration, collection, identification, evaluation, storage, conservation, exchange and dissemination of genetic materials of plants, animals and microbes;
- Scientific and biotechnological research;
- Fostering relationship with other national satellite genetic research centres located in research institutes, universities and polytechnics as well as relevant organizations, on programmes concerning genetic resources and biotechnology;
- Collect, characterize, evaluate and maintain plant germ plasm and foster its utilization;
- Organize and co-ordinate local germplasm explorations.
- Serve as the national authority for the validation, registration and release of new crop varieties, livestock breeds, fisheries, and maintain a national register of all in the country;
- Promote training opportunities to personnel connected with germ plasm collection, maintenance and multiplication as well as others in the area of vegetation conservation;
- Operate as the central organ of the country for liaison with international organizations such as the International Plant Genetic Resources Institute (IPGRI), Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), International Centre for Research and Agroforestry (ICRAF), International Institute for Tropical Agriculture (IITA), concerning Plant Genetic Resource;
- Advise government on matters concerning plant resources and vegetation conservation.

NACGRAB, since its inception, has a total collection of approximately 12,500 accessions consisting of both indigenous and exotic germ plasm mainly of food crops, vegetables, tubers, fodder, industrial, medicinal and forest plants.

(iii) Physical Facilities/Equipment

- Physical facilities available for Plant Genetic Resources Conservation and Utilization include seed preparation and processing laboratory, viability testing and drying rooms.
  Equipment physically installed and are in use include:
  - Seed cleaners,
  - Separators,
  - Dehumidifiers,
  - Incubators,
  - Digital moisture content machine, among others.
- There is a short-term/active collection storage room being maintained at 18°C and 30% RH;
- Long-term/base collection prefabricated room being maintained at –20°C and 100% RH.

(iv) Seed Genebank

A total of 7,000 accessions of 216 crop species, i.e. economic and food crops, are being kept in the seed banks (short and long term).

(v) Field Genebank

The field Genebank covers an area of approximately 12 hectares of farmland; hosting about 4,000 living collections.

- Herbarium Unit: The unit was established in July 2004. Over 1,000 plant species have been collected and documented.
- Tissue Culture (Biotechnology): Protocols have been developed for micro propagation of economic crops and some endangered species. Over 10,000 plantlets of various crops are being maintained in the growth room.
- Cryo Preservation: In order to meet the challenges of emerging technology, equipment is being acquired for

pollen and animal semen culture preservation at low temperature of about -196^0C, i.e. Liquid Nitrogen.

- Animal/Livestock Resources: Snailry and chicken breeding units are in place.

2.3.3 Plant Genetic Resources Resolutions and Recommendations: Fallout of the National Consensus Meeting in 1995

Emphasis was placed on the need to fund and manage NACGRAB properly. Being the focal point for Plant Genetic Resources Conservation activities, the Centre was recognized as a strategically important entity that requires full government support. Adequate support is needed to enable NACGRAB take its rightful position in research and development in Nigeria. The following areas were recognized under the conservation activities of NACGRAB:

- *Conservation*

  The group recognized the importance of an integrated approach to conservation of plant genetic resources, which should make use of the following *ex-situ* conservation methodologies: field genebanks, seed genebanks, including forest reserves, fetish groves, nature reserves, on-farm conservation and home gardens.

- NACGRAB should play a co-ordinating role in germplasm exploration, collection and conservation. National institutions should by regulation inform NACGRAB of intended collection missions (activity plans) and should collect in duplicate. One set should be kept by NACGRAB as a base collection and the other set as an active collection for research.

- NACGRAB should play a co-ordinating role in *in-situ* and *ex-situ* conservation of forest genetic resources. In this wise, the establishment of the National Botanic Garden and Herbarium in Abuja and elsewhere will be most useful for conservation and educational proposes. The latter should be a major national policy in order to sensitize the Nigerian youths as they visit the gardens and arboreta.

