NJB, Volume 32(2), December, 2019

CONSERVATION OF PLANT GENETIC RESOURCES FOR SUSTAINABLE DEVELOPMENT: A NIGERIAN PERSPECTIVE

PROFESSOR S. P. BAKO

VICE-CHANCELLOR, KWARARAFA UNIVERSITY, WUKARI, NIGERIA AND PROFESSOR OF ENVIRONMENTAL PLANT BIOLOGY AND BIOTECHNOLOGY, DEPARTMENT OF BOTANY, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

Correspondence: spbako2002@yahoo.com

A plenary paper presented at the 28th Annual Conference of the Botanical Society of Nigeria (BOSON) held at Federal University, Dutse, Jigawa State, Nigeria. September 8th - 13th, 2019

ABSTRACT

The paper discusses issues on conservation of plant genetic recourses in relation to sustainable development within a Nigerian context. It considers general concepts of the loss of biodiversity and various approaches to their conservation at the global level, focusing on major and minor food crops, underutilised species, wild relatives of food crops and diversity within species, which gives rise to crop varieties. The paper further situates conservation concerns within an Africa framework, highlighting current challenges and efforts at conservation across Africa. It examines the range of ecological zones in Nigeria, and their component abundance of plant genetic resources, as well as the threats and pressures that face them due to rapidly expanding human populations and the resultant urbanisation. Highlighting the significance of wild relatives of crop plants to the Nigerian plant genetic resources, it concludes by reviewing *ex situ* and *in situ* conservation activities in Nigeria and the need to provide a robust, long-term and environmentally sound basis for the conservation of plant genetic resources for sustainable development.

Key words: Plants Genetic Resources; conservation; sustainable development; Nigeria

INTRODUCTION: GENERAL CONCEPTS

Loss of Biodiversity

It is considered that domestication of plants and animals by man started about 10,000 years ago. The advents of technology and increased human populations have consistently put pressure on the habitats of plants and animals, and had resulted in progressive declines of biodiversity. Increased growth of human populations and the consequent increases in agriculture and industry not only destroyed unmanaged habitats (and their biodiversity), but also narrowed down the genetic diversity of crops (Olorode, 2004). Although animal, plant, marine and microbial biodiversity keeps our ecosystems functional and economies productive, the world is still experiencing a dramatic loss of biodiversity. It is contended, though, that the pace of loss of biodiversity due to deforestation has slowed globally since the 1990s. However, it remains considerably high with annual deforestation of about 13 million hectares, affecting critical animal and plant habitats. It has been reported that the Living Planet Index (LPI) (which measures trends in selected species populations) shows an overall decline of 60% over the last 40 years, with significantly greater losses occurring in tropical developing countries, mainly as a result of habitat loss, degradation, and overexploitation. This has had negative effects on human livelihoods, water supply, food security and resilience to extreme events. It also has consequences for the world's extreme poor who dwell in rural areas and rely on stability and services of ecosystems to make a living. Deforestation and land conversion contribute about 25% of global greenhouse emissions, and the loss of diversity reduces the resilience of ecosystems to climate change and other disturbances (The World Bank, 2019).

Approaches to Conservation

Conservation is often defined as the "management of human use of the biosphere so that it may be of the greatest sustainable benefit to present generations while retaining its potential to meet the needs and aspirations of future generations". Therefore, conservation embraces preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment (IUCN / UNEP/ WWF, 1991).

There are two basic approaches to conservation. These are: *in situ* and *ex situ* methods. *In situ* refers to maintaining plants and animals in their original habitats, that include farmers' fields (on-farm conservation) and nature reserves (Game reserves, Forest reserves, National parks, etc). *Ex situ* conservation, on the other hand, refers to maintaining organisms outside their original habitats in gene banking facilities such as seedbanks/seed stores, field gene banks, botanical gardens/arboreta and *in vitro* storage facilities that apply biotechnologies for plant conservation. *Ex situ* and *in situ* approaches are not mutually exclusive, as the most effective system may be a combination of two or more methods. Different conservation systems complement each other and provide insurance against the shortcomings of any one method.

The Global Diversity of Plant Species in Relation to their Conservation

It has been estimated that there are between 300,000 and 500,000 species of higher (i.e. Angiosperms/Flowering and Gymnosperms/Cone-bearing) plants, of which approximately 250,000 have been identified and/or described. The disproportionate emphasis placed on conservation of species that contribute food or feed value to man has become obvious. However, as Olorode (2004) noted, conservation efforts should adopt more comprehensive strategies that must be environmentally sound. These efforts must focus attention not only on germplasm that have known potential use but also those that sustain the habitats in which the "useful" plants evolved. Such include, but may not be limited to, the seven categories of target groups identified by Olorode (1995) as: cover crops for soil protection and reclamation; including grasses, shrubs and trees; dominant species, fodder species and range grasses; wild fruits; wild leaf vegetables; cultivated plants and their wild relatives (van Soest, 1990); ornamental and decorative plants. These collections should provide material for studies on phenology, regeneration and reproductive biology, all of which are crucial for the habitat rehabilitation programmes as part of conservation strategies.

However, the reality has been that, because of the urgency of needs, commercialization and profit, conservation of plant genetic materials has tended to be driven almost entirely by utilitarian considerations that are consequently selective in terms of target taxa or groups of taxa. Conservation of the so-called useful plants goes the way of dominant crops, resulting in monocultures that are associated with all the debility of a progressively narrowed genetic base. Although from a scientific and ecological point of view, such tendencies are short-sighted, it must be recognized that these tendencies are often forced on researchers partly because of conceptual limitations and preferences by policy makers and funding agencies.

CONSERVATION OF AGRO-BIODIVERSITY FOR SUSTAINABLE DEVELOPMENT: A GLOBAL OUTLOOK

Major Crops

Of the approximately 250,000 species of higher plants so far described, about 30,000 are edible and about 7,000 have been cultivated or collected by humans for food at one time or another. According to the FAO (1997), "The largely unintended consequence of the introduction of new varieties of crops has been the replacement and loss of traditional, highly variable farmers' varieties (Figure 1).

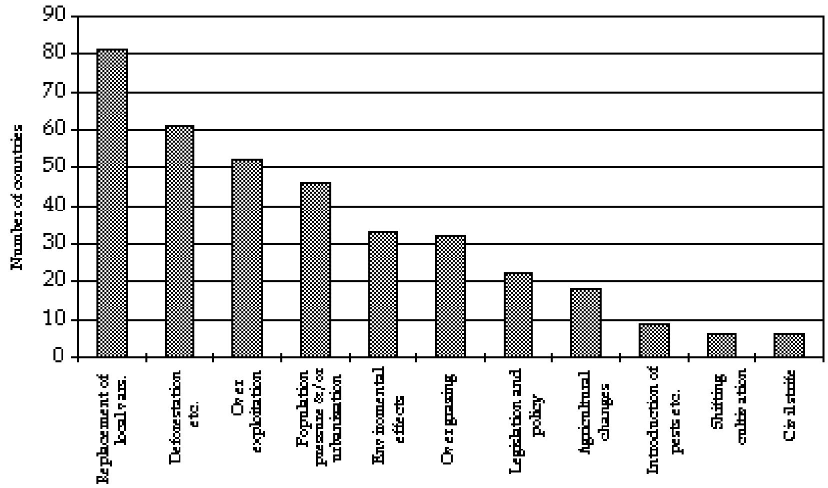

Figure1. Major factors that contribute to loss of plant genetic diversity

It is contended that the spread of modern, commercial agriculture is the main cause of the loss of genetic diversity in contemporary times. Although several thousand species may be considered to contribute to food security, it is often stated that only 30 crops “feed the world”. These are the crops which provide over 90% of dietary energy (calories) or protein (see Figures 2and 3).

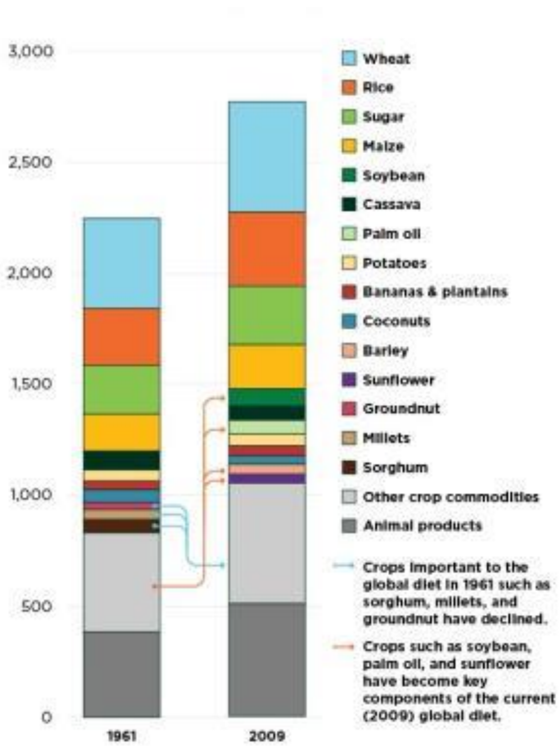

Figure 2. Relative contributions of major crops to the average food supply composition for calories (kcal/capita/day) worldwide, 1961 and 2009 (Source: Khoury, 2014).

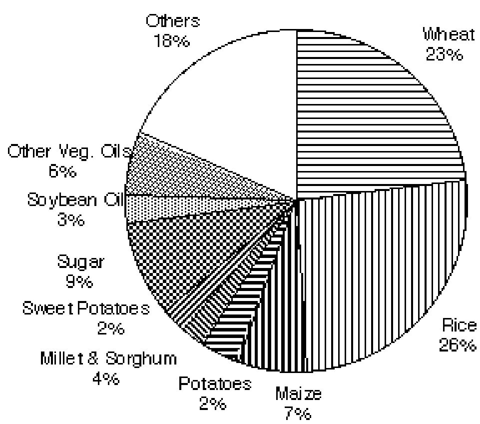

Figure 3. Major contributors to global plant derived energy intake (Source: FAO Food balance sheet 1984-1986), Rome, 1991)

Figure 3 shows that wheat, rice and maize alone provide more than half of the global plant-derived energy intake. These three crops have received the most investment in terms of conservation and improvement. A further six crops, sorghum, millet, potatoes, sweet potatoes, soybean and sugar (cane/beet), bring the total to 75% of the energy intake. There are many other species that are important to large numbers of people at sub-national levels that may not be captured within aggregations made at national levels. These include local staples (e.g. oca, teff, fonio and bambara groundnut), whose conservation and crop improvement tend to be neglected. A large number of crops are also important as sources of other dietary factors (protein, fats, vitamins and minerals, etc.). Given this importance of a relatively small number of crops for global food security, it is particularly important that the diversity within major crops is effectively conserved and managed.

Minor crops and underutilized species

The terms "minor crops" and "underutilized species" refer to plants which fulfil a wide range of functions (FAO, 1997). Such "minor staples" include various species of yam, proso millet, fonio ("hungry rice"), Bambara groundnut, oca, taro/cocoyam, canihua, breadfruit, Amaranths, quinoa, acanyt and buckwheat. Further, FAO (1997) has outlined the following as important groups of underutilized species:

(i) Vegetables, fruits and other species, including wild plants and "weeds" gathered for food, which contribute to nutrition and dietary diversification.
(ii) Multipurpose trees, including trees managed in agroforestry systems and wild species that are harvested.
(iii) Crops that can contribute to agricultural diversification including uncultivated or little cultivated species with alimentary or agricultural potential benefits.

It is reported that the countries of the West and Central African sub-regions identified a large number of underutilized species that are important to the livelihoods of local populations, including cereals (7 species), legumes (8), roots and tubers (4), oil crops (8), fruits and nuts (31), vegetables and spices (17), beverages (4), medicinal plants (38) and 44 genera of forages (FAO, 1997).

Given the importance of underutilized species, it was suggested that when priorities are set according to species, consideration be given to underutilized species as a group in order to avoid their further marginalization.

Wild species

A number of countries report the use of wild food during periods of famine and especially during the hunger season before harvests of major crops (FAO, 1997). Wild foods including roots and tubers, leafy vegetables and fruits are sources of important vitamins, minerals and other nutrients which complement the staple crops eaten by many in poor rural households where the most vulnerable people, including children and the elderly live (FAO, 1997). Such wild resources also represent ready sources of income for cash-poor households and may provide a significant proportion of total household income. Wild species that are related to crops are also important as resources for crop improvement, and often as useful species in their own right (e.g. forage grasses).

Diversity within species

While the number of plant species which supply most of the world's energy and protein is relatively small, the diversity within such species is often immense.

For example, estimates of the number of distinct varieties of the rice species, *Oryza sativa*, range from tens of thousands to more than 100,000. Furthermore, at least seven different vegetables derive from the single wild cabbage species, *Brassica oleracea*. These are kale, cauliflower, cabbage, Brussels sprouts, kohlrabi, broccoli, calabrese, and savoy cabbage. Genetic variation also exists within these vegetables and numerous different varieties of each can be found.