- Inventories of plant species, flora and habitats should be carried out by FRIN and NACGRAB in collaboration with other organizations and relevant institutions, particularly NGOs where these are appropriate.
- Demarcation of collection sites should be based on agro-ecological zones, and sites for germ plasms collection should include fetish groves, home gardens and ecological buffer zones.
- An action plan for integrated conservation of germ plasms should be developed and this should include *in-situ*, *ex-situ* and on-farm conservation methodologies. The use of biotechnology applications such as *in-vitro* conservation should be an integral part of the conservation strategy.
- Collection and documentation of indigenous knowledge should be considered as important components of conservation. Information on plant uses, distribution, threat status, phenology, including taxonomy, should be considered for documentation. Here again, relevant NGOs such as NCF should be involved in this activity. This should be integrated into the national conservation strategy.
- All conservation activities should be well co-ordinated at the national level with sufficient public education. Creation of adequate awareness on conservation of plant genetic resources, particularly at the community level, should be ensured. To facilitate this, proper experimental or activity protocols should be developed and such documentation made readily available.
- The participation of women in the conservation of plant genetic resources should be encouraged and supported at the community level. The involvement of women groups should be encouraged.
- The public and private sectors should also be encouraged to give adequate support, including funding, to plant genetic resources collection and utilization activities in Nigeria.
- NACGRAB should put in place zonal offices or outlets in six agro-ecologies for the enhancement of its activities.

2.3.4 National Biodiversity Strategic and Action Plan

The goal of the Strategic and Action Plan, developed and published by the Federal Ministry of Environment, is:

> To develop appropriate framework and programme instruments for the conservation of Nigeria's biological diversity and enhance its sustainable use by integrating biodiversity considerations into national planning, policy and decision-making processes. This will be achieved through:
>
> - Biodiversity conservation;
> - Sustainable use of biological resources;
> - Conservation of agro-biodiversity;
> - Biosafety guidelines; and
> - Biodiversity – industry interface.

2.3.5 Sustainable Utilization of Biological Resources

This National Biodiversity Strategy and Action Plan (NBSAP), initiated the formation of a private sector-driven Bioresources Industry Organization of Nigeria (BION), to engage the private sector and civil society in monitoring the use of biodiversity for the production of consumer goods. The objectives of BION include:

- Assisting Nigeria bio-based industries;
- Promoting public awareness of the benefits of bioresources;
- Promoting the sustainable use of bioresources through the establishment of bio-based enterprises in Nigeria;
- Encouraging the development of policies, regulations and laws that would promote the safe and sustainable utilization of biological resources; and
- Establishment of co-operative networks and relationships with similar organizations in Africa, Europe, America, Asia, etc.

2.3.6 The Global Plan of Action

The Global Plan of Action (GPA) for the conservation and sustainable utilization of Plant Genetic Resources for Food and Agriculture is a set of recommendations and activities which grows logically out of the State of the World Report. The FAO

International Technical Conference on Plant Genetic Resources held in Leipzig, Germany, formally adopted the Plan on 23 June, 1996 and, with it, a Leipzig Declaration that affirmed government-level commitment to implementing the Plan in the context of national efforts to strengthen world food security. Nigeria is a signatory to the plan.

The Global Plan of Action is intended as a framework, guide and catalyst for action at community, national, regional and international levels. It seeks to create an efficient system for the conservation and sustainable use of plant genetic resources, through better co-operation, co-ordination and planning, and through the strengthening of capacities. It is an essential contribution to successful implementation of the Convention on Biological Diversity.

The main objectives of GPA are to:

- Ensure the conservation of plant genetic resources for food and agriculture as the basis of food security;
- Promote sustainable use of plant genetic resources to foster development and reduce hunger and poverty;
- Promote the fair and equitable sharing of the benefits arising from the use of plant genetic resources;
- Assist countries and institutions to identify priorities for action;
- Strengthen existing programmes and enhance institutional capacity.

2.4 Policy Framework for Meeting the Overall Challenge of Nigerian Biodiversity

The conceptual framework adopted for the NBSAP include:

- Integration of environmental processes (climate, vegetation, soils, water) and societal processes (economic, political, social/cultural) in biodiversity conservation;
- Interaction between these processes through *time*, recognizing that different processes have different fundamental temporal characteristics and linking these processes through adaptive management;

- Interaction at and between different *scales* from the household to the global scene in determining the socio-economic aspects of sustainable use of genetic materials;
- That the pattern of interaction is determined by the structure and application of authority within a Federal political structure, in which biodiversity conservation is recognized as a major aspect of resource management but decision concerning what and how biodiversity is to be conserved involves many - between conservation and other management goals.

Therefore, to meet the overall goal of Biodiversity Protection in Nigeria, and in consonance with Articles 1,3,5,6,18,20 and 21 of the Convention, the following specific goals, relating to conservation, sustainable use and access and benefit sharing and some cross-sectoral issues, should be pursued:

Goal 1 - Conservation

Aim: To conserve biodiversity for the present and future generations.

Strategic Directions:

- Promote and enhance measures for both *in-situ* and *ex-situ* conservation through identification, evaluation, monitoring, research, education, public awareness and training.
- Increase understanding of the status, genetic diversity and ecological relationships of species and populations.
- Expand and strengthen the network of protected areas to include all the major ecosystems/savannahs, high forests, wetlands, mangroves and montanes.
- Restore and establish grazing reserves and stock routes for nomadic pastoralists.
- Protect watersheds along all interstate watercourses to protect the water bodies and aquatic biodiversity.
- Establish migratory corridors, where practicable, for isolated species and populations.

- Identify genetic resources at the species level based on their present or potential socio-economic value and their conservation status.
- Assess the conservation status of target species and their population.
- Identify specific conservation requirements or priorities at the population level for single species and at the ecosystem level for groups of species.
- Encourage the development of *ex-situ* facilities, including rescue and breeding centres, to protect threatened species.
- Develop and implement restoration/rehabilitation plans in degraded ecosystems.
- Conserve biological resources that are essential to agriculture, industry, domesticated animals, plants and microbes and their wild relatives.
- Develop and promote programmes that encourage beneficial co-existence of biodiversity in agricultural farms.
- Establish reserves to conserve freshwater, brackish water and marine biodiversity.
- Establish and maintain forest seed and cloned genebanks to conserve the genetic diversity of tree species.
- Implement measures to eliminate or reduce air pollution that adversely affect biodiversity.
- Monitor the effects of climate change on ecosystems, species and genetic diversity.

Goal 2 – Sustainable Use and Access and Benefit Sharing

Aim: To promote sustainable use of biological resources and ensure fair and equitable sharing of benefits for poverty reduction.

Strategic Directions:

- Promote farming systems that are compatible with biodiversity conservation.
- Integrate community management of biodiversity as a means of poverty reduction and within the context of national planning.

- Protect and promote policy guidance for bioprospecting and indigenous knowledge (intellectual property right).
- Adopt integrated management approach for the control and utilization of invasive species, particularly water hyacinth, Nypa palm and cattail (*Typha sp.*)
- Establish norms for the use of biodiversity for eco-tourism.
- Improve methods and technologies that support the sustainable use of biological resources and eliminate or minimize adverse impacts on biodiversity resulting from resource use.
- Reduce the adverse impacts of forest management practices on watersheds, soils, other ecosystems and species.
- Take all necessary steps to prevent the introduction of harmful alien and living modified organisms and eliminate or reduce their adverse effects to acceptable levels.
- Determine and mitigate human impacts on biodiversity.
- Identify mechanisms to use traditional knowledge innovations and practices, and encourage equitable sharing of benefits arising from the initialization of such knowledge, innovation and practices.

Goal 3 – Cross-Sectoral Issues

Aim: To enhance biodiversity management capability through education and awareness, appropriate formulation of policy and legislation, research and international co-operation.

Strategic Directions:

- Review with the objective of eliminating government policies and programmes that create unintentional adverse impacts on biodiversity.
- Strengthen measures to reduce and eliminate the release of substances that are harmful to ecosystems, species and genetic resources.
- Develop indicators to monitor trends and support the management of wild populations, species, habitats and ecosystems.

- Increase the nation's biodiversity management capacity (human, infrastructural, institutional and technological) and strengthen national centres for the exchange of data and information relevant to the conservation of biodiversity.
- Prepare and implement legislations and policies, inventories, plants, guidelines, monitoring programmes and other measures to support the establishment and management of protected areas.