Crop varieties

An aggregation of previously published works (Harlan, 1975; Bolster, 1985; Dennis, 1987; Gepts and Clegg, 1989; Mordern *et al.*, 1989; Jaradat ,1991; Tomooka, 1991; Brush, 1991; Ceccarelli *et al.*, 1992; Alika *et al.*, 1993; Hodgkin *et al.*, 1993) have recognised that cultivated varieties are broadly classified as "modern varieties" and "farmers' varieties". Modern varieties are professionally bred "high-yielding varieties" (HYVs) or high-response varieties, with a high degree of genetic uniformity and, except for F_1 hybrids and synthetic or composite varieties, they breed true. Farmers' varieties (landraces or traditional varieties), on the other hand, are the product of breeding or selection carried out by farmers continuously over many generations. Farmers' varieties are not genetically uniform as they retain high levels of genetic diversity. Although these varieties may be difficult to define or distinguish with certainty, they may be recognized and named morphologically. Different landraces differ in adaptation to factors such as soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Because of their genetic diversity, most conservation efforts target these landraces. The inherent variation within farmers' varieties, or landraces, is especially high for cross-pollinated species such as maize and millet. This is particularly important for optimizing output from highly variable environments. For self-pollinated crops such as rice, wheat and barley, however, and for vegetatively propagated crops such as potatoes and bananas, individual varieties are less variable, but the number of varieties that could be developed may be very high.

Global Conservation efforts

For agro-biodiversity, *ex situ* conservation is the most significant method. Accessions are kept in gene banks maintained by public or private institutions acting either alone or working with other institutions. Seeds are kept in specially designed cold stores or, for vegetatively propagated crops and crops with recalcitrant seeds, as living plants grown in field gene banks. In some cases, tissue samples are stored *in vitro* or cryogenically and a few species are also maintained as pollen or embryos.

According to the Food and Agriculture Organization of the United Nations (FAO, 1997), there were more than 1,750 individual gene banks worldwide. About 130 of these held more than 10,000 accessions each. There are also substantial *ex situ* collections in over 2,500 botanical gardens around the world. Gene banks are located on all continents, with relatively fewer numbers in Africa. The largest collections have been built up over a period of more than 35 years by the Consultative Group on International Agricultural Research (CGIAR). In 1994, these were brought under the International Network of *ex situ* collections of the FAO, and managed under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Based on figures from the World Information and Early Warning System (WIEWS) and country reports, it was estimated that about 7.4 million accessions are currently maintained globally. More than 1.4 million were reported in the first State of the World (SoW) report. Various analyses suggested that between 25 and 30 percent of the total holdings (or 1.9-2.2 million accessions) were distinct, with the remainder being duplicates held either in the same or, more frequently, different collections (FAO, 1997).

It was further reported that germplasm of many crops was conserved in more than 1, 240 gene banks worldwide and these added up to a total of about 4.6 million samples. Of these, about 51 percent were conserved in more than 800 gene banks of the contracting parties of the ITPGRFA and 13 percent was stored in the collections of the CGIAR centres. Of the total 7.4 million accessions, national government genebanks conserved about 6.6 million, 45 percent of which was held in only seven countries down from 12 countries in 1996. This increasing concentration of *ex situ* germplasm in fewer countries and research centres highlights the importance of mechanisms to ensure facilitated access by sister organizations (FAO, 1997).

THE AFRICAN OUTLOOK

Country reports from across Africa indicate that the continent is endowed with a rich genetic resource base. In a detailed review, Mugabe (1998) reported that countries of tropical and sub-tropical Africa had 40,000-45,000 higher plant species. South Africa alone had an estimated 20,000 indigenous plant species and possesses more than eight percent of the world's vascular plants. Kenya had at least 8,000 species of plants, while Cameroun had more than 15,000. Malawi's forests occupy some 3.6 million hectares of land area, which made up 38 percent of the total, 97 percent of which were covered by indigenous species. The continent as a whole held at least 25 percent of the global pool of plant genetic resources and contributed significantly to the world's trade in genetic material. The abundance of plant genetic resources in Africa is largely associated with its ecological variability and diversity. Most of the region enjoys a tropical climate that is favourable to the evolution of unique plant genetic resources (Mugabe, 1998).

Furthermore, Africa gave the world some of its most important crops. The world's major regions of crop diversity include the Ethiopian highlands, the Sahelian transition zone, the delta of the Niger River and the humid forest zone of West and Central Africa. The highlands of Ethiopia are a centre of origin for coffee, and a centre of diversity for sorghum, lentil, wheat and barley. Tropical West Africa is a centre of origin for African rice (*Oryza glaberrima*) and a centre of diversity for oil palm, yams and cowpeas (Mugabe, 1998).

It is, therefore, clear that Africa's strength lies in its natural resources, including the genetic resources that are the foundation for growth and stability in agriculture, forestry and the environment. Africa's economies, cultures and political systems are primarily dependent on how well plant genetic resources are conserved and utilized. In the light of this, the continent's economic transformation and its ability to integrate itself into the evolving global system, largely depends on agricultural transformation that is based on plant genetic resources (PGR) (Mugabe 1998). The New Partnership for Africa's Development (NEPAD) launched at the Organization of African Unity (OAU) summit in Lusaka, Zambia, in July 2001 makes references to the role that genetic resources in general had played and will continue to play in the lives of African people, as well as in the fulfilment of some of the principal elements of the programmes under the NEPAD. Because of their importance and the definite roles they play and will play in future, there is a need to ensure that genetic resources issues are placed firmly on the agenda of the NEPAD, the African Union (AU) and any other emerging regional or sub-regional initiatives. Since PGR form the basis of a dynamic, diverse and adaptable agriculture and thriving traditional medicine, they are fundamental to national health and food security. Their conservation and sustainable use must, therefore, be part of the region's developmental strategy (Mugabe, 1998).

Recognizing and believing in the role of plant genetic resources, and the need to bring their conservation and sustainable use to the centre of dialogues and debates on Africa's future, the International Plant Genetic Resources Institute (IPGRI) and the African Centre for Technology Studies (ACTS) embarked on a joint programme commencing with the organization of a Roundtable on Plant Genetic Resources in Africa's Economic Renewal. The roundtable which held on 2-3 April 2002 sought to identify and promote specific issues on conservation and sustainable use of plant genetic resources that should be part and parcel of the African Renewal process as well as the NEPAD's programme focus. It also sought to provide practical and technical components to the regional initiative and to facilitate more harmonious policy approaches to genetic resources conservation and sustainable use within the region, especially in agriculture, health, poverty alleviation and the sustainable economic development of the continent (Mugabe, 1998).

Current challenges to conservation in Africa

The genetic base of Africa's plant diversity is being seriously eroded, largely as a result of introduction of high-yielding varieties and exotic species, climate change, socio-economic factors, natural disasters and armed conflicts. The ongoing genetic erosion - the loss of genetic diversity - can also have important negative impacts on the rural poor. The loss of genetic resources has become phenomenal and is a major source of concern for the global community.

Conservation efforts in Africa

It is reported that many African nations are involved in collection, storage, duplication, characterization, regeneration and movement/ distribution of germplasm. According to a review of Country reports from across

Africa by Mugabe (1998), African countries variously carried out collecting missions that resulted in more than 35,000 new accessions, encompassing a wide range of species including cereals, oil plants, fruits, roots/tubers, legumes, nuts and local vegetables. Based on such reports, it was apparent that data on storage facilities in Africa were less complete than for other regions. Most countries reported having seed and field gene banks, but only Benin, Cameroon, the Congo, Ghana, Kenya, Mali, Nigeria and Uganda reported having *in vitro* storage facilities. No country specified having the ability to conserve germplasm cryogenically. Seed gene banks are generally much more important and widespread than field gene banks in the continent. Ethiopia, for example, reported having 60,000 accessions in its national seed gene bank and 9,000 in its field gene bank. Burkina Faso, the Niger and Zambia all reported having many more accessions in their seed gene banks than in their field gene banks. Although most countries reported having long-, medium- and/or short-term storage facilities, they also mentioned numerous problems in their use, including reliability of electricity, supplies pests and disease-related problems as well as lack of staff, equipment, or funds. Guinea reported the loss of its entire *ex situ* collection as a result of a failure in the electricity supply. Burkina Faso, Cameroon, Ethiopia, Mali and the Niger reported the safety duplication of some of their germplasm in gene banks of the CGIAR countries. Ghana and Namibia both indicated that the majority of their germplasm was duplicated within the country. The regional Southern African Development Community (SADC) gene bank provides safety duplication for all member-country collections under long-term storage conditions. Uganda had not yet embarked on a programme of safety duplication, but Kenya reported having deposited safety duplicates of some of its germplasm in the Millennium Seed Bank, Kew.

Regular viability testing was carried out in Madagascar, Nigeria, Uganda and Zambia, but generally not elsewhere. The systematic regeneration of stored material appears sporadic, although Ethiopia reported regular regeneration of germplasm when viability fell below 85 percent. Funding, staffing and facilities were frequently reported to be inadequate to allow the necessary germplasm regeneration to be undertaken.

Ongoing regeneration backlogs have been reported for the fonio and sorghum national collections in Mali, as well as for cereal and vegetable collections held at the Institut sénégalais de recherche agricole – Unité de recherche comune en culture *in vitro* (ISRAURCI) in Senegal and at the Institute of Biodiversity Conservation (IBC) in Ethiopia. The national genebank of the United Republic of Tanzania also warned about a decreasing capacity to manage regeneration that has resulted in growing backlogs for both cross- and self pollinated crop collections.

Most of the African nations reported having characterization and evaluation data on their collections, but with some exceptions (e.g. most SADC countries, as well as Ethiopia, Kenya and Mali), it was generally incomplete and not standardized. Togo indicated that its documentation was in a rudimentary state and several other countries reported serious weaknesses. Kenya reported its intention to develop national documentation systems that are in line with the SADC Documentation and Information System (SDIS) system in use in all SADC countries. While three countries reported that they still maintained some records on paper and eight use spreadsheets, at least eight others have dedicated electronic systems. Ghana, Kenya and Togo reported using generic databases to manage information on *ex situ* collections.

Furthermore, it was found that in most African nations there has been an increase in the morphological characterization of materials in *ex situ* collections since the publication of the first SoW report. The work has mostly been carried out by national Plant Genetic Resources for Food and Agriculture (PGRFA) centres and programmes, sometimes in collaboration with research institutes and universities.

The level of morphological characterization is high for Ethiopia's collections of cereals, pulse and oil crops (97 percent), Mali's collections of cereals and vegetables (99 percent) and Senegal's collection of groundnut (100 percent). Ninety percent of Ghana's important cocoa collection is characterized for morphological traits, 10 percent using molecular makers and 80 percent has been evaluated agronomically and for biotic stresses. Several countries including Kenya, Malawi and Namibia reported having generated morphological characterization data, but agronomic and particularly, molecular characterization data were scarce across Africa. Generally, it was apparent

from the country reports that a considerable amount of work is still needed in most countries. Capacity, particularly for new molecular techniques, is still far from adequate.

Little data on germplasm movement was provided in the country reports from Africa. Uganda indicated that there was no national monitoring system for germplasm movement in place and Mali reported that germplasm movement was poorly documented. Both Ghana and Guinea stated that there was considerable movement, but no figures were available. A significant increase in germplasm movement since 1996 was reported by Malawi, which distributed more than 1,000 accessions and Kenya which distributed 3,189 accessions over a five-year period. In its country report, Ethiopia estimated that an average of 5,000 samples had been distributed to national programmes.

THE NIGERIAN EXPERIENCE IN CONSERVATION

Nigeria, as one of the most populous countries in Africa, has a landmass of over 923,768 square kilometres including about 13,000 square kilometres of water. It is enclosed within latitudes 4° 16´North and 13° 52´North of the equator and between longitudes 2°49´E and 14°37´East of Greenwich Meridian. The population of Nigeria was estimated in 2010 at about 160 million, representing 20% of the entire African population. This population grows at a rate of 3.2% annually (NBS, 2007).

Associated with the varied ecological zones is an array of flora and fauna species. Attempts at conservation of these species have resulted in the creation of a system of protected areas (See Figures 4 and 5). There are 7,895 plant species from 338 families and 2, 215 genera that have been identified in Nigeria (FGN, 2006). The northern region, with Sudanian affinities, has 39 endemic species, western and central region 38, and the eastern region 128 endemic species. Nigerian moist forests are rich in epiphytic ferns and orchids, and contain over 560 species of trees which attain heights of at least 12 metres and girth of 60 centimetres (USAID, 2008).

Due to the relatively large number of plant species identified in Nigeria, Nigeria has been ranked the 11th in biodiversity in Africa. In addition, the West African Forests is one of the 25 biodiversity hotspots of global significance for conservation priorities (Myers *et al*., 2000) and the Nigerian tropical rainforests form a significant part of this. The great diversity of plant species found in Nigeria is not unconnected with the diversity of ecosystems and habitats as well as the tropical climate in the country.

The high forest zone of the country occupies 14% of the total land area and accounts for 2.1 million hectares of forest reserves. The Savanna zones of the country occupy 86.0% of the total land area and have 7.5 million hectares of reserved forests (See Figure 5).

Moist evergreen forest which becomes deciduous towards the north provide most of the country's timber and is rich in such species as *Triplochiton scleroxylon*, *Terminalia ivorensis*, *Terminalia superba*, *Khaya grandifoliola*, *Khaya ivorensis*; *Entandrophragma* spp; *Milicia* (Syn: *Chlorophora*) *excelsa*, *Nauclea diderrichi*, *Lovoa trichilioides*, *Terrieta utillis*, *Tieghemella heckelii*, *Pericopsis alata* and *Mansonia altissima*.