2.5 Attempts at Sustainable Management of Nigeria's Bioresources

2.5.1. Agriculture and Food Industry

The food industry constitutes the largest industrial sector worldwide for the obvious reason that life is sustained by food. Over the years, as societies increased in population and socio-economic development, the demand for more pre-processing and processing of food products for home use, storage and trade naturally increased. In addition, the demand for uniform quality of food on a year-round basis and high quality standards even at consumption centres remote from source of production has led to improved processing methods. Increasing affluence has also led to a demand for greater food variety.

Types of Food Processing

(i) *Refining:* This is a series of processes that convert sugarcane (or beets) to the common food product called sugar. Raw sugar is subjected to centrifugation, clarification, decoloration and crystallization to produce white crystalline sugar. It is note-worthy, however, that although Nigeria has the potential resources to be a world leader in sugar production, it is sadly, still a major importer of the product.

(ii) *Milling:* This is the process of converting grains into flour by mechanical means. In some cases the flour may be bleached by the application of chemical bleaching agents as in the case, of wheat flour. Maize, guinea corn and soybean flours can be produced by this process.

(iii) Canning: Many types of fresh foods such as fruits, vegetables, meats, fish and soup are preserved for long-term storage by heat treatment and sealing into air-tight containers with or without chemical preservatives. The containers may be metal, usually tinned or untinned steel, aluminium or special-strength glass. Nigeria has very few food industries that can foods, despite the availability of abundant raw materials for canning fruits, vegetables and meat.This leads to huge loss of revenue as these highly seasonal and perishable food crops are allowed to decay and rot annually due to lack of preservative and storage facilities.

*(iv) Concentration:*This is a method whereby foodstuffs that naturally contain high percentage of water may be partially dehydrated. For example, milk is often evaporated from a solid content of 86% to 45% to obtain evaporated milk powder. Orange juice and other fruit juices are also concentrated before marketing. The usual practice is to reduce the volume to about one-third of the original volume. Chemical preservatives may or may not be added before packaging. These processes are generally used for food concentration, namely, evaporation with evaporators; reverse osmosis, and freeze concentration.

(v) Pasteurization: This is a universally applied method of milk preservation. The most common method of pasteurization is the high-temperature-short-time (HTST) method which exposes the milk to 73°C for not less than 16 seconds, followed by rapid cooling. The main purpose of this method is to kill pathogenic (disease-causing), thus eliminating food-borne diseases and inactivate enzymes to improve storage and maintain quality.

(vi) Fermentation: The modern definition of industrial fermentation is any microbial process controlled by humans that produces useful products. Human beings have utilized the action of various micro-organisms for thousands of years in wine-making, bread-baking, cheese-making, etc., even though most of that time the actual agents doing the work were unknown. Micro-organisms, which include bacteria,

yeasts, and moulds, feed upon organic materials. Thus, if they are supplied with the necessary energy foods and other needed nutrients, these microvegetative organisms will not only grow and multiply but will change the food into other chemical substances. These include alcoholic beverages, such as wine, beer, vitamins, enzymes, organic acids, and pharmaceuticals. Fermentation under controlled conditions involves chemical conversions such as oxidation, reduction, hydrolysis and esterification processes. These processes take place industrially in bioreactor systems often designed by chemical or biochemical engineers. There are two main forms of fermentation processes, namely: solid state and submerged fermentation, and mode of production may be batch or continuous. The abundant fermentable agricultural products in the country have been largely neglected or under-utilized. More serious research efforts should be made to tap these bioresources for their fermentation products through the establishment of cottage, small and medium-scale chemical industries.

2.5.1.1. Oils, Fats and Waxes

Fats and oils are found widely distributed in nature in both the plant and animal kingdoms. Waxes are also natural products but differ slightly from fats and oils in basic chemical composition. Whereas fats and oils are mixtures of the glycerides of various fatty acids, waxes are mixed esters of higher polyhydric alcohols, other than glycerol and fatty acids. Fats and oils are consumed mainly by the food, soap and paint industries.

The two general methods employed in obtaining vegetable fats and oils are expression and solvent extraction or a combination of the two. The refining process of vegetable oils involves de-gumming or steam refining, adsorptive bleaching, hydrogenation and decolorization.

Since the methods of oil extraction and refining are well established, the challenge facing the country's scientists is to exhaustively screen more of the nation's oil seeds for more useful applications in addition to the well known traditional

uses. There is need to discover more oils or fats with medicinal, insecticidal and biocidal properties such as in the case of Neem seed oil and sheabutter fat.

2.5.1.2 Agrochemicals

These are chemicals utilized in agriculture to improve the production of crops both in quality and quantity, to control plant and animal life harmful or disadvantageous to humans, animals and crops, and, to a lesser degree, to serve as food supplements or additives. These chemicals include pesticides (e.g. herbicides, insecticides, fungicides, biocides, etc.) and fertilizers. Although most of the pesticides in use are of the synthetic organic or inorganic origin, a few are plant derivatives.

The vast plant bioresources in the country are yet to be tapped for pesticides in agricultural practice. These plant derivatives, which are natural organic compounds, owe their toxicity to the alkaloids, limonoids and glycosides they contain. Examples include pyrethrins derived from the pyrethrum plant, crysanthemum, nicotine; a volatile alkaloid obtained by treating tobacco waste with aqueous alkali followed by steam distillation, and rotenone, a toxic agent derived from the roots of the plant, Dernis, a steroid derived from neem seed oil from *Azadirachta indica* (neem). Plant biocides and bioinsecticides production is a neglected area of development in the country that is worth exploiting.

2.5.2 Health and Medicine

Plants are not the only sources of natural products. Bugs, snakes, toads, spiders, leeches, molluscs, apes, fungi and bacteria are also important sources of biologically useful natural products. Of the 12,000 antibiotics known in 1995, soil bacteria of the genus *Streptomyces* produced 55%, and 22% were from fungi (Berdy, 1995; Stroll, 1997). Five of the top 50 drugs in the market today are derived from fungi. At the present time, it is not known if there is any active research group in Nigerian universities or research institutes that is committed to finding natural products from microbes for medicinal or crop protection

purposes. Many of these organisms synthesize natural products of pharmaceutical interest through fermentation (Table 2.5).

The first major scientific investigation targeting the control of human diseases with natural products in Nigeria started in the 1970s with efforts to control schistosomiasis and sickle cell anaemia. Sickle cell anaemia is an inherited blood disease that is common amongst the inhabitants of West Africa. The inheritance, clinical diagnosis and molecular basis of this disease are well understood at a fundamental level, and yet the disease suffers a setback because it has no cure. It is about the simplest human genetic disease known (Fatope, 2001). Phytochemists isolated a compound from Fagara species credited with the ability to prevent or reverse the sickling of hemoglobin S in test tubes. A derivative of this compound was synthesized using the natural products as a template. The synthesized product was found to be more potent than the one from nature. Fatope and Abraham (1987) fiddled with exact arrangement of atoms in the natural and synthetic compounds with a view to increasing their bioactivity. The efforts yielded results that defined the scope of activities expected from this class of compounds as far as the control of the symptoms of sickle cell disease is concerned. Today, the Pharmaceutical Research Institute at Abuja and a Nigerian pharmaceutical company, Niemeth, Plc, have developed bio-based drugs that are used to manage the crisis phase of a sickling patient.

Calabar bean is the seed of an African vine; a climbing plant that grows along rivers in certain areas of Nigeria. The seeds were used as an ordeal poison. The poison was administered as water extract of Calabar beans to suspected criminals. Only the innocents were expected to survive. Death was considered a proof of guilt. We know today that Calabar beans contain natural products that can kill. If an individual quickly vomits after drinking the water extract of Calabar beans, he or she will survive. If vomiting is delayed, the individual will die of respiratory arrest. Unless a connection is made between ability to vomit and innocence, our forefathers in this respect were dead wrong! The major chemical in Calabar beans that kills fast is physostigamine (Fatope, 2001). It was first isolated in 1864, its structure

determined in 1925, and Percy, L. Julian (1899-1975), an African-American, synthesized it in 1935. Physostigamine is readily supplied today by synthesis and it is used for treating glaucoma. Glaucoma is responsible for blindness, and about 7 million people suffer from this disease. Derivatives of physostigamine are still under study for potential uses in treating Alzheimer's disease.