The rest of the country's vegetation in the Northern Savanna comprises of Derived Savanna, Guinea Savanna, Sudan Savanna and Sahel Savanna and species such as *Parkia biglobosa*, *Prosopis africana*, *Vitellaria paradoxa*, *Adansonia digitata*, *Acacia* spp. *Balanites aegyptiaca*, *Tamarindus indica, Terminalia* spp and *Combretum* spp are common woody species.

However, despite the biological richness of Nigeria, these genetic resources are faced with threats and extinction. A number of factors are responsible for these threats and pressure on biological diversity in Nigeria, and they include agricultural activities, bush burning, fuelwood collection, logging and grazing. The massive rate of deforestation is a direct cause of biodiversity loss. According to the 2005 FAO Forest Resources Assessment Report, Nigeria had the highest rate of deforestation of primary forests between years 2000 and 2005 (FAO, 2005). This is related to the fact that the demand for tropical hardwoods is increasing daily. Nigeria is the highest producer of timber in Africa, producing more than 100 million cubic metres annually as at 1998 (FAO, 2001) and wood accounts for about 85% of domestic energy use in the country (FEPA, 1992, 2003; CBD 2001). The survival of rural dwellers and urban poor depends on finding enough wood to cook their meals. In contemporary times, it is contended that fuel wood constitutes the main source of fuel for cooking by over 76% of the Nigerian population.

UNDP figures for 1993 showed Nigeria consuming 262,783 metric tons of fuel wood. Wood accounts for about 85% of domestic energy use in the country (FMEnv., 2006). Illegal logging and overexploitation has continued to pose serious threats to the country's forest resources and the environment. The high population in Nigeria puts increasing pressure on the environmental and genetic resources in the country (Borokini *et al*., 2010).

Bush fires have become a major environmental hazard in most parts of Nigeria. Through these avoidable practices, thousands of hectares of our forest are lost every year, especially in the dry season. Worse still, invasive alien species, found in all taxonomic groups, from bacteria to mammals, are second only to habitat destruction as a threat to biodiversity (Mooney and Hofgaard, 1999). Many factors that support the introduction and spread of invasive species include land use changes, forest activities, economic intentions, tourism and trade among others. In Nigeria, several plants have been identified as invasive species: the water hyacinth (*Eichhornia crassipes*), Typha- Kachalla grass (*Typha domingensis*), Wild sunflower *(Tithonia diversifolia)* and Nipa palm (*Nypa fructicans*), which have grave effects on both water ecosystems and terrestrial habitats.

As a result, it has been reported that of the 560 native tree species in Nigeria, 16 are critically endangered as listed in the IUCN Red list, 18 are endangered, while 138 are vulnerable. In addition, out of 4,715 vascular plant species in Nigeria, 205 are endemic, while 170 are threatened (IUCN, 2004). Since we do not yet know how to recreate a species once it has become extinct (Kimmlins, 1987), the need for conservation of genetic resources of species and ecosystems has become imperative.

Wild species and wild relatives of crop plants in Nigeria

Genetic variability is the basic tool used by plant breeders in crop improvement. The basic source of such variability exists both in the advanced and primitive cultivars as well as in the wild and weedy relatives of the cultivated species.

Out of six species of the genus *Oryza* that are known to occur in Nigeria, *O. sativa* L., the white rice, is, perhaps, the most familiar. *Oryza glaberrima* which is indigenous to Nigeria and West Africa is now growing wild and seems to have disappeared. In much the same manner, an upland variety of *O. sativa* widely cultivated in the Western part of Nigeria some decades ago seems to have disappeared from the farms and are only found in government experimental stations. *Oryza perennis*, *O. longistaminata*, *O. punctata* and *O. tissenantus* represent the wild rice species of Nigeria. These at present are considered to have no economic value but constitute part of the genetic diversity in the genus *Oryza* in Nigeria (FAO, 1996).

With regards to the edible yams, six species of the genus *Dioscorea* namely *D. alata*, *D. bulbifera*, *D. cayensis*, *D. dumentorum*, *D. esculenta* and *D. rotundata* occur naturally in Nigeria. Each of these has wild relatives and show considerable genetic diversity. However, only *D. cayensis, D. esculenta* and *D. rotundata* are popularly cultivated and have received more attention from both the research scientists and the farmers (FAO, 1996).

Most of the fruits and vegetables in regular cultivation in Nigeria are exotic species. The over 20 indigenous wild species of vegetables and fruits are still under-exploited and, therefore, under-utilized. Furthermore, wild fruits and food trees are well known values of the forests. They provide fruits and their associated nutritional values which enhance rural and urban health, while the leaves from the food trees, and in particular leafy – vegetables (plant proteins) serve as soup condiments. These species are more common in the high forests, especially in the wetter areas, but various other species are also known in the savanna or even in the drier Sahel savannas for their values.

For germplasm conservation, particularly in the case of the wild relatives of cultivated crops, research efforts are crucial. An inventory of the flora as now constituted will indicate critical areas to be conserved *in situ*. Only recently the Forestry Research Institute of Nigeria (FRIN) cooperated with the National Centre for Germplasm Conservation and Biotechnology (NACGRAB) on evaluating the problems of endangered plants. It is envisaged that a "Red Data Book" will be kept at NACGRAB and at the FRIN Herbarium to help conservation work, especially as it relates to the needs and requirements of breeders in all areas of agricultural research. Lack of adequate knowledge of the variations in taxonomic status of Nigerian flora poses additional complications for effective genetic conservation and utilization. However, the preparation of a comprehensive flora will adequately bridge this gap (FAO, 1996).

In the case of vegetation, studies have shown that some, particularly the wetlands, are ecologically fragile. They thus need special attention. Because of the present erosion of the genetic resources of vegetation, however, coastal vegetation, mangrove, swamp forest and riparian forest, moist lowland forest and the highlands need stricter conservation. Recent work on the delineation of strict Nature Reserves (SNR) within the forest reserves is a welcome development. The problem of security in these SNR's, however, is great.

Conservation activities in Nigeria

Conservation efforts in Nigeria involves the establishment and management of national parks, game reserves, forest reserves, biosphere reserves, strict nature reserves (SNRs) and relevant research institutes/ academic institutions, which establish and manage arboreta, botanical/zoological gardens and gene banks. In addition, biotechnological applications to conservation efforts in Nigeria have witnessed the introduction of tissue culture applications as a new method of plant conservation.

***In situ* conservation activities**

Conservation backed by legislation of Natural Vegetation and modified ecosystems started in 1937. This has cumulatively resulted in the creation of 56 forest reserves and community forests as well as 27 Game reserves, National parks, Strict nature reserves and wildlife sanctuaries in Nigeria (USAID, 2008), and the country has 12 strict Nature Reserves (SNRs) (see Figures 4 and 5). Other forms of *in situ* conservation e.g. botanical garden, arboreta etc. are maintained by Universities and tertiary institutions in the country. According to government regulation, there is a total ban on exploitation of these in the *in situ* conserved areas. However, because of problems involved in the implementation of the government legislation, illegal exploitation and felling of forest trees are carried out even in the reserved areas (USAID, 2008).