In Kano, "Tinya" is a dreaded plant. The natives once exploited Tinya toxin for homicidal murder and protection of millets from damages by birds. This plant has been investigated and daphnane diterpene esters responsible for skin irritation by Tinya, and other compounds that contribute to Tinya toxin were isolated (Fatope *et al.*, 1996). Cytotoxic compounds were also selectively obtained, with potencies approaching 10,000 times that of Adriamycin when tested against human kidney carcinoma. This implies that some components of Tinya toxin may be selectively used against kidney cancer. Unfortunately, no one in Nigeria today, is interested in exploiting these findings further. A foreign pharmaceutical company showed interest but was only keen on buying off the products.

2.5.3 Industry

Chemical processes in industrial applications have helped produce innumerable and valuable consumer products, a few of which are highlighted below:

(a) Enzymes

Enzymes and microorganisms are utilized industrially to effect chemical modification of materials or to direct the outcome of synthetic reactions (as in enzyme applications in organic synthesis, microbial transformations, etc.) They are biocatalysts that have found widespread industrial applications worldwide. The chemical industries that utilize industrial enzymes include: Alcohol, baking, brewing, dairy, detergents, effluents, by-products and biogas, flavouring and colouring, fruit juice, leather, paper, plant tissues, proteins, starch, textiles, wine, edible oils, immobilized enzymes, membrane cleaning, mineral oils and drilling muds, antibiotics, yeast extract and analytical applications.

(b) Perfumes

A perfume may be defined as any mixture of pleasantly odorous substances incorporated in a suitable vehicle or carrier (Austin, 1984). Formerly, almost all the products used in perfumery were of natural origin. In recent years, however, synthetic perfumes or blends have been introduced into the world market.

Perfumes or fragrances make a major contribution to the cosmetic industry, second only to the amount used in soaps and detergents. Perfumes are used industrially in masking, neutralizing and altering the odour of various products as well as in creating a distinctive aroma for normally odourless objects. Essential oils, however, constitute one group of odorous substances used in perfumery. They may be defined as volatile odoriferous oils of vegetable origin. An essential oil is usually a mixture of compounds which are, in the main, insoluble in water but soluble in organic solvents, although enough of the oil may dissolve in water to give a strong odour to the solution in certain cases. They are found in buds, flowers, leaves, bark, stems, fruits, seeds, wood, roots and rhizomes and in some trees in oleoresinous exudates. Volatile oils may be recovered from plants by a variety of methods such as: (i) expression (ii) distillation (usually with steam); (iii) extraction with volatile solvents; (iv) enfleurage; and (v) maceration.

It is noteworthy that in spite of the various essential oil-producing plants in the country, no effort has been made by either the government or the private sector to tap these resources fully. The National Research Institute for Chemical Technology (NARICT) in Zaria has however done advanced research in this area. There are no known small, medium or large-scale production enterprises in the country. Thus, the country's requirements of perfumes, whether natural or synthetic, are still being met wholly by importation, an undesirable situation which needs urgent remedy.

(c) Woods

Wood processors classify woods into two groups: (i) hardwoods, which come from deciduous trees, and (ii) softwoods, which

come from conifers. The solid portion of wood is over 95% organic. It is a mixture of three groups of polymers – (i) cellulose, currently most valuable as fibre, (ii) hemicellulose, less valuable than cellulose, and (iii) lignin.

Generally, there is a worldwide underutilization of wood products which arises from the complexity of the material. There is also lack of integration of chemical, pulp and lumber companies, lack of interest of processing companies in producing and selling by-products, as well as lack of chemical knowledge of the dilute form in which many of the by-products are available. Over the years, research has shown that many useful chemicals can be obtained from wood and wood by-products. Destructive hardwood distillation can provide such useful chemicals as acetone, acetic acid and methanol. Others include resin steam and solvent process, and lignin and sulphite lignosulphonates which are used in tertiary oil recovery in "pumped-out" oil wells.

Vegetable tannins, dyes, essential oils, activated charcoal, vanillin, and turpentine extracted from gum; oleoresins collected from tapped pine trees by particleboard from sawdust, are some of the useful by-products of the wood industry that are worth exploiting for economic benefits to the country. Currently, development of these by-products is virtually neglected in spite of the nation's rich forestry bioresources.