While efforts are needed to ensure the protection and enforcement, it is desirable that other strict forest reserves are created.

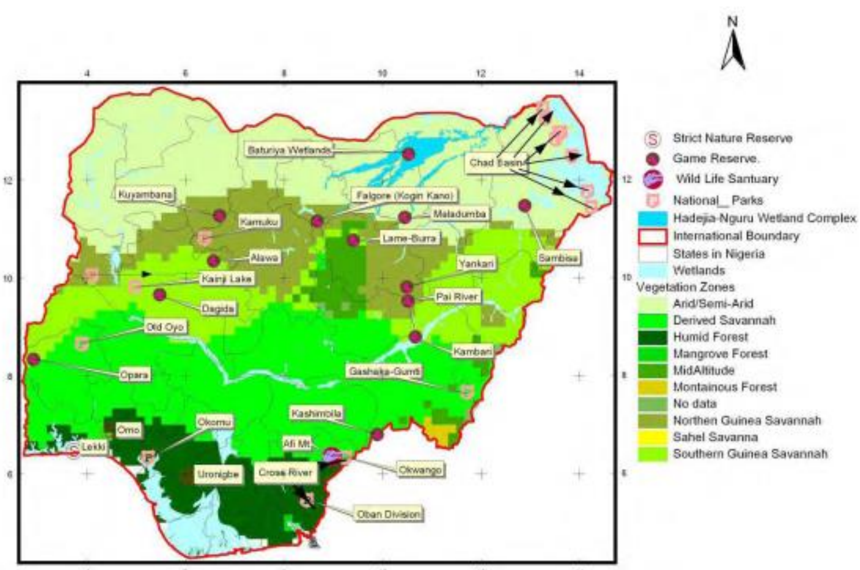

Figure 4. National parks, game reserves and similar protected areas in Nigeria (Source: USAID, 2008)

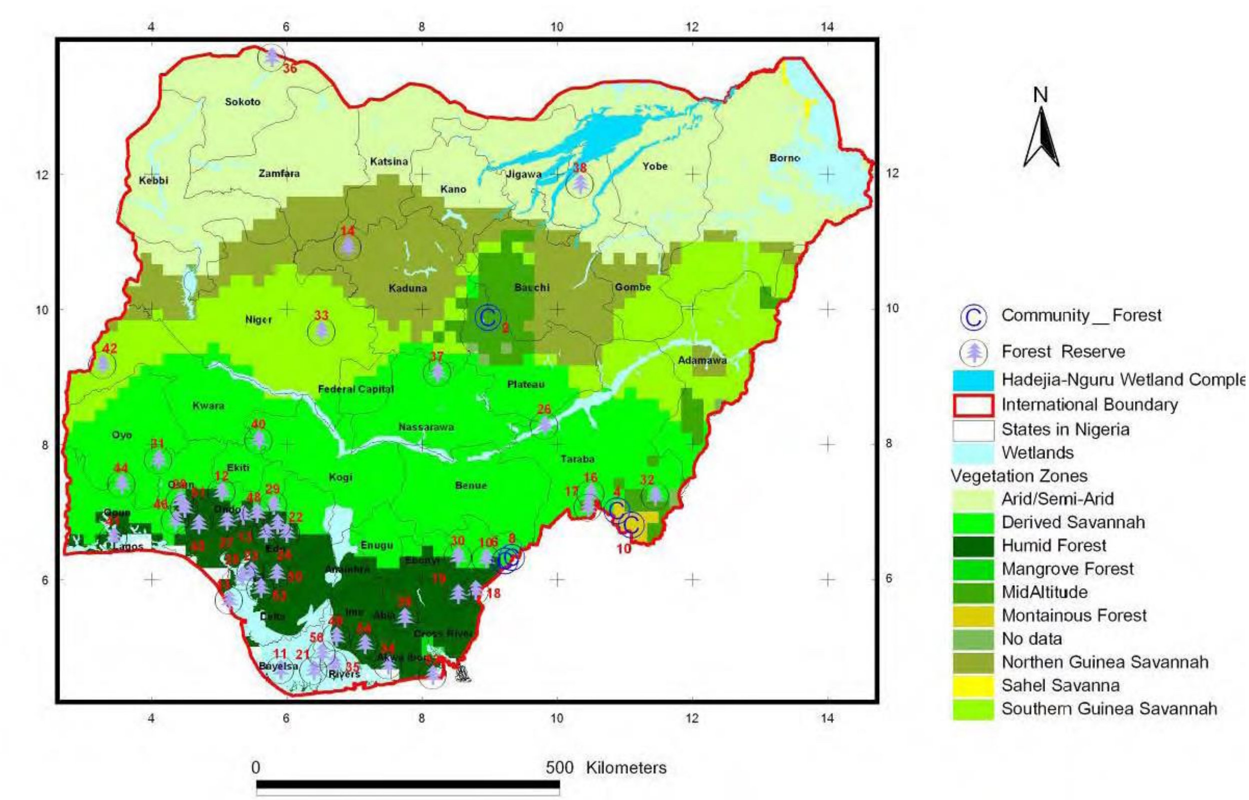

Figure 5. Forest reserves and community reserves in Nigeria (Source: USAID, 2008)

Key to Forest Reserves and Community Forests

Community Forests

2 Amurum Woodlands 3 Andoni 4 Buru Forests 5 Damper Sanctuary 6 Mbe Mountains 7 Nun River 8 Obudu Plateau 9 Finima Nature Park 10 Afrobe/Akwabe

Forest Reserves

10 Afi River 11 Apoi Creek 12 Akure 13 Akure-Ofosu 14 Akwazanta 16 Baissa 17 Bisaula 18 Cross River North 26 ross River South 20 Donga River 21 Edumanom 22 Ehor 23 Ekenwan 24 Ekiadolor 25 Gele-Gele 26 Ibi 27 Idanre 28 Ife 29 Ifon 30 Ikirigon 31 Oba Hills 32 Kurmin Danko 33 Lizai 34 Lower Imo 35 Lower Orashi River 36 Mada River North 37 Mada River South 38 Minna 39 Obot-Ndom 40 Ogbe 41 Ogun River 42 Okuta 43 Olague 44 Olokemeji 45 Oluwa 46 Omo 47 Owan 48 Owo 49 Sombrero 50 Sapoba 51 Shasha 52 Stubbs Creek 53 Kpe-Sobo 54 Upper Imo River 55 Upper Ogun River 56 Upper Orashi River

Forest Regeneration and Management

Artificial forest regeneration with exotic and indigenous tree species is commonly embarked upon to augment forest wood supply (Olorode, 2004). The first plantations were established in southern Nigeria with exotic species like *Tectona grandis*, *Gmelina arborea*, *Pinus* spp and indigenous species like *Nauclea diderrichii*, *Terminalia* spp. Later, afforestation went up North with species useful for environmental protection in sand dune fixation a

shelter belts as well as fuel woods, poles, pulp and paper. These include *Acacia* spp, *Dalbergia* spp; *Gmelina arborea*, *Pinus* spp and *Eucalyptus* spp.