(d) Leather

Hides and skins are important by-products of the livestock industry and the wild animal game. Raw skin is subjected to a series of chemical processes called tanning to produce a non-putrescible, weather-resistant product called leather. Leather is used for the manufacture of shoes and other goods such as garments, gloves, handbags, belts and football. NARICT's research and development efforts have produced some chemical inputs for leather manufacture from indigenous biomaterials such as bating enzymes from animal pancreas, fungi and some plants. A sulphated lubricant called fat-liquor has been produced and used successfully for the lubrication of leather using groundnut oil as the raw material.

(e) Gelatin

Gelatin is an organic nitrogenous colloidal protein substance whose principal value depends on its coagulative, protective and adhesive powers. It is obtained by chemical hydrolysis of collagen fibres of the animal skin, bones (ossein) and tendons (animal by-products). Poor quality gelatin is called glue. Quality gelatin finds use in the food industry, as emulsifier, in pharmaceutical capsules and photographic and X-ray films. Poor quality gelatin or glue is used as adhesive in leatherwork, woodwork and particleboard making. NARICT's pioneering R & D work in gelatin and glue production is yielding good results.

2.6 The Institutional Framework and Deficiencies in Human Resources Development

Article 6A of the Convention on Biodiversity Development requires each contracting party to "develop national strategies, plans or programmes for the conservation and sustainable use of biological resources; or, adapt for this purpose, existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the contracting party concerned." Since the Earth Summit, Nigeria has taken a number of significant actions related to the Biodiversity Convention in response to the global commitments made in Rio. A Country Study on Biological Diversity in Nigeria was carried out in 1992 (NNBSAP, 2006). The articulation and publication of the National Strategy and Action Plan for Biodiversity Conservation by the Federal Ministry of Environment is a follow-up to these initial responses. Further response is the articulation of all components of bioresources management and use/entrepreneurship in this "Blueprint" which is a roadmap for bioresources entrepreneurs.

The Federal Ministry of Environment and its counterparts in the states have a major mandate for general conservation of Nigeria's biodiversity in their various locations. The Federal Ministry of Science and Technology, relevant research institutes, universities and agencies, have various roles to play in ensuring sustainable exploitation, management and utilization of the

bioresources to meet the socio-economic and entrepreneurial demands of the society. The National Planning Commission (NPC)/Office responsible for national planning has the role of co-ordinating the translation of national and regional aspirations into developmental activities in bioresources entrepreneurship in a sustainable manner. The National Planning Commission is also to ensure the bridging of gaps between policy trusts needed and the mobilization of R&D, and consulting agencies to meet national demand or requirement. The Commission provides guidelines for sharing knowledge and infrastructure to the benefit of the nation and for ensuring that R&D results in all fields are implemented for the benefit of the nation.

While the Federal Ministry of Science and Technology is responsible for framing, planning, programming and budgeting for all national S&T activities, including biotechnology activities (bioresources entrepreneurship), the National Biotechnology Development Agency (NABDA) has structures, machinery and procedures which form the framework within which government's decisions concerning biotechnology and bioresources development are made and implemented. Also, government, through the Ministry of Science and Technology, had established a National Centre for Genetic Resources and Biotechnology (NACGRAB), at Ibadan, to co-ordinate and promote bioresources conservation, research and development in Nigeria. The activities of NACGRAB had earlier on been discussed above, while the objectives of the Nigerian biotechnology and bioresources development programme are as highlighted in Box 2.2.

Box 2.2 The Main Objectives of the Biotechnology Development Programme

The main objectives of the biotechnology development programme include:

(i) Ensure that Nigeria becomes self-reliant in the development and application of biotechnology-based products and services;

(ii) Ensure that Nigerians have access to, and benefit from, safe, ethical and profitable uses of biotechnology-based products and services;

(iii) Ensure that biotechnology is profitably applied to government's stewardship such as assurance of high quality health services, food security, environmental protection safety;

(iv) Promote sustenance in the development and application of acceptable and profitable technologies through strategic investments in biotech R&D to support innovation and economic development;

(v) Ensure global competitiveness and the export of products of the Nigerian biotechnology industry;

(vi) Establish and maintain profitable national and international collaborative relationships between government and all other stakeholders and interest groups on matters relating to the prospects of the biotechnology industry;

(vii) Develop suitable mechanisms and activities to support the emergence of biotechnology enterprises for the commercialization of biotechnology products, so as to ensure a sustainable food security, job and wealth creation, efficient and cheap health-care delivery as well as a safe environment;

(viii) Develop appropriate legislation, compatible with international regulations, so as to ensure biosafety, in line with social and ethical considerations and to protect intellectual, industrial property and farmers' rights;

(ix) Maintain sustainable exploitation of bioresources for our food and agriculture, health-care delivery and industrial utilization;
(x) Ensure a sustainable mechanism for adequate funding of biotechnology activities through national and international funding agencies;
(xi) Evolve a centralized co-ordination of the development of biotechnology to avoid unnecessary duplication and wastages as well as attainment of national objectives.

Source: National Biotechnology Development Agency: Policy

References

Adejuwon, J.O. (1976). "Human Impacts on African Environmental System," pp. 140-158. In *Contemporary African: Geography and Change.* Knight, C.G. and J. Newman (eds). Englewood Cliffs, N.J. Prentice Hall Inc.

Austin, G.T. (1984). In: *Shreve's Chemical Industries* (5th ed.). McGraw-Hill Inc. New York: 859.

Berdy, J. (1995). "Are Actinomycetes Exhausted Source of Secondary Metabolites?" *Proceedings of the 9th International Symposium on the Biology of Actinomycetes, Part 1.* New York: Allerton Press. Inc., 2-3.

FAO (1980). *Agricultural Development in Nigeria, 1965-1980,* Rome: Food and Agricultural Organization of the United Nations (FAO).

Fatope, M.O. and Abraham, D.J. (1987). "Design, Syntheis, and Testing Anti-sickling Agents 10. (2,2-Dimethylchromen-6-yl) Alkaloic Acids". *J. Med Chem*: 39: 1005-1008.

Fatope, M.O. (2001). "Natural Products Science: Looking back and Looking Forward." *Inaugural Lecture, Bayero University, Kano*: 1-13.

National Biotechnology Policy (2001). National Biotechnology Development Agency: Federal Ministry of Science and Technology, Abuja, Nigeria. p. 17.

Nigeria National Biodiversity Strategy and Action Plan (2006). Federal Ministry of Environment, Housing and Urban Development, Abuja, Nigeria. p. 82.

Okafor, J. C. (1981). "Woody Plants of Nutritional Importance in Traditional Farming Systems of the Nigerian Humid Tropics." A Thesis Submitted to Faculty of Agriculture and Forestry in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, University of Ibadan.

Okafor, J. C. and Ham, Rebecca, (1999). "Identification, Utilization and Conservation of Medicinal Plants in southeastern Nigeria. Issues in African Biodiversity." *The Biodiversity Support Program.* Number 3, July 1999.

Okigbo, B. N. (2005). Bioresources and Sustainable Development. Keynote Address Delivered at the National Colloquium on Sustainable Development as a Basis of a National Blueprint for Natural Resources Management and Utilization, April, 25-26, Yenagoa, Bayelsa State.

Okigbo, B. N. *et al* (1979). Report of the Committee Appointed to Review the Niger Techno Final Report on the Socio-Economic Considerations and Sheet Erosion Aspects of Soil Erosion Control in Imo and Anambra States. Kaduna: Federal Department of Agriculture, Land Resources Division.

Okigbo, B.N. (1986) . "Broadening the Food Base in Africa: The Potential of Traditional Food Crops." *Food and Nutrition* Vol. 12 (1), pp. 4-17.

Okigbo, B.N. (2000). Enhancing the Development of Research in Agriculture, Root Crops and Natural Science for Food Self-sufficiency, Poverty Alleviation and Rural Development." *Keynote Address Presented at the 13th. National Workshop on Sustainable Agriculture, Food Self-sufficiency, Poverty Alleviation and Rural Development.* May 22, 2000, National Root Crops Research Institute (NRCRI), Umudike.

Spedding, C.R.W. (1979). *An Introduction to Agricultural Systems.* London: Applied Science Publishers Ltd.

Strohl, W. (1997). "Industrial Antibiotics: Today and the Future." In: *Biotechnology of Antibiotics* (2nd Edition). Strohl, W.(ed). New York: Marcel Dekker 1-47.