Under the fourth National Development Plan, afforestation with the use of indigenous forest tree species like *Nauclea diderrichii*, *Khaya ivorensis*, *Lovoa trichilioides*, *Triplochiton scleroxylon*, *Milicia* (Syn. *Chlorophora*) *excelsa*, *Terimnalia ivorensis* and *Terminalia superba* was proposed. However, biological problems such as inadequate seed supply and insect pest problems prevented the use of indigenous species.

Introductions and afforestation present paradoxes in conservation, because of two reasons. Firstly, that introduction and afforestation programmes (whether of indigenous or introduced species) tend to yield forest stands that are monocultures or oligocultures with the consequent simplification of ecosystems that are unstable. Secondly, there is the danger of introducing species that are susceptible to foreign diseases or potential hosts of such. There is, therefore, a need for conscious efforts to evaluate the environmental impact on genetic resources of native plants being used in afforestation programmes, in addition to the work on provenance trials, selection, improvement and diseases and pests of forest trees (Howland and Bowen, 1977; Ladipo, 1986; Olorode, 2004), as well as the potential for genetic erosion in natural habitats.

***Ex situ* collections**

According to an excellent review of conservation activities in Nigeria, Borokini *et al.* (2010) reported that one institutional framework strategy was the establishment of National Centre for Genetic Resources and Biotechnology (NACGRAB), located in Ibadan, Nigeria as the national focal point for the conservation of plant, animal and microbial genetic resources; with the mandate to conserve all genetic resources indigenous in Nigeria using all conservation methods possible, including biotechnological applications; as well as network with relevant national research institutes in germplasm exchange, conservation and management. This centre has a field gene bank that covers about 12 hectares and, holds a large variety of plants with diverse growth forms. It had since inception accumulated a total collection of approximately 2,500 accessions consisting of both indigenous and exotic germplasm mainly of food crops, vegetables, tuber, fodder, industrial, medicinal and forest plants. Furthermore, the authors reported that the Centre received most of their exotic materials from organizations like International Crops Research Institute for the Semi-arid Tropics (ICRISAT), the International Centre for Maize and Wheat Improvement (CMMYT), Centre for Agricultural Research in Dry Areas (ICARDA) and ICRAF which now works together with NACGRAB in the collection and conservation of *Irvingia* and *Vernonia amygdalina*.

Plant Genetic Resources Conservation activities at the Centre are being funded under the National Rolling Plan by the Federal Government. Routine activities of field gene bank maintenance, seed processing and viability testing prior to storage are on-going activities at the Centre. Collaborative evaluation and characterization of some economic crops like wheat and barley with relevant research Institutes are a continuous exercise. The Centre in collaboration with International Centre for Research in Agroforestry (ICRAF) is engaged in collection of endangered indigenous forest species. Furthermore, the National Gene bank Centre collaborates with all the national institutional gene banks and maintains useful duplicates of material stored in institutional gene banks (Borokini *et al*., 2010).

Storage facilities/equipment

Borokini *et al*. (2010) further reported that equipment received from UNDP/FAO/IPRI that were physically installed and put to use included a prefabricated long-term storage room maintained at -20°C and relative humidity of 15%. There is a modified room for short-term storage which is maintained at 15°C and 30% RH. There are also a few freezers and refrigerators used for additional storage. The two storage facilities have in-built dehumidifiers.

The long-term storage room had base collections whilst the short-term storage room held active collections. As a procedure, all seeds are stored in hermetically sealed cans and air-tight containers, at the appropriate moisture content level. Functional laboratories at the Centre include a germplasm extraction room, threshing room and viability/germination room. Processing equipment includes seed dusters, ovens, incubators, seed separators and

balances. Nigeria being a member of ECOWAS would readily accommodate germplasm from the sub-region for safe-keeping.

Documentation

In line with international best practice, all samples are accompanied with passport data, characterization data, evaluation data, indigenous and breeders' records in the process of documentation. Also preliminary evaluation data are registered in the passport data and 80% of the samples are documented (Borokini *et al* ., 2010).

The country genetic resources bank does not exchange any data with other genebanks on regional or a crop basis. Also, the national gene bank has no *in situ* collections, but those being currently maintained by research institutes are continuously evaluated and described under the institutes' breeding programme (FAO, 1996).

Evaluation and characterization

It was further reported by Borokini *et al*. (2010) that the national programme is engaged in characterization and evaluation of germplasm according to international guidelines with assistance from relevant sister organizations. Furthermore, farmers are involved in the evaluation of collections through requests in respect of indigenous information.

The establishment and use of the field gene banks for conservation of the recalcitrant, tree, roots and tuber crops and medicinal plants in NACGRAB has proved very useful and there is protection and security for the plant germplasm, which is lacking in the *in situ* gene banks and reserves in various locations in the country. A major challenge with establishment of field gene banks is the adaptability of the plants to the new habitat which is different from their natural habitat. However, the climatic condition in Ibadan supports the adaptation of species collected from a wide range of climates available in Nigeria (FAO, 1996, 2019). Conservation efforts of NACGRAB and in Nigeria at large, should consider the need to establish *ex situ* live collections (field gene banks) at the different ecological zones of the country.

CONCLUSION

The foregoing has highlighted the critical need for concerted efforts at conservation of plant genetic resources in Nigeria, as well as emphasized the gaps that exist therein. These gaps exist because the various questions on the issues of policy conceptions, strategies and priorities on the conservation of genetic resources remain unresolved. It is, therefore, imperative to provide a robust, long-term and environmentally-sound basis for the conservation of plant genetic resources for sustainable development in Nigeria.

REFERENCES

Alika, J.E., Aken'Ova, M.E. and Fatoukan, C. A. (1993). Variation among maize (*Zea mays* L) accessions of Bendel State, Nigeria. Multivariate analysis of agronomic data. *Euphytica*, 66:65 -71.

Bolster, J.S. (1985). Selection for perceptual distinctiveness: evidence from Aguarana cultivars of *Manihot esculenta*. *Economic Botany*, 39:310-325.

Borokini, T. I., Okere, A. U., Giwa, A. O., Daramola, B.O. and Odofin, W. T. (2010). Biodiversity and conservation of plant genetic resources in Field Genebank of the National Centre for Genetic Resources and Biotechnology, Ibadan, Nigeria. *International Journal of Biodiversity and Conservation*, Vol. 2(3):037-050, March 2010 Available online http://www.academicjournals.org/ijbc.

Brush, S.B. (1991). Farmer conservation of new world crops: the case of Andean potatoes. *Diversity*, 7:75-79.

Ceccarelli, S., Valkoiun, J., Erskine, W., Weigland, S., Miller, R. and van Leur, J.A.G. (1992). Plant genetic resources and plant improvement as tools to develop sustainable agriculture. *Experimental Agriculture*, 28:89-98.

Committee on Biodiversity (CBD)(2001). NIGERIA: First National Biodiversity Report July 2001 https://www.cbd.int › doc › world › ng-nr-01-en.

Dennis, J.V. (1987). Farmer management of rice variety diversity in northern Thailand. Cornell University, Itahca, N.Y. (Ph.D. thesis).

Food and Agriculture Organization of the United Nations (FAO) (1996). Nigeria: Country Report to the FAO international Technical conference on plant genetic resources (Leipzig,1996). Prepared by: Sarumi, M.B., Ladipo, D.O., Denton, L., Olapade, E.O., Badaru, K., Ughasoro, C. 108p.

Food and Agriculture Organization of the United Nations (1997). The state of the world's plant genetic resources for food and Agriculture Rome, 1997.

Food and Agriculture Organization of the United Nations (FAO) (2001). Global Forest Resources Assessment 2000. FAO Forestry Paper 140. FAO, Rome, Italy.

Food and Agriculture Organization of the United Nations (FAO) (2005). State of the World's Forests 2005. FAO, Rome, Italy.

Food and Agriculture Organization of the United Nations (FAO) (2019). The State of the World's Biodiversity for Food and Agriculture, J.Bélanger & D. Pilling (eds.). FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 p. (http://www.fao.org/3/CA3129EN/CA3129EN.pdf).

Federal Environmental Protection Agency (FEPA) (1992). Federal Environmental Protection Agency. Biological Diversity in Nigeria, A Country Study 1991 - 1992.

Federal Environmental Protection Agency (FEPA) (2003). National Biodiversity Strategy and Action Plan.

Federal Government of Nigeria (FGN) (2006). Draft Report. National Capacity Needs Self-Assessment for Environmental Management. Federal Ministry of Environment.

Federal Ministry of Environment (FMEnv) (2006). *Nigeria First National Biodiversity Report*, Federal Ministry of Environment, Abuja.

Gepts, P. and Clegg, M.T. (1989). Genetic diversity in pearl millet (*Pennisetum glaucum* [L] R.Br.) at the DNA sequence level. *Journal of Heredity*, 80:203-208.

Harlan, J.R. (1975). Our vanishing genetic resources. *Science,* 188:618–621.

Hodgkin, T., Rao, V. R. and Riley, K. (1993). Current issues in conserving crop landraces *in situ*. Paper presented to the on-farm conservation workshop, Bogor, Indonesia, 6-8 December 1993.

Howland, P. and Bowen, M. R. (1977). West African Hardwoods Improvement Project Research Report 1971-1977: *Triplochyton scleroxylon* K. Schum and other West African Tropical Hardwoods. Federal Department of Forestry, Lagos, Nigeria.

IUCN/UNEP/WWF (1991). International Union for Conservation of Nature and Natural Resources, United Nations Environmental Programmes and World Wide Fund for Nature (IUCN/UNEP/WWF) 1991. Caring for the Earth. A Strategy for Sustainable Living.IUCN, UNEP, and WWF, Gland, Switzerland.

International Union for Conservation of Nature and Natural Resources (IUCN) (World Conservation Union) (2004). Red list of threatened species. IUCN, Gland, Switzerland. Available from http://www.iucn.org/themes/ssc/redlist.htm.

Jaradat, A. A. (1991). Phenotypic divergence for morphological and yield-related traits among landrace genotypes of durum wheat from Jordan. *Euphytica*, 52:155-164.

Khoury, C. (2014). How many crops feed the world? *Plantvillage*, International Centre for Tropical Agriculture (CIAT), 2014.

Kimmlins, J.P. (1987). *Forest Ecology*. Macmillan Publishing Company, New York, p. 531.

Ladipo, D.O. (1986). Pests and Diseases in Forest trees: potentials for selection and breeding for resistance in Nigeria. *Paper presented at the 13th Annual Conference of the Genetics Society of Nigeria* at FRIN, Ibadan.

Mooney, H.A. and Hofgaard, A. (1999). Biological invasions and global change. In: Sandlund, O.T., Schei, P.J. and Viken, A. (eds.). *Invasive species and biodiversity management,* based on a selection of papers presented at the Norway/UN Conference on Alien Species, Trondheim, Norway. *Population and Community Biology Series*, 24. Dordrecht, Netherlands, Kluwer Academic Publishers. pp: 139 - 148.

Mordern, C.W., Doebley, J.F. and Schertz, K. F. (1989). Allozyme variation in old world races of *Sorghum bicolor* (Poaceae). *American Journal of Botany*, 76:247-255.

Mugabe, J. (1998). Conservation and utilization of plant genetic resources in Africa: A profile of policy, legislative and institutional measures. Discussion paper no. 7. African Centre for Technology Studies (ACTS) 32p.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., de Fonseca, G.A.B. and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403p.

National Bureau of Statistics (NBS) (2007). 2006 Population Census. Available at www.nigerianstat.gov.ng

Olorode, O. (1995). Genetic Resources, Biodiversity, Environment and Development. Invited Conference Paper presented at the 23rd Annual Conference of the Genetics Society of Nigeria, University of Uyo, May,1995.

Olorode, O. (2004). Conservation of Plant Genetic Resources. *African Journal of Traditional, Complementary and Alternative Medicines* Vol. 1, Num. 1, 2004, pp. 4- 14.

The World Bank (2019). Biodiversity IBRD-IDA. https://www.worldbank.org/en/topic/biodiversity.

Tomooka, N. (1991). Genetic diversity and landrace differentiation of mungbean, *Vigna radiata* (L) Wilczek, and evaluation of its wild relatives (the subgenus *Ceratotropis*) as breeding materials. *Technical Bulletin of TARC*, 28. *Tropical Agricultural Research Centre*, Tsukuba, Ibaraki, Japan.

United States Agency for International Development (USAID) (2008). *Nigeria Biodiversity and Tropical Forestry Assessment.* Published for USAID by Chemonics International Inc. June 2008.

van Soest, L. J. M. (1990). Plant genetic resources: safe for the future in gene banks. *Impact of Science on Society:* No. 158. UNESCO (Paris). pp. 107-120.